



**Government of the People's Republic of Bangladesh  
Ministry of Communications  
Roads and Highways Department**

# **CONSTRUCTION PRACTICES AND PROCEDURES MANUAL**

**MAY 2001**

**FOREWORD**  
**to**  
**Construction Practices and Procedures Manual**

It has long been recognised that the existing departmental Contract Procedures and related documentation, need to be up-dated in order to ensure that the Department can operate more efficiently and effectively whilst producing field work of a consistently high quality.

During the past few months several committees have reviewed current departmental practices and contract documentation. These committees were asked to formulate new procedures and documentation, which would be more in line with recognised international forms of contract. The committees consisted of senior RHD Officers from both Headquarters Wings and Field Zones assisted by consultants from IDC3 and RRMP2.

The new Contract Documentation consists of the following:

- Volume 1 - The Tender
- Volume 2 - The Conditions of Contract
- Volume 3 - Technical Specifications
- Volume 4 - Drawings

Volumes 2 and 3 are standard for all new RHD contracts and are therefore issued as printed and bound books. Volume 1 will be produced for each individual contract but the document format and contract forms will remain unchanged.

Other documents which do not form a part of the Formal Contract Documents, but play a vital part in the control of quality have also been produced. These include a new RHD Standard Test Procedures Manual and explanatory guides on a number of topics.

This Construction Practices and Procedures Manual is intended to provide a quick field guide to the construction methods to be adopted for the most commonly used construction items included in the Specifications

This document was prepared by consultants funded by GoB through RRMP2 funds. My thanks go to them and to the RHD Officers of BRRL who assisted in the production of this document. My thanks are also due to the many Executive Engineers of RHD who attended training at RHDTTC under the control of Mr. Khondoker Nurul Arefin SE (RHD) and Director RHDTTC for the feedback they provided.



Handwritten signature and date: 15/05/01

May 2001

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## Introduction

This Procedure Manual provides a guide to the correct construction practices and procedures for use on road contracts by the Roads and Highways Department.

This document is not intended to be comprehensive and therefore does not provide information on all construction activities. It refers to the Standard Technical Specification; however, it does not replace any aspect of that document and if there is any conflict, the Specification takes precedence. Also for any activities not included in this Manual, refer to the Standard or Particular Specification (if applicable) for details.

The contractor is responsible for the method of construction and quality of the constructed works and any work not undertaken in line with the Specification or with this document should be brought to the attention of more senior RHD officers (the Engineer) immediately.

Throughout the site ( the area where the works are being constructed ) the contractor is responsible for supplying all the necessary signs and other equipment to ensure the smooth and safe flow of traffic. Also the construction should be carried out in a safe and controlled manner to prevent damage to vehicles and the general public from construction equipment, site materials and activities.

This document makes reference to materials testing, for example for determining in-situ densities, by referring to STP6.2, these are tests included within the Standard Test Procedures Manual.

Included in the appendices of this manual are:

- A summary of the material requirements and the compaction standards for each layer – refer to Appendix 'A' and Appendix 'B' .
- The work sequence and the necessary laboratory testing for a road embankment – refer to Appendix 'C'.
- The test frequency to ensure the compliance of the material standards for each pavement layer – refer to Appendix 'D'.

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## **1.0 CLEARING, GRUBBING AND EXCAVATION.**

### **Key Points**

- **Before any construction the roadway must be cleared of all vegetation and trees including their roots removed.**
- **Cross sections should be taken prior to any excavation works.**
- **All construction works must be carried out in as safe a manner as possible.**
- **Excavated suitable materials should be used when possible in the works.**
- **Provision has to be made for drainage of the temporary and permanent works.**
- **Soil containing vegetable matter is not suitable as fill material.**
- **Borrow pits should not affect the stability of the road, or any other structure.**

### **1.1 Clearing and Grubbing (Specification 2.1)**

Before any construction starts the roadway must be cleared of debris. Unless there are specific reasons, agreed to by the Engineer in writing, all materials including trees, grass, crops and structures, which fall within the road alignment must be removed.

Also all major stumps and roots need to be removed (grubbed out) and the holes left must be filled with compacted suitable fill material.

Figure 1 shows an example of the clearing and grubbing which is required.

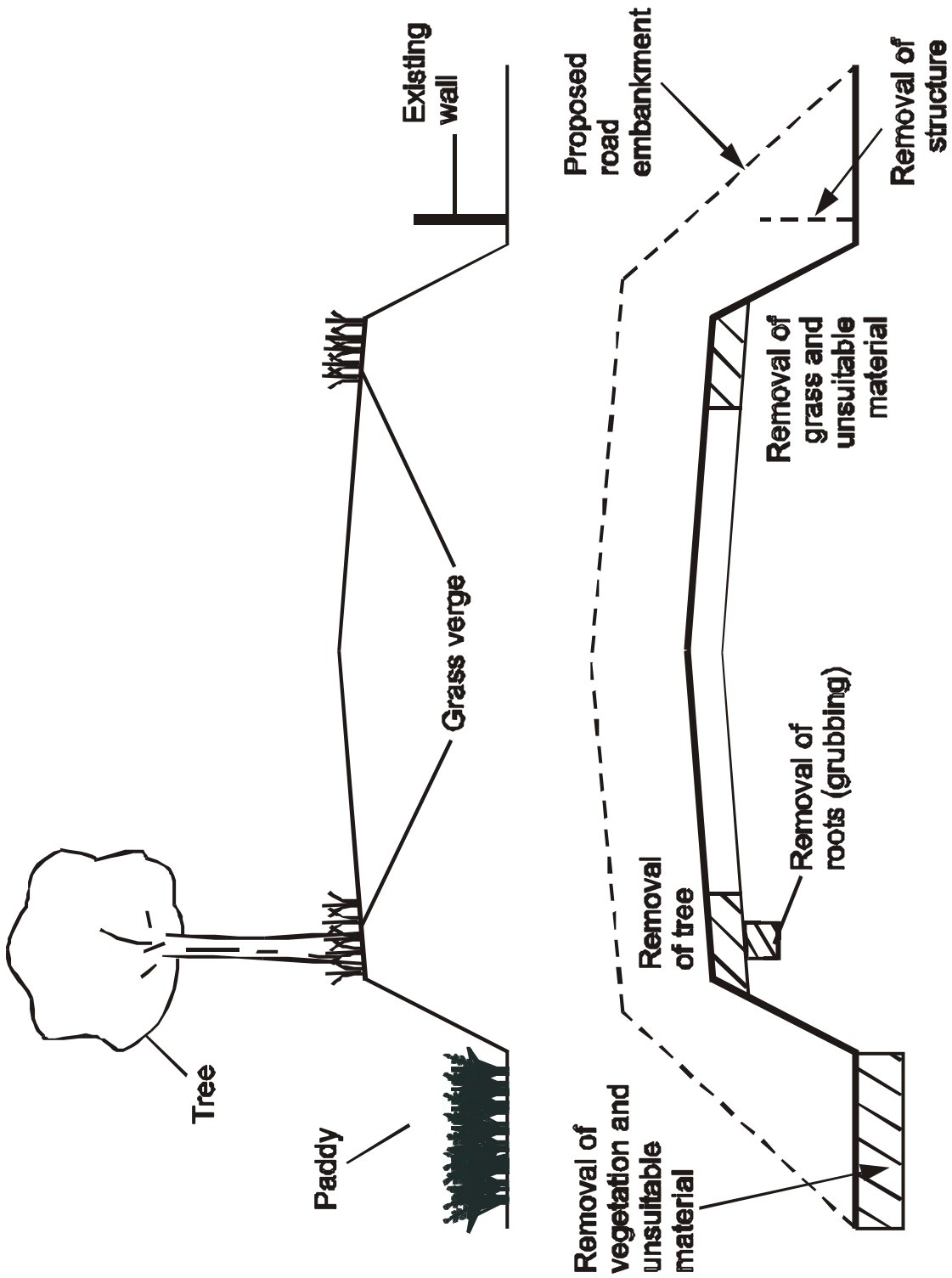


Figure 1. Clearing and grubbing of roadway

## **1.2 Excavation (Specification 2.2, 2.3, 2.4, 2.5 and 2.9)**

### **1.2.1 General**

Before any excavation, including the removal of any areas of unsuitable materials, cross-sections should be taken of the undisturbed ground. From this information, and the cross sections taken of the completed road, earthwork quantities can be calculated.

No existing material, which will remain in the completed works, should be loosened unnecessarily during excavation.

Excavation works, along with all construction activities, must be undertaken in as safe a manner as possible to minimise the dangers to road users and the contractors personnel.

### **1.2.2 Excavated Material**

Excavated materials need assessing as suitable or unsuitable. Suitable materials should be used when possible in the works. The excavated materials can be temporarily stockpiled, but must cause no damage to roads, services or property and not prevent water draining from the road or from the surrounding land.

Any excess suitable material, which is not required for the construction of the Works or any material classified as unsuitable is the property of RHD. The Contractor should stockpile these materials separately, as directed, or place the material in an approved location on site. To be suitable as fill material the soil must not contain any vegetable matter. To be suitable as road pavement the requirements for sub base or base materials must be met. Materials excavated from existing road pavements may meet the necessary requirements directly, or after breaking and mixing with other materials.

### **1.2.3 Drainage and Channel Excavation**

During construction, ditches are required to be maintained to ensure proper drainage at all times. Any necessary ditches and channels should be constructed and maintained to ensure there is no damage to the roadway section. All existing ditches, or drainage channels, which the road crosses, need to be closed at the edge of the embankment, unless pipes or structures are to be constructed and, where necessary, alternative outfalls are to be provided.

Any canals and channels which are located within the embankment area need to be cleaned up and then back filled with sand. The sand fill should reach a level of 500 mm above the water level, but thereafter earthworks (as described in Embankments below) can be placed.

### **1.2.4 Borrow Pits**

The borrow pits should be kept as drained as possible. Borrow pits should not be constructed where they might:-

- a) Affect the stability or safety of the highway, see Figure 2, or any railway or other structures, which may be present.
- b) Prevent natural or artificial drainage or irrigation.
- c) Damage adjacent property or future expansion plans for the highway.

As materials are only paid for when included in the embankment, there is no need to measure the volume of material removed from any borrow pits.



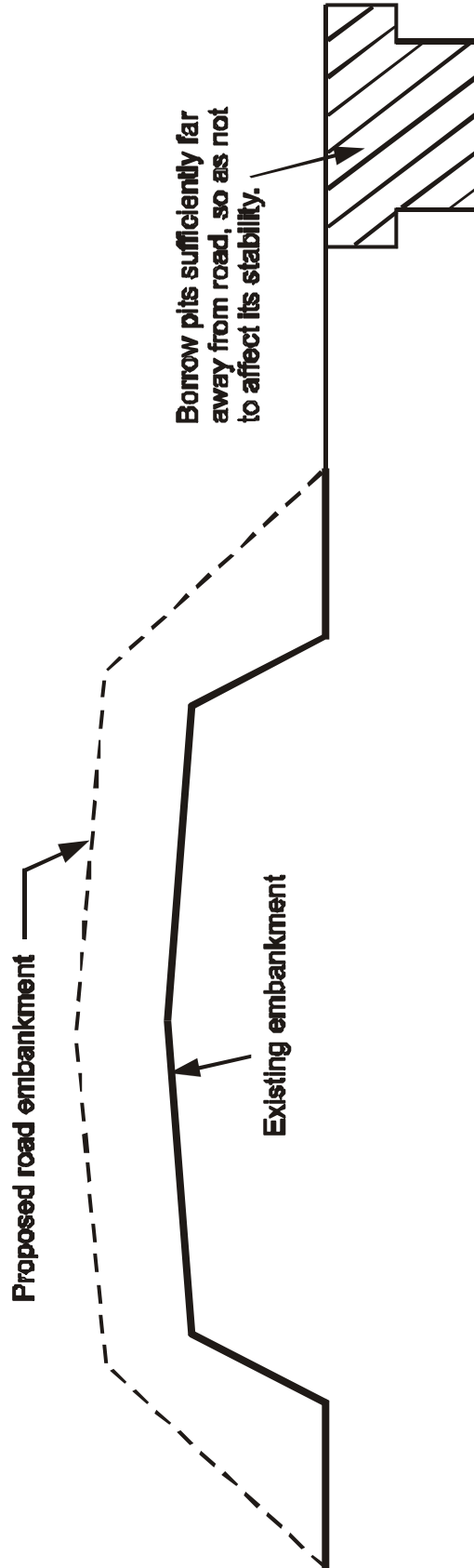


Figure 2. Borrow pits locations

## **2.0 EMBANKMENT (Specification 2.6)**

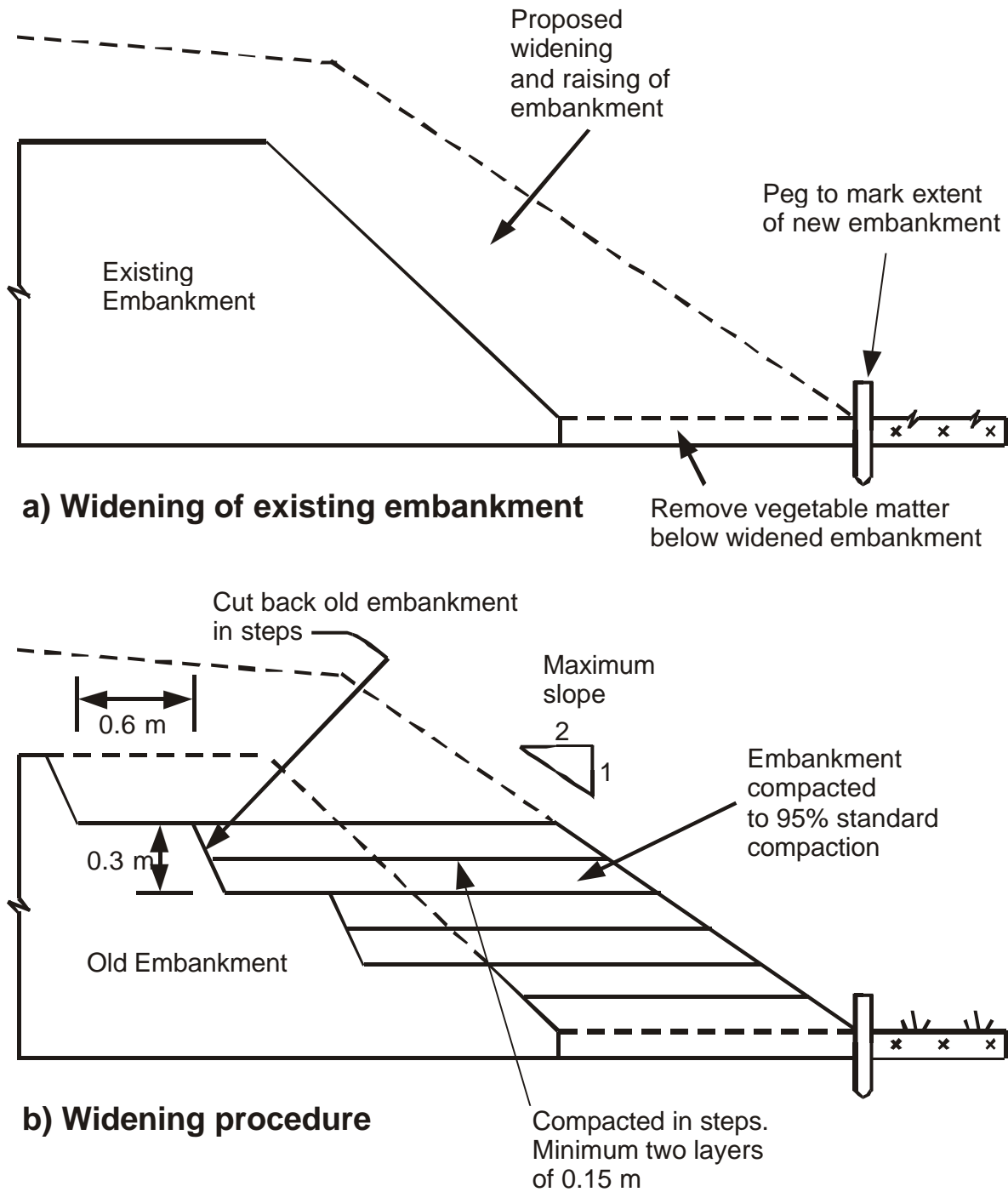
### **Key Points**

- **All fill materials must be free from vegetable matter and the material must be approved as suitable.**
- **The material should be of an appropriate nature and at a moisture content that it can be compacted to form a stable layer.**
- **Generally embankments should be constructed in 150 mm compacted layers parallel to the finished grade of the road.**
- **For each completed layer the density should be checked (One test for each 1,000 square metres) by laboratory personnel. If test results show the required density is not achieved further compaction is necessary**
- **Any soft areas must be rectified before further material is placed. Each earthworks layer requires to be approved before the next layer can be started.**

### **2.1 Embankment Construction Methods**

Before placing any material, clearing and grubbing and the removal of any unsuitable materials needs to have been completed. Also any necessary information to determine earthwork quantities should have been collected (normally cross sections of the original ground).

Where an existing embankment is widened, the new fill material must be fully keyed into the old embankment by means of benching. Steps not less than 300 mm high and 600 mm wide should be cut into the old embankment prior to any filling, see Figure 3. Material cut from these benches may be used as fill, if it is suitable.



**Figure 3. Embankment widening procedure**

Normally embankments should be constructed in layers approximately parallel to the finished grade of the road. The grade and crossfall should be maintained during construction, as this will enable water to run off the embankment allowing construction work to start as soon as possible after rainfall and avoid soft spots forming.

All fill material used must be free from roots, or any vegetable matter. Each layer of fill should be less than 150 mm on completion of the compaction. Compaction must be undertaken using appropriate equipment. If large rollers (very heavy vibrating compaction) are used it may be possible to increase the depth of the layers but this should only occur after checking that adequate compaction is being achieved. Generally the compaction should begin at the outer embankment edges and gradually progress toward the centre rolling in a longitudinal direction so that the full width is uniformly compacted. In order to ensure proper compaction of the embankment slope it is good practice to overfill by 150 – 300 mm and then trim the embankment to the specified shape. The arisings can be re-used as fill material.

The fill material needs to be of a type and moisture content so that it can be compacted to form stable layers. The water content of each layer, before being compacted, must be assessed. The material may require water to be added or be allowed to dry to bring the moisture content close to the optimum in order to make it possible to achieve the required dry density and hence degree of compaction.

Normally one density test for each 1,000 square metres of every layer should be carried out by laboratory personnel. These tests should be carried out at random and be across the full width of the embankment. If the test results show that the density is less than that required, then further compaction to obtain at least the required density is necessary. Results of all the compaction tests undertaken should be kept on file.

If it is not possible to arrange for compaction testing at the appropriate time (e.g. where this would delay the contractor) a visual check of the earthworks should be made. If the layer appears to be satisfactorily compacted, approval may be given. In this case tests must be carried out on the subsequent layer. This procedure is not acceptable for any layer within 300 mm of the subgrade level.

As an alternative the Dynamic Cone Penetrometer (DCP) can be used to test earthworks. The DCP is a rapid in-situ method which after correlation can be utilised to obtain CBR's and density results.

If the embankment contains any -

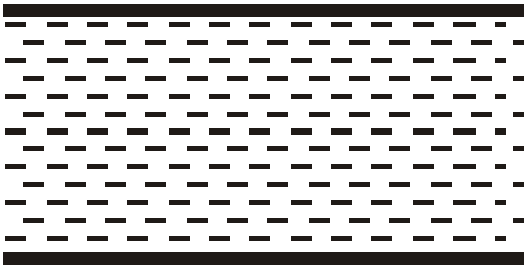
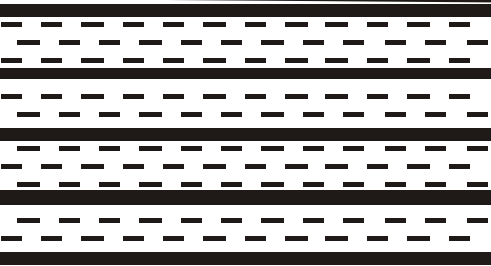
- soft areas this generally means insufficient compaction has been used. Further rolling required.
- spongy areas, (which move under the wheel of the roller) this generally means the materials have been placed too wet. In this case the material needs to dry out, and to enable this to occur scarification of the surface is often necessary.

Each compacted layer requires to be approved before the Contractor can commence on a new layer. If the Contractor does not obtain approval before starting a new layer, or does not follow acceptable procedures, the contractor must be advised of the non-compliance and the Engineer informed immediately.

Adequate compaction for embankments (refer to Appendix 'B') is to ensure that only limited settlement will occur with time. If the embankment settles unevenly this will give an uneven surface to the road. Figure 4 provides a comparison between placing material in a single thick layer and placing thinner layers in an approved manner. It is particularly important to adequately compact fill material adjacent to bridges and culverts to prevent noticeable transverse level differences occurring.

### Figure 4. Compaction of Materials

#### Comparison of Alternative Methods

THICK LAYER PLACED THEN COMPACTED	THINNER LAYERS EACH COMPACTED
	
<p>Top of layer compacted, but overall poorly compacted.</p> <p>Gaps between materials ( high voids).</p>	<p>All layers well compacted.</p> <p>Few gaps between materials ( low voids).</p>
<p>Poor compaction.</p> <p>Allows water to enter layer. Weakens the material.</p> <p>Settling in time, may cause uneven pavement surface.</p>	<p>Good compaction.</p> <p>Prevents water entering layer. ( material retains it strength).</p> <p>Little Settlement.</p>
<p><b>UNACCEPTABLE</b></p>	<p><b>APPROVED MANNER</b></p>
	<p><b>SPECIFIED</b></p>

### **3.0 SUBGRADE (Specification 2.7 and 2.12)**

#### **Key Points**

- **All subgrade material must be free from vegetable matter.**
- **The subgrade must be shaped to the required profile.**
- **The subgrade should be of an appropriate material and at a moisture content that it can be compacted to form a stable layer, for the full width of the embankment.**
- **Three tests to check the compaction for each 1,000 square metres should be completed. If the results show the required density is not achieved further compaction is necessary.**
- **When specified, subgrade drains should be constructed to the edge of the embankment.**
- **The compacted subgrade layer requires to be approved with any soft areas being rectified, before work can start on the pavement.**

The subgrade is the layer of embankment immediately below the pavement. This may be undisturbed local material or may be soil excavated elsewhere and placed as fill. In either case it has to be prepared to give added strength.

All subgrade material must be free of vegetable matter. The material also needs to be of a type and moisture content that it can be compacted to form a stable layer. If the material in the subgrade level is found to be unsuitable, this must be excavated and replaced with suitable material, which should then be compacted.

The subgrade must be prepared over the full width of the embankment, including the shoulders. This is generally carried out in lengths of greater than 100 metres. In some cases to

maintain traffic, part width working may be necessary. If this is the case it is vital that the full width of the embankment meets the subgrade material and compaction requirements.

When the road is to be placed on existing material, this should be fully loosened to a depth of 150 mm below the subgrade level. Any lumps should be removed or broken up to be less than 50 mm in size.

The subgrade must be compacted uniformly by use of adequate and appropriate compaction equipment. The material should be at a moisture content close to optimum throughout the layer so that it can be compacted to produce a dense compacted layer. Generally the compaction should begin at the outer edges of the embankment and by rolling in a longitudinal direction gradually progress towards the centre so that each section receives equal compaction.

Three compaction tests are required for each 1,000 square metres of subgrade. If the test results show that the density is less than that required, further compaction will be necessary. After which the density should be rechecked to ensure the required dry density has been achieved.

The surface of the finished subgrade must be to the required cross section with a tolerance of 20mm above or below the specified level at any point. Typically the subgrade should be checked at not greater than 25m intervals, where necessary shorter lengths can be checked. There must be no depressions which could form water ponding areas in the subgrade.

The subgrade layer must be approved before the Contractor can start on the construction of the road pavement.

Before any shoulder fill is placed, all subgrade preparation and subgrade drainage work require to be completed. For the shoulder a compaction test must be carried out for every 500 square metres of finished layer.



### 3.1 Subgrade Drains

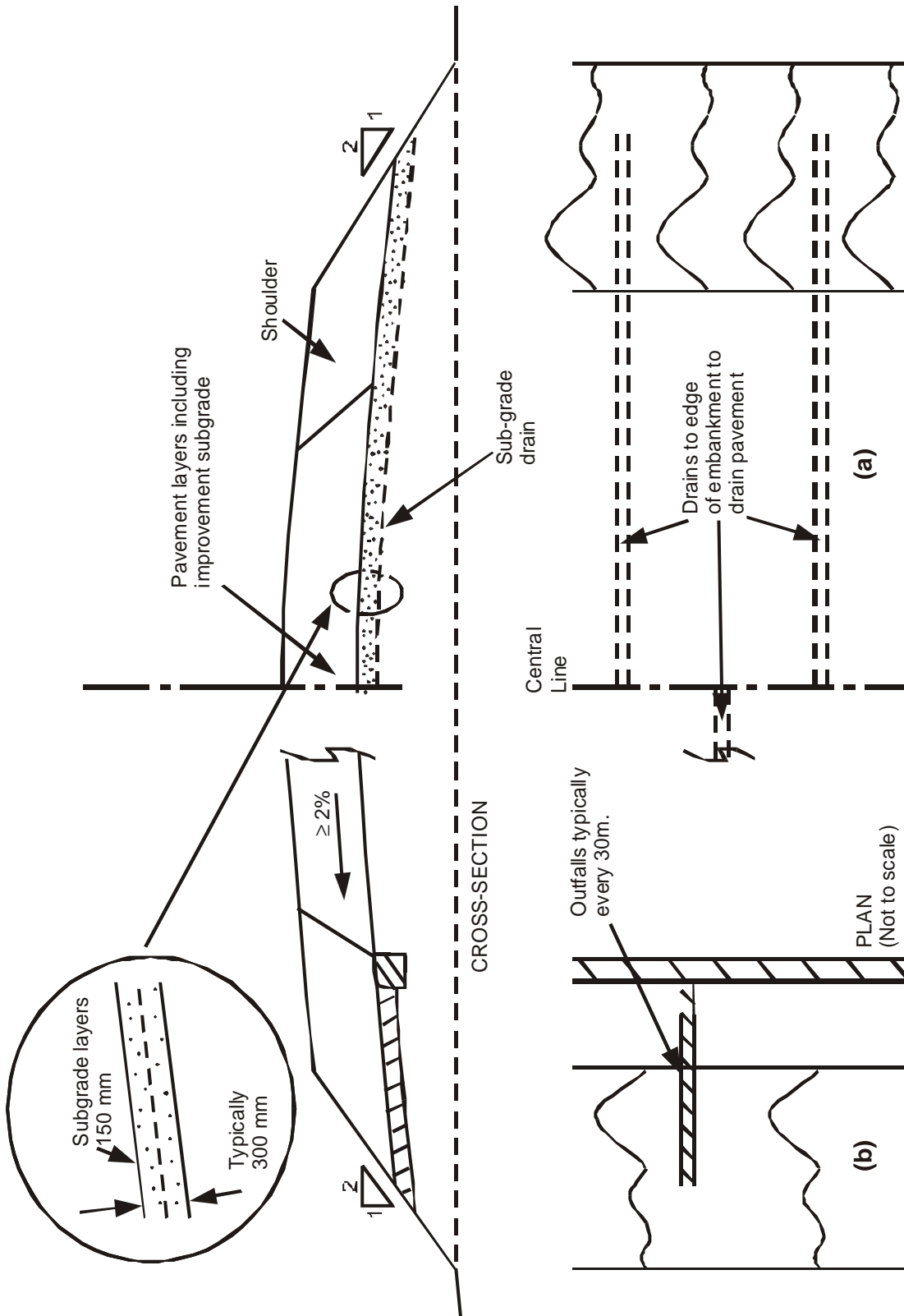
Subgrade drains are constructed to ensure that water in the pavement, which would weaken the road, is allowed to drain away.

Subgrade drains should be extended to the edge of the embankment with drains on opposite sides of the road being staggered. In case of roads with minimal longitudinal fall it is often better to install subgrade drains longitudinally at the edge of the road pavement, see Figure 5.

Subgrade drains should be excavated by hand in the prepared subgrade. The excavation should be filled with clean sand or gravel, which contains no vegetable matter, silt or clay. The backfill must be compacted by hand ramming and struck off level with, or slightly above, the finished subgrade level.

The finished backfill must be immediately covered with an approved separator material. The separator material is normally specified and will be woven rot proof fabric, geotextile membrane or perforated heavy duty polythene sheeting. The separator material should extend 150mm beyond the edges of the drain on all exposed faces. Any joints in the fabric should overlap by at least 150mm.

Materials over the drain should be placed by hand for at least 100mm above the separator membrane prior to rolling either the pavement or the shoulder materials.



**Figure 5. Sub-grade drains**  
 (a) Transverse subgrade drains staggered to opposite sides  
 (b) Longitudinal subgrade drain with outfall

#### **4.0 PAVEMENT LAYERS (Specification 2.8, 2.10, 2.11, 3.1, 3.2 and 3.3)**

##### **Key Points**

- **At least seven days before a proposed material's use a sample of the material along with laboratory test results have to be submitted by the contractor to the Engineer for approval. Fresh approval is required if the material is changed.**
- **The material for sub base and base must be graded, with sufficient fines that they can be properly compacted. All areas of segregated coarse or fine material must be corrected, or removed and replaced with complying material.**
- **Continued checks on materials must be carried out throughout the contract period. If the materials' tests indicate changes have occurred the contractor and the Engineer must be immediately informed.**
- **The moisture content of the material at the time of compaction must be appropriate to produce a dense compacted layer.**
- **If a pavement layer, does not conform with the thickness or tolerance required, the layer must be corrected. Once the correction is completed the area should be rechecked to ensure it conforms to the correct depth, cross fall and degree of compaction.**
- **Each layer should be tested for compaction (3 tests for each 1000 square metres). If the test results show that the required density is not achieved, further compaction must be undertaken.**
- **Each layer of pavement must be shaped, compacted and approved ahead of the placing of subsequent material.**

## 4.1 General

On large contracts Contractors are required to make arrangements for areas to process and stockpile pavement materials. Therefore generally the preparation and storage of materials along the road should not be allowed. On small contracts, however, or when existing pavement materials are to be used in the new works this may be allowed.

A sample for each material proposed to be used, along with test results, has to be submitted at least seven days before the material is used. The sample should be checked to see if the materials conform to the Specification. If the materials meet the requirements of the Specification, approval should be given by the Engineer for their use.

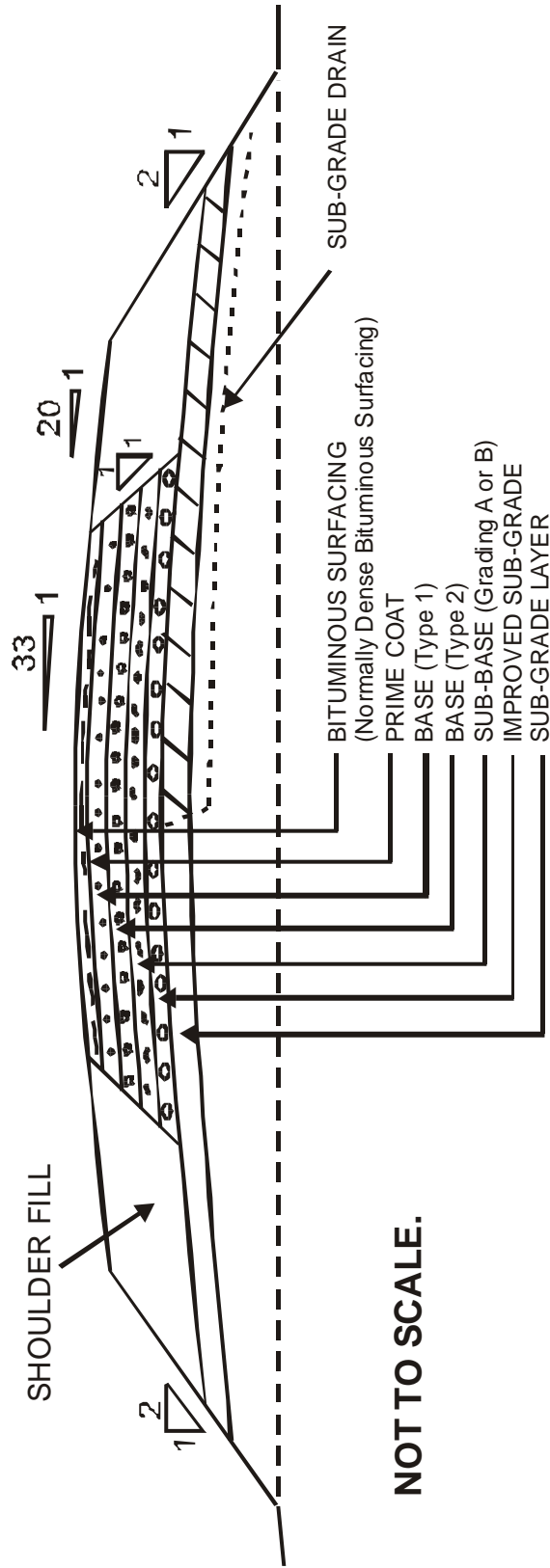
A typical cross section showing the pavement layers through a road is shown in Figure 6.

## 4.2 Materials

**Improved Subgrade** - Material for improved subgrade should be locally available material which is a natural or artificial mixture of sand or other mineral aggregate, free from vegetable matter. The material should not be greater than 5 mm and should not contain clay or soft particles.

**Sub-Base** - Sub base is the secondary load spreading layer of the pavement. The material should be a natural or artificial aggregate (or a combination) with no vegetable matter, soft particles or clay. The material requires to have varying sizes of material (well graded) with sufficient fine material so that it can be compacted to produce a close and tight surface texture. The coarse aggregates should not appear particularly flaky or elongated (see Figure 7).

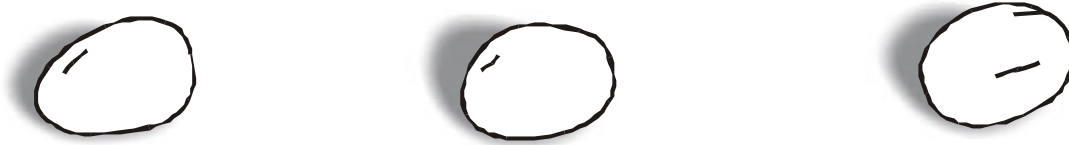
**Figure 6. Pavement Layers (New Road Construction)**



**NOT TO SCALE.**

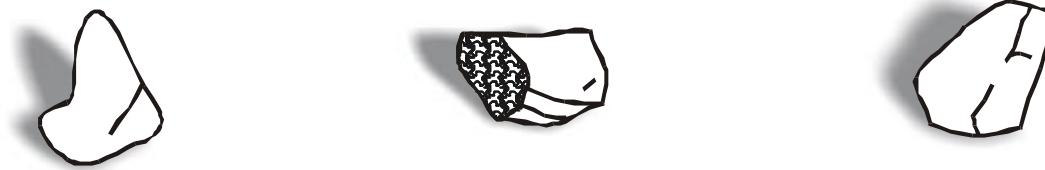
NOTE.

1. Separate Base Type 1 and 2 are not always incorporated into road pavement, it is common to have only one base type in the pavement.
2. Width of road pavement, shoulders and verges depends on road class selected.



Rounded - smooth, circular particles

e.g. Gravel not generally acceptable unless broken for asphalt and concrete



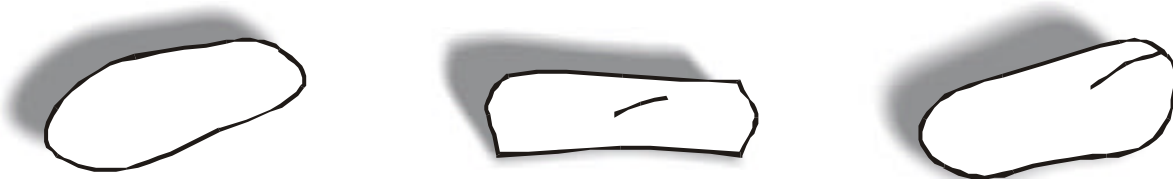
Angular - sharp corner

e.g. Crushed stone. Acceptable all pavement and concrete materials.



Flaky - flat, thin pieces, easily crushed

Not acceptable for pavement or concrete materials.



Elongated - long thin particles, relatively easily broken to smaller pieces

Not acceptable for pavement or concrete materials.

**Figure 7. Particle shapes**

**Aggregate Base** - Aggregate base is the main load spreading layer. It should consist of hard pieces of rock, brick or gravel crushed to the required size, and a filler of sand or other fine mineral matter. The material must be graded, with sufficient fines so that it can be compacted to produce a close and tight surface texture. The materials should not contain clay and the coarse aggregate should not appear particularly flaky or elongated (see Figure 7).

Figure 8 provides a comparison between uniform single sized material and well graded materials. This illustrates that well graded materials, provided the road is adequately rolled, will produce a suitably compacted layer.

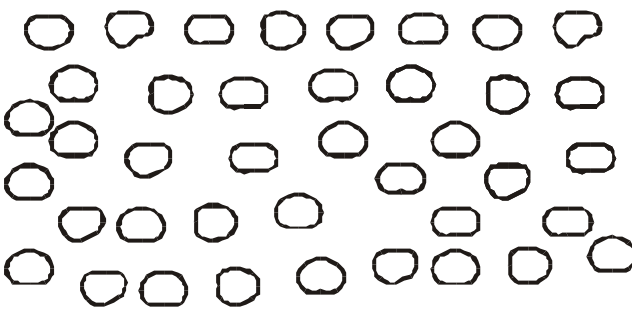
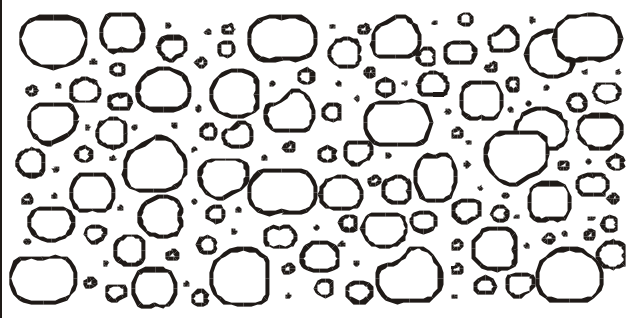
### 4.3 Construction Methods of Pavements

The grading and quality of the materials need to be monitored throughout the works. Samples of the materials brought to site should be regularly taken for testing (see table at back of this report for frequency) to ensure that the materials continue to conform with the specification. If the tests indicate changes have occurred the contractor is to be notified of the non-compliance and the Engineer must be informed immediately.

Each layer needs to be inspected and be acceptable immediately prior to laying the next layer. If the previous layer is acceptable material should be spread in layers of nearly equal thickness up to 150mm un-compacted thickness. Where sand and aggregates are combined together to meet the specified grading, care should be taken to prevent separation into fine and coarse parts (segregation). If separation occurs, this either needs to be corrected, or the material should be removed and replaced.

When the shoulder construction is the same as for the road, the material should be spread, for the full width of the pavement and shoulders at the same time.

**Figure 8. Uniform and Graded Aggregates  
For Sub-Base and Base Course Layers**

<p align="center"><b>UNIFORM</b> Single Size or Gap Graded</p>	<p align="center"><b>WELL GRADED</b> Large, Medium and Small Materials</p>
	
<p>Uniform size, so poorly graded material. High voids ratio (gaps between large particles).</p>	<p>Not uniform size, well graded material. Low voids ratio (enough small materials to fill gaps).</p>
<p>Poor compaction. Allows water to enter layer, which weakens it. Settles in time.</p>	<p>Good compaction. Prevents water entering layer (stronger). Little settlement.</p>
<p align="center"><b>UNACCEPTABLE</b></p>	<p align="center"><b>APPROVED MANNER</b></p>
	<p align="center"><b>SPECIFIED</b></p>



The moisture content at the time of spreading requires to be appropriate to produce a dense compacted layer. This requires that the material contains a moisture content close to optimum throughout the layer. Additional water, or time to allow the pavement material to dry, prior to, or during compaction may be required. This is the contractor's responsibility and no additional payment be made.

After spreading, each layer requires to be compacted with suitable and adequate compaction equipment, see Photo 1. Rolling should begin from the outer edge of the placed material and gradually progress towards the centre, rolling in generally a longitudinal direction. However, on super-elevated curves, the rolling should begin at the low side and progress towards the high side.

Density of the compacted pavement layer must be determined by laboratory personnel in accordance with STP 6.2 with at least three tests being made for each 1,000 square metres. If the test results show that the achieved dry density is less than that required, further compaction is necessary. After further compaction the layer should be tested again to ensure the required density is achieved. Results of all the compaction tests should be kept on file as a permanent record.

The level and thickness of each pavement layer should be checked every 20 m. A pavement layer, which does not conform to the requirements for that layer (thickness or tolerance of surface, see Table 4.1), must be corrected. This should be done by loosening the affected areas, adding or removing materials and re-rolling, mixing and watering, if necessary. Once this has been done the area should be checked again to ensure it conforms to all the requirements for that pavement layer.

**Table 4.1 Tolerance of Surface and Thickness of Layer**

	<b>Improved subgrade</b>	<b>Sub base</b>	<b>Base</b>
Tolerance above or below proposed level.	No point more than 20 mm above or below.	No point more than 15 mm above or below.	No point more than 10 mm above or below.
Thickness of finished layer			
On average not less than the:	required thickness	required thickness	required thickness
No point thinner than:	20 mm less than the required thickness	10 mm less than the required thickness	10 mm less than the required thickness

When the pavement is spread next to concrete kerbs or gutters, care must be taken not to damage them. If they are damaged due to the Contractor's carelessness they should be removed and replaced at the Contractor's expense.

At the start of constructing the improved sub grade and sub-base layers a field compaction trial should be carried out. This is to determine the optimum moisture content and the required number of passes of the compaction equipment to comply with the Specification. This trial should also determine the relationship between the loose and compacted thickness to ensure the material placed is adequately compacted to the specified density and the finished surface profile complies with the design level and permitted tolerances. Provided the method produces satisfactory results it should then be used for all subsequent compaction of that material. In this case provided the Contractor follows the agreed procedure, the frequency of checking the compacted density of the layer may be reduced with the Engineer's approval.



Photo 1. Rolling Pavement Layers, suitable and adequate compaction equipment must be used.



Photo 2. Spray Bar at the Rear of Bitumen Distributor, Spraying Bituminous Prime Coat.



Photo 3. Mechanical spreader spreading aggregate on recently sprayed bitumen surface.



Photo 4. Multi Tyre Roller (PTR).

## **5.0 BITUMINOUS LAYERS AND MIXES (Specification 3.4 to 3.12)**

### **Key Points**

- **At least 14 days in advance of a proposed material's use, samples of the material along with laboratory test results should be submitted to the Engineer. If approved, the contractor should then carry out trial mixes.**
- **The surface upon which the bitumen or bituminous mixture is to be placed must be thoroughly cleaned immediately before the bitumen or mixture is placed.**
- **Bituminous materials should be placed only when the surface is dry, when rain does not appear imminent and when the prepared roadbed is in a satisfactory condition.**
- **The entire surface to be primed must be covered evenly. Prior to any spraying, the nozzles on the spray bar of the distributor should be checked to ensure that they are all working. Where appropriate the distributor should be calibrated to ensure the required rate of spray is achieved. Depending on the nature of the surface to be primed a light application of water just prior to priming may be beneficial to aid penetration of the bituminous material.**
- **No bituminous mixtures should be placed until the prime coat has dried.**
- **Tack coat may need to be applied to make the road surface sticky prior to the bituminous carpeting layer being placed.**
- **For Primer Seals and Bitumen Surface Treatments the aggregate must be spread and rolled into bitumen immediately after spraying, preferably rolling should be by multi tyre rollers.**

- **No dense bituminous surfacing can occur until both the job mix formula and the trial sections have been approved.**
- **Thereafter all asphalt work is required to follow the approved Job Mix formula and the procedures established by the approved trials.**
- **Each day dense bituminous surfacing is laid, three Marshall specimens should be prepared and tested (STP 10.9.10.10). Samples to be collected from either the plant or the laid mat, as directed by the Engineer. Samples should also be taken each day to determine the mix composition (Extraction of bitumen test and grading, STP 10.4.72).**
- **All equipment proposed to be used by the Contractor requires to be in good condition and operated by competent and experienced operatives.**
- **Dense bituminous surfacing must be thoroughly compacted as soon as the material will support the roller without undue displacement or cracking. Excess use of water on the roller drums is to be avoid as this cools the asphalt mat.**
- **The surface of the mixture after compaction must be close and tight, and free from dragging cracks. Any mixture that is defective should be removed and replaced with fresh hot material, which should be compacted immediately.**
- **After final rolling, samples should be cut from areas of bituminous surfacing for density and thickness measurement at 50m intervals. Where samples have been taken, fresh material must be placed and thoroughly compacted.**

## **5.1 General**

Samples of all materials proposed to be use in the works, along with test results, should be received by the Engineer at least 14 days before the proposed use of materials. If the materials comply with the Specification, agreement should be given for test mixes or trials to be undertaken. Even if the

initial bitumen sample provided complies with the Specification each consignment of bitumen delivered to site must be accompanied by a certificate. This should show the place of manufacture and the results of standard tests carried out on the particular batch of bitumen.

Before any bitumen is sprayed, or bituminous mixtures are placed, the road surface requires to be inspected. Any areas of base course, which appear broken or loose should be removed. Either the full depth of the base course requires to be reworked, or a bituminous rectifying layer should be placed and thoroughly rolled until it conforms to the surrounding surface. The surface must also be cleaned immediately before any material is sprayed or placed. Bituminous materials should generally be placed only when the surface is dry and when rain does not appear imminent.

The bitumen should only be utilised at the temperature range in Table 5.1 below:

**Table 5.1**

<b>Spraying Temperatures For Bitumen</b>		
<b>Type</b>	<b>Grade</b>	<b>Temperature (°C)</b>
Cut-Backs R.C. or M.C.	30	38 – 57
	70	57 – 71
	250	77 – 94
	800	99 – 113
	3,000	118 – 132
Penetration Grade Bitumen	60 - 70	151 – 161
	80 - 100	151 – 161
	200 - 300	138 – 151
Emulsion: As necessary for uniform spraying and satisfactory penetration		

## 5.2 Bituminous Prime Coat

A bituminous prime coat is a thin layer of bitumen sprayed on to a prepared road base. Either MC 30 or MC 70 cut back bitumen should be used, which should be sprayed within the temperature range included in Table 5.1. The prime coat will normally be sprayed from a spray bar at the rear of a bitumen distributor, as shown in Photo 2, at the rate given in the Contract Documents. Alternatively the rate can be directed by the Engineer.

It is important that the entire surface is uniformly covered and so prior to starting any spraying the nozzles in the spray bar need to be checked to ensure they are working. Also the spray bar should be at the correct height,  $h$ , and be parallel to the road surface see Figure 9 so that each point of the road is sprayed from three separate jets. As an alternative and only generally on small projects the contractor can propose equipment and methods (including labour intensive methods).

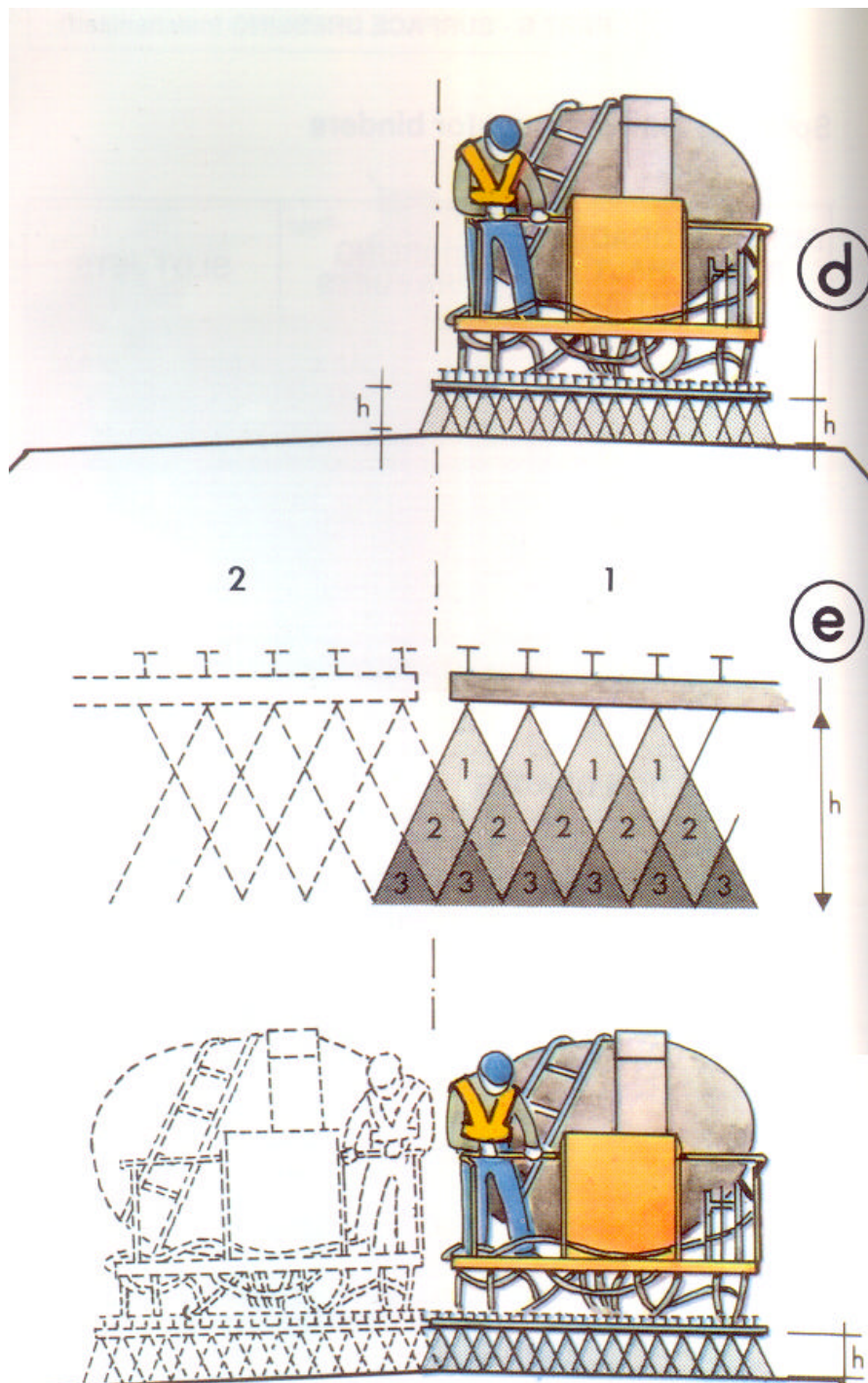
No further bituminous layers must be applied until the prime coat has dried, this should occur within 48 hours.

## 5.3 Bituminous Tack Coat

A tack coat is normally applied to make the road surface sticky prior to dense bituminous surfacing or carpeting being placed. To ensure this occurs the tack coat should therefore only be sprayed immediately before the carpeting is placed.

The tack coat will normally be applied by bitumen distributor unless labour intensive methods are agreed. The tack coat material requires to be uniformly distributed over the surface without streaking.





**Figure 9. Spraying a road surface with Prime Coat**

NOTE. After first side sprayed (1); second run undertaken (2). The process can be repeated as many times as required to spray the full road width.

The bitumen used should either be cut back bitumen RC 30, RC 70, or rapid setting emulsion and this should be sprayed within the temperature range given in Table 5.1.

#### **5.4 Primer Seal**

A primer seal consists of pea gravel material rolled into a cut back bitumen, which has been sprayed on to a prepared surface. The Pea gravel should be graded so that 100% of the material falls within the size range of 2.4 mm to 6.3 mm. The Pea-gravel must be free from any organic matter or clay and should be completely dust free.

The procedure to be followed is:

- Cut back bitumen is sprayed on the prepared surface
- Screened pea gravel aggregate spread to provide a dense uniform cover one stone thick.
- The aggregate to be rolled into the bitumen immediately using a rubber tyred roller for at least 4 passes before the road is opened to traffic.

#### **5.5 Bituminous Surface Treatment**

This surfacing consists of nominal single size aggregate rolled into a bitumen layer, which has been sprayed on to a prepared surface. This is often known as a single surface dressing. The procedure can be repeated using a smaller single size stone rolled into the gaps to promote a good interlock between the layers, this is known as a double surface dressing.

The aggregate requires to be hard, crushed stone or crushed gravel of uniform quality. This should be free from any dust and contain no vegetable matter and should not be flaky or

elongated (see Figure 7). The aggregate must not be used until it appears dry as water prevents bitumen adhering effectively to the aggregate.

The rates of bitumen and aggregates may be specified in the contract documents, but these are normally established from site trials. The bitumen layer will generally be sprayed using a bitumen distributor using the same method shown in Figure 9, but for small areas hand spraying equipment is used. The bitumen should generally be either RC 800 or RC 3000 cut back bitumen or rapid setting emulsion at the appropriate temperature given in Table 5.1.

Immediately after the bitumen is sprayed the aggregate should be spread uniformly using a mechanical aggregate spreader, see Photo 3. At this stage the surface requires to be inspected and further aggregate should be placed in any insufficiently covered areas by using the spreader or covering by hand methods.

Immediately after spreading, the aggregate requires to be rolled, preferably with one or more pneumatic tyred rollers. An example of a multi tyred roller is shown in Photo 4. The rolling must be continued, for as long as is necessary to ensure the aggregate is firmly embedded into the bitumen. If tyred rollers are not available steel wheeled rollers may be permitted. However, in this case the finished surface must be checked to ensure that the aggregate is not crushed and is being fully embedded into the bitumen.

## **5.6 Dense Bituminous Surfacing (Asphalt)**

A dense Bituminous Surfacing consists of graded aggregates, including a filler, coated with bitumen. The material is laid hot and is compacted to form a dense impervious layer. The surfacing can either form the road surface or a seal coat can be laid on the asphalt.

On large contracts the bituminous materials are manufactured, transported and placed by plant (Section 5.6.3). On smaller contracts, more labour intensive methods are generally used (Section 5.6.4). In either case due to the high cost of the materials, it is vital that the works are undertaken to the specified quality. Therefore a job mix should be undertaken (Section 5.6.2) and the asphalt should be to the thickness and compaction standards as specified (Section 5.6.5).

### 5.6.1 Materials

Samples of materials proposed to be used with their test results have to be received by the Engineer at least 14 days before the materials' proposed use. Full requirements for materials are given within the Specification. If the materials meet the Specification approval should be given (by the Engineer) for the contractor to manufacture job mixes. The following points, which relate to materials, should be noted when considering whether materials are acceptable:

- Crushed stone or crushed gravel should be used for the coarse aggregate, that fraction larger than 5 mm. The aggregate should be free from vegetable matter and the particles should not be soft , flaky or elongated (see Figure 7).
- The fine aggregate, that fraction smaller than 5mm, should consist of natural sand, stone screenings, or a combination of both. The aggregate should consist of clean angular particles, with the material being free from vegetable matter, soft particles and dust.
- In order to achieve the specified grading mineral filler may be required. This should be either a natural rock dust or a fine mineral matter (Portland cement or hydrated lime) and should be dry and free from lumps.

The quality of the materials needs to be regularly checked throughout the duration of the contract works. If there appears to be any deterioration the Contractor and the Engineer should be notified and samples of the materials should be taken and sent for testing.

### **5.6.2 Formula for Job Mix**

After approval of the materials the contractor must design a job mix formula. To ensure the road surfacing performs satisfactorily the mix must be designed to have a low percentage of air voids and good fatigue behaviour. To ensure these characteristics are achieved it is vital that the proportions are established and this occurs with the production of the job mix. The formula must provide details of the mixing proportions of the various constituents, the percentage of aggregate passing each sieve size and the percentage of the bitumen which will be used.

The mix formula should also provide the methods of mixing and heating of the materials (including means of temperature control) and the means of transportation, laying and compaction. A temperature for the emptying of the mixture from the mixer, and a temperature at which the mixture is to be delivered on the road are also required.

All the above information must be provided to the Engineer who, if satisfied, will approve the job mix. After approval the Contractor is required to lay trial sections of surfacing for each formula to demonstrate that the works will be to the specified quality.

Generally no contract surfacing works may be carried out until the mix formula has been approved and the trial sections have been satisfactorily completed. However, the Engineer may allow the manufacture of asphalt to start on small contracts (this must be approved in writing) in which case, the

temperature and grading of the materials requires to be closely monitored. When a mix formula has been approved it is vital that all the asphalt conforms to the formula within the following tolerances:

- Passing sieves 10 mm and larger.....± 8%
- Passing sieves between 10 mm and 0.075 mm.....± 5%
- Passing 0.075 mm sieve .....± 1%
- Bitumen content (single test result) .....± 0.50%
- Bitumen content (three consecutive test results) .....± 0.40%
- Temperature of mixture when emptied from mixer .....± 15° C
- Temperature of mixture at delivery on road .....± 15° C

Each day three samples of the asphalt must be taken and tested (Marshall specimens). Also the temperature when emptied from the mixer and when delivered to the road should be continuously monitored. Samples should also be taken daily and tested in accordance with STP 10.4 (Extraction of bitumen) to determine the composition and the percentage of bitumen included in the mix, as well as, gradation of the mix. When unsatisfactory results are obtained the Contractor must take immediate corrective action, if he does not, the Engineer must be informed.

The Engineer should also be informed if any changes in the materials occur and he may require a new mix formula and further trials to be undertaken

**5.6.3 Asphalt (Plant Method)**

Manufacture, Transportation and Placing

The Contractor must supply sufficient qualified personnel to ensure the correct operation of the asphalt plant and the laying of the material. All the equipment proposed to be used by the Contractor requires to be in good condition and to be operated by competent and experienced operatives. The Contractor must maintain records of batch numbers and the

areas that are asphalt paved. This means if results later indicate that the asphalt did not comply with the Specification its location can be identified and if required the material can be removed.

Trucks for hauling the asphalt must have clean and smooth metal beds. The beds should be sprayed with limited amounts of soapy water, thinned fuel oil, paraffin oil, or lime solution to prevent the mixture from sticking to the beds. Each truckload should be covered with canvas, or other suitable covering, to protect the asphalt from the weather.

Self powered pavers, capable of spreading and finishing to the required cross section will normally be used, as shown in Photo 5. Photo 6 shows a truck containing asphalt backing up to the paver to deliver the material. The paver must be able to place the thickness of material required per square metre. Immediately the mixture has been spread and struck off, the surface requires to be checked and any inequalities adjusted. In irregular sections or small areas where it is impractical to use a paver, hand methods can be used, subject to the approval of the Engineer.

### Rolling

Due to the quantity produced by asphalt plants and the requirement to achieve satisfactory compaction a number of rollers are required. The mixture must be thoroughly compacted as soon as the material will support a roller without undue displacement or cracking. Sufficient rollers should be used so as to ensure that the required degree of compaction of the asphalt mat (refer to Appendix 'B') is achieved before the temperature falls below 107°C.

The first rolling including all joints and edges, and the final rolling should be done with a steel wheeled tandem roller, which must be able to operate with and without vibration.

For initial rolling, the drive roll should be nearest the paver and the speed of the roller should not exceed 4 km/hr. This is illustrated by Photo 7, which shows the steel wheeled roller at the rear of the paver, with a multi tyre roller rolling previously placed asphalt. The second or intermediate rolling, should be done with pneumatic tyred rollers (PTR), see Photo 4, in this case the speed should not exceed 6 km/hr.

Rolling should generally start longitudinally at the sides and proceed toward the centre of the pavement. Successive passes of the roller should overlap by at least one half of the width of the roller and alternative passes should not stop at the same point.

The wheels of rollers must be kept properly moistened with sufficient water to prevent adhesion of the mixture to the roller. However, excess use of water is to be avoided as this will cool the asphalt mat. Also, at no time should rollers be allowed to stand on newly laid material, as the surface may deform if this is allowed to occur.

#### 5.6.4 Asphalt (Manual Method)

For manual methods temperature control is particularly important and a thermometer should be located at each mixing unit. The temperature of the bitumen, mineral aggregates and bituminous mixture should comply with the job mix formula (if applicable), or should be within the limits stated below.

##### Bitumen

The 80/100 penetration grade bitumen normally used can be poured (albeit slowly) into a locally produced wood fired boiler. Once the boiler is approximately 30% full the wood in the firebox should be ignited.

Temperature control at the boiler is critical to prevent the bitumen being over heated (cooked). When the thermometer within the mass of bitumen reaches 150°C the firebox should



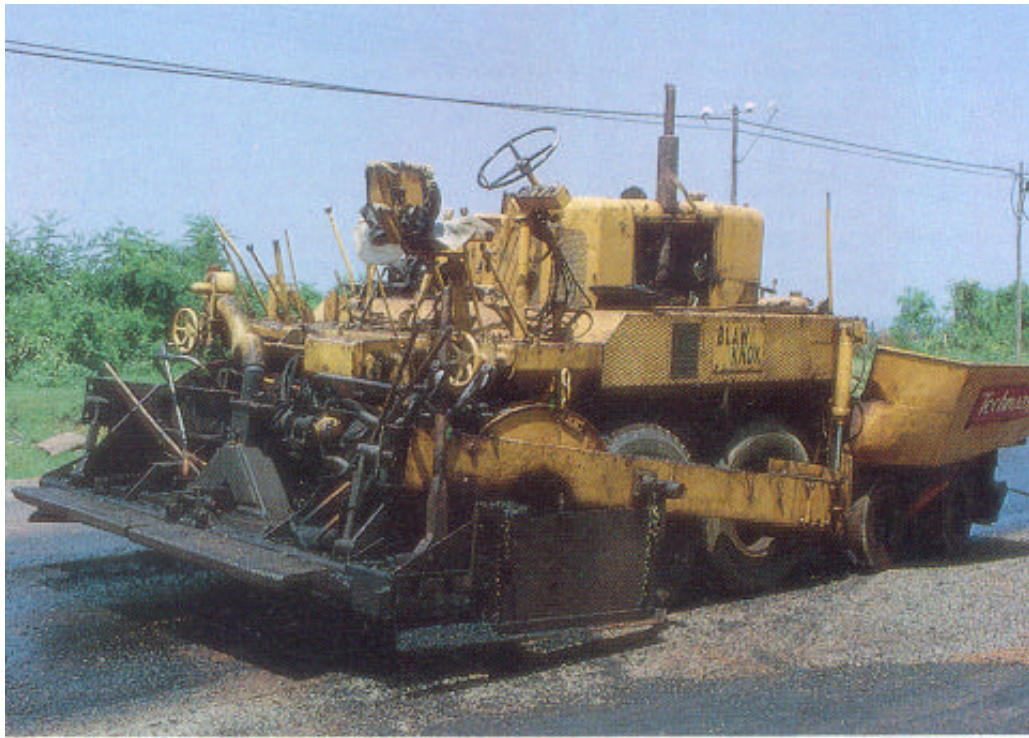


Photo 5. Asphalt Paver.



Photo 6. Truck Containing Asphalt backing up to Paver.



Photo 7. Asphalt Compacted immediately by Steel Wheeled Roller, with Multi Tyre Roller in distance.



Photo 8. Gauging Box to ensure delivery of correct volume of Aggregate for each batch.

be emptied or the fire extinguished. The residual heat within the tar boiler will continue to heat the bitumen. The temperature should be monitored and once it starts to fall and reaches 155°C the fire box should be re-ignited as the temperature will soon fall below 150°C. The heating operation should be repeated as many times as necessary to maintain the temperature in the appropriate range. With experience an operator can soon judge the amount of firewood required to achieve and maintain the specified temperatures. The temperature of the bitumen must not be allowed to exceed **163°C**. Any bitumen heated above this temperature is to be discarded and the tar boiler refilled with new bitumen and the heating process started again. Such 'cooked' bitumen may, with the Engineer's approval, be subsequently used to make prime coat.

#### Aggregate and Mixing

Gauging (measuring) boxes should be constructed for each type of aggregate. These must be to the required size to deliver for each batch the correct volume of aggregate to comply with the approved job mix. An example of a gauging box is shown in Photo 8.

The gauging boxes should be emptied into rectangular steel pans, which have handles at each corner. These pans should be heated on top of a metal frame under which heating is provided by firewood and sawdust. The aggregates should be continually raked to ensure thorough mixing and even heating. The temperature of the aggregate must reach above 163°C, after which the pan should be transferred to an unheated frame. The raking should then continue until the aggregate temperature has reduced to the maximum mixing temperature permitted (163°C).

At this stage the heated bitumen should be drawn off from the boiler, (into gauge tins) and added to the aggregate in the pan on the unheated frame. As the two ingredients are at approximately the same temperature there is no risk of fire.

The aggregate and bitumen should then be thoroughly mixed within the range of 135°C to 163°C with the temperature for each batch being recorded and later submitted by the Contractor

### Spreading and Rolling

When the mixing is satisfactorily completed, the pan should be carried to the adjacent work for placing. The depth of the finished surfacing can be controlled using mild steel angles as side shutters. For example, an angle of 65 × 65 mm with an uncompacted asphalt depth of 65 mm being placed, is required to achieve a compacted 50 mm surfacing depth. The cross-fall or super elevation should be controlled using 65 × 6 mm steel plate at intermediate points between the edge and the crown of the road.

In manual methods as the speed of asphalt placement is likely to be less in many cases only one roller is used. If the Contractor is using a 3.5 ton vibrating roller the initial pass should be with NO vibration. After this initial roll the side and intermediate shutters should then be moved to their next location while the roller, with vibration ON, completes the compaction process.

Trials will be required to assess the number of passes to achieve full compaction for each type of roller. Compaction is generally achieved when all roller marks have been removed. It is vital that the asphalt is rolled immediately after placing when the mat can withstand the rolling and full compaction must be achieved before the temperature drops below 107°C .

#### **5.6.5 Finishing, Compaction and Tolerances**

If more than one layer of asphalt is laid the longitudinal joints in successive courses should be staggered by a minimum of 250 mm, with the joint in the top course being in the centre of

the road. Transverse joints should be staggered by a minimum of 1m.

Before placing mixtures against them, all contact surfaces of kerbs, gutters, headers, manholes etc. should be given a thin uniform coating of hot bitumen. In locations where the use of rollers adjacent to these fixtures is not possible hot hand or mechanical tampers, which will give an equivalent compaction to rollers, should be used.

After final rolling full depth samples should be cut for each 50m of completed surfacing to check the density and the thickness of the layer by an approved coring machine. Where samples have been taken, fresh material must be placed, and thoroughly compacted. The density shall not be less than 97% of the marshall density and the thickness of any individual core shall not be less than the specified thickness by more than 5 mm. The average thickness of the mat shall not be less than the specified thickness.

After compaction the surface of the road should appear to be impervious and to be free from any dragging cracks or other surface blemishes. The surface should also be checked at intervals not exceeding 10 m by a 3m straight edge and a crown template. The variation between two contacts should not exceed 5 millimetres.

Any asphalt area that is defective, including any areas where petroleum products have been dropped or spilled, must be removed and replaced with fresh hot mixture. This asphalt requires to be compacted immediately and re-tested as appropriate.

Lastly, ideally sections of the newly laid surfacing should be protected from traffic until the mixture has cooled to ambient air temperature (about 6 hours). However, in many cases it will not be possible to allow all this time to elapse.

## **5.7 Premix Bituminous Seal Coat (Manual Method)**

A seal coat consists of generally fine graded aggregates coated with bitumen. This is placed on newly laid bituminous carpeting or an existing bituminous surface, to seal the surface. However, if well graded premixes, which have been properly controlled, have been placed a seal coat may not be required.

The aggregates should consist of 6.3mm down graded clean pea gravel free from any vegetable matter. Where required to achieve the grading the aggregate should be mixed with clean natural sand, which is non-plastic, and also contains no vegetable matter.

A similar procedure to that detailed in Section 5.6 should be followed. The Contractor must initially submit samples and produce a job mix formula. Thereafter the construction should follow the methods detailed in the relevant sections above.

The completed surfacing after compaction should appear to be close and tight.

## 6.0 BRICK PAVEMENT (Specification 3.13)

### Key Points

- **Prior to any bricks being placed the subgrade and / or improved subgrade should be inspected and approved.**
- **Only First class bricks laid in a regular manner should be used.**
- **Once laid the gaps between the bricks should be filled with sand and water should be sprinkled on the surface.**

The subgrade and/or improved subgrade requires to be prepared and compacted to the appropriate degree – refer to Appendix 'B' of this manual. The surface should be inspected and if acceptable, approved, before any bricks are laid on the surface. Only First class bricks laid in a regular and uniform manner should be used, with the bricks either complying with End Edging, Herringbone or Flat Soling Bonds.

Once laid the interstices between the bricks should be filled by brushing in sand and the surfacing should then be sprinkled with water.

On completion of the brick pavement the surface should be checked. The finished surface should not differ from the specified level by more than 20 mm. When checked by a 3m straight edge the surface shall not deviate by more than 10 mm, when placed parallel to the centre line, and 12 mm when placed transversely. Any section of paving not complying shall be corrected. This should be undertaken by removing bricks in the unacceptable area, reshaping the underlying surface and then replacing the bricks.

The maximum level difference between adjacent bricks shall not exceed 3 mm after placing and bedding in.

## **7.0 CONCRETE including REINFORCEMENT (Specification 5.1 and 5.2)**

### **Key Points**

- **At least 14 days before a material is proposed to be used samples of the material along with laboratory test results should be submitted to the Engineer. If approved, the Contractor should carry out trial mixes.**
- **Until a trial mix for a type of concrete has been approved (by the Engineer), no concrete of that class may be placed in the Works.**
- **Continued checks on materials should occur throughout the contract period. If tests indicate changes have occurred the Contractor must be notified and the Engineer informed immediately.**
- **Reinforcement must be free from dirt, oil, grease, paint, and loose or thick rust.**
- **All reinforcement must be placed, supported and secured at the locations shown on the Drawings prior to any concreting operations, using pre-cast cover blocks.**
- **At least 24 hours before any proposed pour the Contractor must provide notification in writing. The reinforcement, materials and equipment must then be checked and the contractor informed of aspects that need to be corrected, or rectified. Only after correction should the concrete pour be allowed to proceed.**
- **Within 20 minutes of the mixing being completed, concrete must reach its final position in the forms. The concrete requires to be placed to avoid segregation of the materials.**



- **Concrete must be thoroughly compacted by mechanical vibration immediately the concrete is placed in the forms. Enough vibrators must be on site for this to be achieved.**
- **Temperature of concrete at the time of placing shall not exceed 35<sup>0</sup>C.**
- **Three concrete cubes or cylinders should be taken for each days casting, or for large pours for every 15m<sup>3</sup> concrete placed. The samples should be taken at random to ensure all the concrete placed in the Works meets the specified requirements.**
- **All surfaces must be kept thoroughly wet for 7 days after concrete is placed. Thereafter the concrete must be watered daily for the following 2 weeks to prevent the concrete drying out.**

## **7.1 Materials**

Samples of materials proposed to be used and their test results have to be received at least 14 days before their proposed use. If the samples comply with the Specification the Engineer should give his agreement for the Contractor to proceed with test mixes and trials.

Full material requirements are given within the Specification for cement, water, and aggregates. However, the following site requirements should be noted:

- Bagged or bulk cement which has partially set or which contains lumps of caked cement must be rejected. The use of cement reclaimed from discarded or used bags is not permitted. Any cement stored for a long time needs to be tested before its use.

- If accepted by the Engineer river water may be used, however, if the water's appearance deteriorates the use of this source of water must be stopped.
- Admixtures are only allowed with the written approval of the Engineer.
- The coarse aggregate (that larger than 5 mm), with the exception of blinding concrete, must consist of hard durable crushed or broken rock. This should be clean, free from dust and contain no vegetable matter and should not appear particularly flaky or elongated (see Figure 7).
- The fine aggregate (that smaller than 5mm) should consist of either natural sand or fine aggregates. Crushed materials from different sources of supply must not be mixed or stored in the same pile, unless this has been approved.
- The grading and quality of the aggregates need to be checked throughout the works. Samples of the materials brought to site should be taken regularly and tested to ensure that the materials continue to meet those specified.
- Reinforcement needs to be handled and stored to ensure it does not become bent out of the desired shape. When it is placed in the works it should be free from dirt, oil, grease, paint and loose or thick rust.

## **7.2 Trial Mixes for Concrete**

After the cement and aggregates have been approved the Contractor must carry out trial mixes. These must be made in the design proportions to prove and establish the workability, strength and water/cement ratio of the concrete. The concrete should be made in full scale trials using the same type of plant and equipment, which will be used for the Works. Concrete cubes or cylinders should be taken and these should be

crushed after 28 days to ensure the concrete has reached the required strength.

The Contractor is required to submit all the relevant information to the Engineer who will approve the mix if he is satisfied. Thereafter no changes in any of the materials or the mix proportions are allowed. If any changes occur on site the Contractor must be informed immediately as must also the Engineer who may require further trial mixes to be undertaken.

Until the trial mix for a particular concrete class have been approved, no concrete of that class may be placed in the Works.

### **7.3 Construction Methods**

The Contractor must maintain an adequate number of trained and experienced supervisors at the Site to control the work.

A layer of 75mm thickness blinding concrete must be provided for all concrete structures. This should be placed on a single layer brick flat soling laid directly on the prepared soil.

Reinforcement bars require to be cut and bent cold to the dimensions on the drawings. The method and the equipment the contractor intends to use to bend reinforcement, needs to be inspected and, if acceptable, approved. Welding of reinforcing steel is not normally accepted and should only occur after specific authorisation is given.

Cover blocks are required to ensure that the reinforcement is correctly positioned, as the use of any small stones or wood blocks within the forms is not allowed. Cover blocks should be precast 50mm x 50mm blocks, to ensure 50mm cover or 75mm x 75mm blocks when the concrete works are below finished ground level; unless otherwise indicated on the contract drawings. The maximum size of aggregate should be

6mm and a mix proportion of one part of cement to 2 parts of sand by weight should be used. Wire requires to be cast into the blocks so that they can be tied to the reinforcement. The blocks should also be fixed so that they will not overturn when the concrete is placed.

Changes in sizes of reinforcement bars to that shown on the drawings are only permitted if specific authorisation is given. If bars are substituted they must have a cross sectional area equal, or greater to, the design area. If the Contractor wishes to use more splices than are indicated and/or necessary, the Contractor must furnish Working Drawings for approval. Any such changes of reinforcement that occur will not result in any extra payments to the Contractor.

At least 24 hours before any concrete pour the Contractor needs to inform site staff of the proposed pour in writing. At this stage, before the concrete pour can proceed, the following require to be checked:

- Whether the reinforcement is placed, supported and secured at the locations shown on the Drawings.
- Whether the inside of the form is thoroughly clean and there is no debris.
- Whether the forms are rigid enough to maintain the concrete in position and any voids/gaps are filled.
- Whether the forms are of an appropriate material to produce an acceptable finish.
- Whether all the materials required are on site for the completion of the concrete pour (unless concrete manufactured elsewhere).
- Whether there are sufficient vibrators and mixers on site, which are all in working condition.

If any items above are not ready the contractor should be informed of the measures which must be taken before the concrete pour can proceed. Once all the conditions are satisfied then approval for the concrete pour to proceed can be given.

The correct volume of materials (cement, aggregates and water) to comply with the approved job mix must be used for each batch of concrete. The usual method of controlling the quantity added is to construct measuring boxes, see Photo 8, or other types of containers, which will provide the appropriate volume of materials for one bag of cement.

Concrete must reach its final position in the forms within 20 minutes of mixing. The concrete must be placed in a manner, which avoids materials separating, and which ensures there is no movement of the reinforcement within the forms.

When the concrete is placed it requires to be thoroughly compacted by mechanical vibration. The vibrators need to work the concrete around the reinforcement and into the corners and angles of the forms. The vibrators must be inserted and withdrawn from the concrete slowly at the point the concrete is deposited.

Sufficient working vibrators must be used to compact all the concrete immediately it is placed in the forms. A working vibrator will visibly affect recently placed concrete at least 450 mm from where the vibrator is located. However, vibrators should not be used to move concrete around the forms; in this case spades should be used. The vibration should last long enough to thoroughly compact the concrete, but should not continue so as to cause segregation. Any grout loss from the forms should be immediately stopped.

At least one slump test for every 25m<sup>3</sup> of concrete placed should be carried out. Normally, unless a different value is indicated on the drawings or in the documents, the slump should not be greater than 75mm. Examples of slump test results are given in Figure 10. A minimum of 3 concrete cubes or cylinders should be taken for each day's casting but on large concrete pours these should be taken for every 15m<sup>3</sup> of concrete placed. When samples of concrete are taken the slump of the concrete also needs to be measured.

## **8 BRICKWORK (Specification 5.5)**

### **Key Points**

- **Only First class bricks, which have been soaked in water for at least three hours should be used.**
- **Any cement mortar, which has taken initial set must not be used.**

### **8.1 Materials**

Only first class bricks, which are regular and uniform in size and of good colour, should be used. The bricks should also be free from flaws, cracks, or other blemishes.

The cement mortar used must consist of a mixture of one part by weight of cement to two parts of sand. The cement and sand should be mixed dry, and then the minimum water necessary to produce a workable mixture should be added. In no case should the water/cement ratio exceed 50% by weight. Mortar, which has taken initial set, must not be used and the contractor must remove the mortar from the site.

### **8.2 Construction Methods**

Bricks must be soaked in water for at least three hours before use. The brickwork requires to be constructed as shown on the Drawings, by properly supervised skilled masons and workmen.

All facework bricks require to be specially selected regarding size, shape and edges. All horizontal joints should be parallel and level. Vertical joints in alternate courses should be directly over one another. Joint thickness should normally be 6 mm, and must not exceed 8 mm. All joints are to be properly dressed and pointed. The brickwork requires to be cured for at least seven days. The same curing method as for concrete can be used.

# APPENDICES

**Appendix A - Summary of Material Requirements for each layer.**

**Appendix B - Compaction Standards for each layer.**

**Appendix C - Work Sequence and necessary laboratory testing for a road embankment.**

**Appendix D - Test Frequency to ensure compliance of the material with the specified standards for each pavement layer.**

# **APPENDIX A**



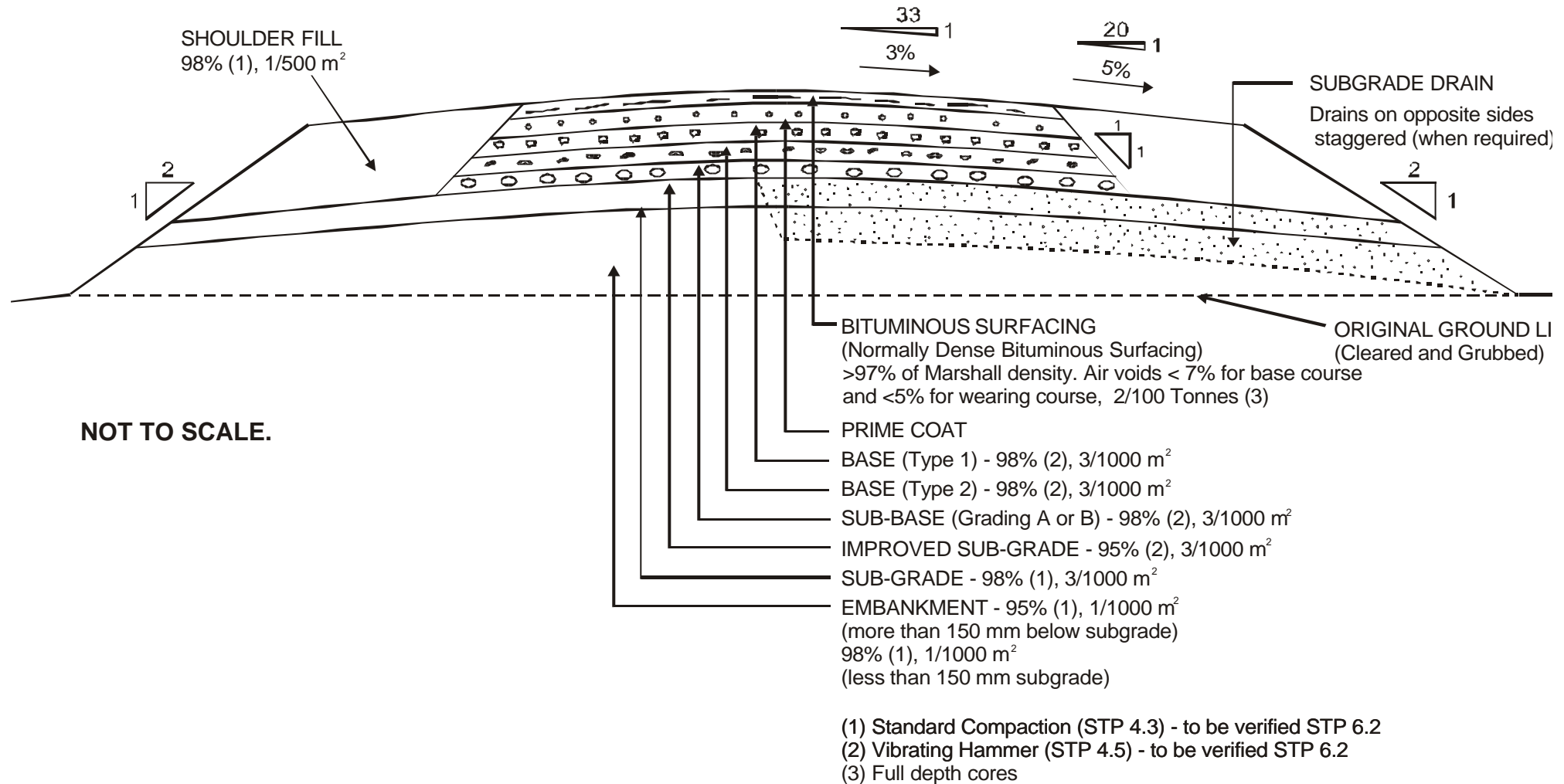
Pavement Layer	LL (STP 3.2) Less than	PI (STP 3.2)	CBR (STP 5.1)	DCP Mm / blow	ACV (STP 7.7.1)	10% FINES (STP 7.7.2)	COMPACTION	
							REQUIREMENT	TEST FREQUENCY (STP 6.2)
<b>Base Type 1</b>	20	<5	80%	<3.5	30	125	98% (2)	3/1000 m <sup>2</sup>
<b>Type 2</b>	20	<5	50%	<5.0	35	90	98% (2)	3/1000 m <sup>2</sup>
<b>Subbase</b>	25	<6	25%	<9.0	38	75	98% (2)	3/1000 m <sup>2</sup>
<b>Improved Subgrade</b>	30	<9	8%	<22	-	-	95% (2)	3/1000 m <sup>2</sup>
<b>Soft Shoulder</b>	40	7-15	8%	<22	-	-	98% (1)	1/500 m <sup>2</sup>
<b>Subgrade</b> (top 150 mm)	50	<15	5%	<30	-	-	98% (1)	3/1000 m <sup>2</sup>
<b>Earthworks</b> (more than 150 mm below Subgrade)	50	<25	3%	<45	-	-	95% (1)	1/1000 m <sup>2</sup>
(1) Standard Compaction (STP 4.3) – to be verified by STP 6.2								
(2) Vibrating Hammer (STP 4.5) – to be verified by STP 6.2								

The acceptance of any material, which does not meet the requirements included in the above table, requires the approval of the Engineer.

NOTE. In some locations, due to the in-situ soil characteristics it may be preferable to accept material below the stated CBR requirements. In this case the thickness of the improved sub-grade should be increased to the depth given in the Pavement Design Manual.

## **APPENDIX B**

**COMPACTION REQUIREMENTS OF ROAD CONSTRUCTION (Also Test Frequency)**



**NOT TO SCALE.**

**NOTE.**

Base Type I and II not always incorporated into road pavement.

## **APPENDIX C**

## Work Sequence for either New Embankment or for raising an Existing Embankment

### LAB WORK

- |     |   |  |
|-----|---|--|
| 1.  | Establish road way for full width and length                              |  |
| 2.  | Take Cross Sections of Existing levels                                    |  |
| 3.  | Clear and grub, the road way  |  |
| 4.  | Excavate any unsuitable material and bench<br>in for widening embankments |  |
| 5.  | Roll Formation  |  |
| 6.  | Fill earthworks maximum 150mm compacted depth                             | <b>CBR, LL, PI,<br/>MDD</b>                                  |
| 7.  | Test compaction of fill layer   | <b>Compaction</b>  |
| 8.  | Repeat 6 and 7, until full height   |  |
| 9.  | Place Sub-grade material  | <b>CBR, LL, PI,<br/>MDD</b>                                  |
| 10. | Test compaction and level of sub-grade Layer                              | <b>Compaction</b>  |
| 11. | Excavate for pipe and/or sub-grade drains (if necessary)                  |  |
| 12. | Place Pipe and bedding (if necessary)                                     |  |
| 13. | Place appropriate Improved sub-grade material at the<br>correct m.c.      | <b>CBR, LL, PI,<br/>Grading,<br/>MDD</b>                     |
| 14. | Test compaction & level of Improved sub-grade layer                       | <b>Compaction</b>  |
| 15. | Place appropriate Sub-base, at correct m.c                                | <b>CBR, LL, PI,<br/>Grading,<br/>MDD, ACV,<br/>10% Fines</b> |
| 16. | Test compaction & level of sub base layer                                 | <b>Compaction</b>  |
| 17. | Place appropriate Base Type 2 material at correct m.c.                    | <b>CBR, LL, PI,<br/>Grading,<br/>MDD, ACV,<br/>10% Fines</b> |
| 18. | Test compaction & level of Base Type 2 layer                              | <b>Compaction</b>  |

## Work Sequence for either New Embankment or for raising an Existing Embankment

	<b><u>LAB WORK</u></b>
19. Place appropriate Base Type 1 material at correct m.c.	<b><i>CBR, LL, PI, Grading, MDD,ACV, 10% Fines</i></b>
20. Test compaction & level of Base Type 1 layer	<b><i>Compaction</i></b>
21. Prime coat sprayed	<b><i>Rate of Spray</i></b>
22. Place Bituminous layer (assumed Dense Bituminous)	<b><i>Marshall</i></b>
23. Test compaction, thickness and surface level and regularity	<b><i>Test Parameters, Grading, Bitumen Content</i></b>

### Notes :

1. m.c. stands for moisture content and this should be close to the optimum so the relevant material can be adequately compacted. Optimum Moisture Content (OMC) is the moisture content at Maximum Dry Density (MDD).
2. All layers have to be inspected and approved before work can commence of any subsequent layer.
3. On some contracts not all pavement layers shown will be required. For example, when improvement works are being undertaken on existing roads, steps 4 to 8 will probably not be required. In this case step 9 will entail loosening to a depth of 150mm below sub-grade level and recompaction.

## **APPENDIX D**

**Laboratory Work Definitions :**

<b>CBR</b>	-	<b>California Bearing Ratio</b>
<b>LL</b>	-	<b>Liquid Limit</b>
<b>PI</b>	-	<b>Plasticity Index</b>
<b>MDD</b>	-	<b>Maximum Dry Density</b>
<b>ACV</b>	-	<b>Aggregate Crushing Value</b>

**SUMMARY OF TEST REQUIREMENTS**

	<b>Washed Grading</b>	<b>Atterberg Limits</b>	<b>Max Dry Density / CBR</b>	<b>In-situ Density</b>	<b>ACV / 10% Fines</b>
<b>Earthworks</b>		1/2000 m <sup>3</sup>	1/2000 m <sup>3</sup>	1/1000 m <sup>2</sup>	
<b>Improved Sub-Grade</b>	1/1000 m <sup>3</sup>	1/1000 m <sup>3</sup>	1/1000 m <sup>3</sup>	3/1000 m <sup>2</sup>	
<b>Sub-Base</b>	1/750 m <sup>3</sup>	1/750 m <sup>3</sup>	1/750 m <sup>3</sup>	3/1000 m <sup>2</sup>	1/2000 m <sup>3</sup>
<b>Base</b>	1/500 m <sup>3</sup>	1/500 m <sup>3</sup>	1/500 m <sup>3</sup>	3/1000 m <sup>2</sup>	1/1000 m <sup>3</sup>

For Bituminous and Concrete Mixes 1 set of tests per 100 m<sup>3</sup> of aggregate for shape, grading, ACV / 10% Fines should be carried out.

Marshall Test and Extraction of Materials for bituminous mixes and slump and concrete cubes / cylinder tests for concrete mixes should be carried out as stated in the specification or directed by the Engineer.