

9.2.10 ROAD REINSTATEMENT WORKS IN CMC ROADS

9.2.10.1 GENERAL

This section applies exclusively to all permanent road reinstatement works required to be carried out in CMC roads under Rehabilitation & Reinforcement of Medium and Large Diameter Pipe Network in CMC Area and under Rehabilitation & Replacement of Small Diameter Distribution Mains in CB1 Area.

All other temporary and permanent road reinstatement, reinstatement of other surfaces shall be according to relevant sections in SUB-SECTION 9.1.1 EARTH WORKS AND TRENCHING IN GENERAL SPECIFICATIONS-CIVIL WORKS.

For safety while working on roads, Contractor shall refer and adhere to "Safety on Road-work" published by Colombo Municipal Council in 1991 or its revisions. A copy of which is available with NWSDB for Contractor's reference.

9.2.10.2 SUB BASE

9.2.10.2.1 Description

This work shall consist of furnishing, placing and compacting sub-base material on a prepared and accepted sub-grade in accordance with the Specification and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

9.2.10.2.2 Materials

(i) Materials for sub base shall be free of unsuitable materials and shall conform to the requirements for types I, II or III as specified below:

(a) Type 1 material shall be natural or artificial mixture of hard durable particles of mineral aggregate, meeting the following requirements.

Grading: The grading shall conform to grading envelopes A, B, C or D in Table 9.2.10-1. The fraction passing the 75 mm sieve shall be not greater than two thirds of the fraction passing the 425 mm sieve.

Plasticity: The portion passing the 425 mm sieve shall, if it is plastic, have a liquid limit not greater than 25 and a plasticity index not greater than 6 for sub-base under rigid pavements and a liquid limit not greater than 35 and a plasticity index not greater than 11 for sub-base under flexible pavement.

Percentage of Wear: The coarse part of the material sampled and tested in accordance with AASHTO test method T96 shall have a percentage of wear not greater than 50. The AIV when tested according to B.S. 812 shall not exceed 35.

Soundness: the material shall not include any fraction that breaks up when alternately wetted and dried.

- (b) Type II material shall be material having the same basic characteristics as Type 1 except that the grading shall conform to grading envelopes E or F in Table 9.2.10-1 and liquid limit and plasticity index shall be limited to 25 and 6 respectively, regardless of the pavement type.

There will be no requirement for the percentage of wear given by AASHTO Test method T 96.

- (c) Type III material shall be soil aggregate material satisfying, in general, the plasticity, and liquid limit requirements for Type I and shall have a CBR value not less than stated on the Drawings when compacted to 98% of maximum dry density as determined by BS 1377, Test 12.

(ii) Method of selection

The material for sub-base shall be the type indicated on the Drawings. If no type is indicated on the Drawings, the Contractor may select material of Type I, II or III.

Table 9.2.10-1 Grading Requirements for Granular Material

BS Sieve Sizes		Percentage by weight passing BS Sieves					
Mm	mm	Grade A	Grade B	Grade C	Grade D	Grade E	Grade F
50		100	100	-	-	-	-
28		-	75 - 95	100	100	100	100
10		30 - 65	40 - 75	50 - 85	60 - 100	-	-
2		15 - 40	20 - 45	25 - 50	40 - 70	40 - 100	55 - 100
	425	8 - 20	15 - 30	15 - 30	25 - 45	20 - 50	30 - 70
	75	2 - 8	5 - 20	5 - 15	5 - 20	6 - 20	8 - 25

9.2.10.2.3 Method of Construction

(i) Preparation of Sub-grade

Before construction of sub-base, the earth work, topsoil, grassing, side ditches and drains for the section concerned shall be completed so that the section of embankment already constructed will be protected against erosion..

The sub-grade shall be shaped and compacted to a dry density of not less than 95% of the Laboratory Modified Proctor Density when tested in accordance with these specifications and completed for at least 150m ahead of the placing of sub-base course material. Notwithstanding any earlier approval of sub-grade, any damage to or deterioration of sub-grade shall be made good before sub-base is laid.

(ii) Spreading Sub-base

Sub-base shall be spread in layers, with uncompacted thickness up to 0.25 m subject to the type of roller to be used and the approval of the Engineer. The layers shall be as nearly equal in thickness as possible. Care shall be taken to prevent segregation of the material into fine and coarse parts.

(iii) Sprinkling, Rolling and Compacting

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer. Rolling operations shall begin from the outer edge of roadbed towards the centre, gradually in a longitudinal direction: except on super elevated curves, where rolling shall begin at the low side and progress towards the high side. Sub-base of sandy material shall be compacted by use of vibrating equipment.

Each layer shall be compacted to at least 100 % of the maximum dry density as determined by BS 1377 Test 12.

Sub-base material, which does not contain sufficient moisture to be compacted in accordance with the requirements of this section, shall be sprinkled with water as directed by the Engineer.

During construction of sub-base, the Contractor shall ensure the sub-base already spread and rolled is properly drained.

Sub-base material containing excess moisture shall be dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer.

The finished sub-base shall not vary more than 15 mm above or below the planned grade at any point. The thickness of the finished sub-base shall be on average not less than the required thickness and not thinner than 15 mm less than the required thickness at any point and the average of five thickness measurements in any 100m of road shall be not thinner than 10mm less than the required thickness. Sub-base, which does not conform to the above requirements, shall be reworked, watered and thoroughly re-compacted to conform.

9.2.10.3 AGGREGATE BASE

9.2.10.3.1 Description

This work shall consist of a base, composed of crushed aggregate material placed and compacted on a prepared and accepted sub-grade, sub-base or other base course in accordance with the Specification and the lines, levels, grades, dimensions and cross sections shown on the drawings and as required by the Engineer..

9.2.10.3.2 Materials

- (i) The materials shall meet the requirements of sub-base provided for in Section 9.2.10.2, Type 1, Grade A or B, except where otherwise herein indicated. The portion of aggregate passing the 425mm sieve shall if it is plastic, in all cases, have a liquid limit not more than 25 and a plasticity index not more than 6. The material shall conform with the grading requirements listed in Table 9.2.10-1. The material shall have a CBR value, after the specified compaction, as indicated on the drawings or, if not indicated, not less than 80. The coarse part of the material sampled and tested in accordance with AASHTO test method T96 shall have a percentage of wear not greater than 40. If no grading is indicated on the Drawings grading A or B from Table 9.2.10-1, shall be used. The AIV when tested according to BS 812 shall not exceed 30.

(ii) Crushed Aggregate

Crushed aggregate shall consist of hard durable particles or fragments of rock or gravel crushed to the required size, and a filter of sand or other finely divided mineral matter. When the aggregate is produced from crushed rock, it shall be from a quarry approved in writing by the Engineer, and crushed and screened to achieve the required grading. When produced from gravel, not less than 50 % by weight of the coarse aggregate shall be particles having at least one fractured face and, if necessary to meet this requirement or to eliminate an excess of filter, the gravel shall be screened before crushing.

9.2.10.3.3 Construction Methods

(i) *Preparation of Sub-grade or Sub-base*

The sub-grade shall be shaped and compacted in conformity with the provisions Sub-section 9.2.10.2.3. The sub-base shall be shaped and compacted in conformity with the provisions SUB-SECTION 9.1.1.4.7 GENERAL SPECIFICATIONS-CIVIL WORKS. The sub-grade and sub-base shall be completed for at least 150m ahead of the placing of the base course material.

(ii) *Spreading Base*

Base shall be spread in layers with un-compacted thickness up to 0.25m subject to the type of roller to be used and the approval of the Engineer. The layers shall be as nearly equal in thickness as possible. Care shall be taken to prevent segregation of the material into coarse and fine parts.

Where the material for shoulders is the same as that used for the base course, the material shall be evenly spread in layers, as specified, for the full width of the roadbed and the base course and the shoulders constructed simultaneously.

Where the shoulders are not of the same material as the base course, then prior to spreading the aggregate base, a partial width of shoulder, not less than 0.7m wide, shall be constructed to the elevation of the top of each un-compacted layer being placed and the inside edge made as straight as practicable. After the partial completion of the shoulders, the aggregate shall be spread upon the sub-grade or preceding layer, and against the previously formed shoulders, in layers of uniform thickness, as specified, to give the required compacted depth shown on the Drawings. The material deposited on the sub-grade or previous layer may be spread and shaped to any method, which will not cause the segregation of the coarse and fine particles. When directed by the Engineer, areas of segregated coarse or fine material shall be re-mixed or removed and replaced with well-graded material.

When the base course is spread contiguous to concrete kerbs or gutters, extreme care shall be exercised not to damage the kerbs or gutters. Any damage to kerbs or gutters by the Contractor, shall warrant the removal and replacement of the kerbs or gutters.

(iii) *Sprinkling, Rolling and compacting*

Immediately after each layer has been spread and shaped satisfactorily, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer.

Rolling operations shall begin along the edges and overlap the shoulder at least 0.7m or as close to the outer edge of the shoulder as practicable where a full width roadbed base course is specified on the Drawings, and progress toward the center, gradually in a longitudinal direction. On super elevated curves, rolling shall begin at the low side and progress towards the high side. The rolling operation shall continue until all roller marks are eliminated, and the course is thoroughly compacted.

Each layer shall be compacted to at least 95% of the maximum dry density as determined by BS 1377, Test 12. Density of the compacted base course shall be determined by BS 1377 Test 12.

Base course material, which does not contain sufficient moisture to be compacted in accordance with the requirements of this Section, shall be sprinkled with water. The Contractor shall supply the necessary water at his own expense.

Base course material containing excess moisture shall be dried prior to or during compaction. Drying of wet material shall be performed by methods approved by the Engineer.

The final shaping and rolling of the shoulders to the full width shall be made after the base course is completed.

(iv) *Surface Tolerance*

In that areas on which pavement is to be placed, any deviation in excess of 10mm from a straight edge 3m long applied to the surface parallel to the centerline of the road and 12mm from a template laid transversely, shall be corrected by loosening, adding or removing material, reshaping and re-compacting.

The base completed in each day's work shall have an average thickness not less than the required thickness. The minimum thickness shall be not less than the required thickness, less 15mm. 80 % of the base laid shall have a thickness not less than the required thickness less 10mm.

Any irregularities, which may develop in the surface during or after construction shall be corrected by removing or loosening the surface, and adding further materials as required.

9.2.10.4 ASPHALTIC MATERIALS

9.2.10.4.1 Description

This section specifies the asphaltic materials to be used in the work.

9.2.10.4.2 Materials

Materials shall be of the type specified on the Drawings. If the material to be used is not specifically designated, the type used shall be approved in writing by the Engineer. In general, materials shall meet the requirements for one of the following types.

9.2.10.4.3 Asphalt Cement

Asphalt Cement shall conform to the requirements (for the appropriate grade) of BS 3690 Standard Specification for Asphalt Bitumen. Asphalt Bitumen shall be intended when material is referred to as “straight run Bitumen”, “penetration grade Bitumen” or by its penetration value (as for example 80-100 pen).

9.2.10.4.4 Cut back Asphalt

Cut back Asphalt shall be of the rapid curing type or the medium curing type and shall conform to the requirements (for the appropriate grade of cut back asphalt) of whichever of the following AASHTO standard Specifications that may apply.

Cut back Asphalt (Rapid Curing Type) Designation M81 – 75

Cut back Asphalt (Medium Curing Type) Designation M82 – 75

Cut back asphalt shall be intended when material is referred to as “cut back bitumen” or is described by one of the grades given in the above named standard specifications (as for example R.C. 2) (Approximately R.C. 250).

9.2.10.4.5 Emulsified Asphalt

Emulsified Asphalt shall be of the cationic type unless the anionic type is explicitly specified.

Cationic emulsified asphalt shall conform to the requirements of AASHTO M208.

Anionic emulsified asphalt, if used, shall conform to the requirements of AASHTO M140.

The type and grade of emulsified asphalt shall be governed by the application and surface conditions and shall be approved by the Engineer.

Emulsified Asphalt shall be intended when material is referred to as Bitumen emulsion.

9.2.10.4.6 Methods of Storage and Handling

Asphaltic material shall be handled and stored with due regard for safety and in such a way that at the time of use in the work material conforms to the Specification. In particular, emulsified asphalt shall be handled with care and not subjected to mechanical shocks or extremes of temperature likely to cause separation of the asphalt. Emulsified asphalt showing signs of separation shall not be used.

9.2.10.5 ASPHALT BOUND BASE

9.2.10.5.1 Description

This work shall consist of a course composed of asphaltic bound base constructed on a prepared and accepted sub-grade, sub-base or other base course in accordance with these Specifications

and the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

9.2.10.5.2 Materials

- (i) Aggregates shall conform to the requirements for crushed rock or crushed gravel, in Sub-section 9.2.10.3 except that the grading shall be as shown in Table 9.2.10 - 2.

Table 9.2.10 – 2 Grading of Aggregate for Asphalt Bound Base

Mm	Aggregate Grading B.S. Sieves mm	Type of Aggregate Crushed Rock / Crushed Gravel % by weight passing	
50		100	100
37.5		95 - 100	95 - 100
28		75 - 90	70 - 90
14		60 - 75	45 - 75
3.35		30 - 45	25 - 45
	75	3 - 6	3 - 6
	Asphalt Binder	% by weight of total mixture as found by analysis	
		3.0 – 4.0	4.0 – 5.0

- (ii) Asphalt materials shall conform to the requirements of Sub-section 9.2.10.4. In the absence of any requirement or permission to the contrary, asphalt cement of 80-100 penetration shall be used.
- (iii) Filter shall comply with the requirements of Sub-Clause 9.2.10.6.1.2.
- (iv). Preparations of materials shall be carried out according to the requirements of Sub-Section 9.10.5.2.

9.2.10.5.3 Construction Methods

- (i) Construction Methods shall conform to the requirements of Sub-section 9.10.5.1.
- (ii) Thickness and Surface Tolerance.

The thickness and surface of the finished course shall conform to the requirements of sub clause 9.2.10.3.3 and to the additional requirement that the average thickness shall not exceed the thickness shown on the Drawings by more than 5%.

9.2.10.6 GENERAL REQUIREMENTS FOR ASPHALTIC BOUND BASES AND SURFACING

9.2.10.6.1 Description

(i) General

This work shall cover the general requirements that are applicable to all types of asphaltic bound bases and surfacing, irrespective of gradation of mineral aggregate, kind and amount of asphaltic material or use. Deviations from these general requirements are indicated in the specific requirements as set forth in the respective sections.

The work shall consist of one or more courses of plant-mixed asphaltic mixtures constructed on a prepared and accepted sub-grade, sub-base, base course or other roadbed in accordance with the Specification and the specific requirements of the Contract, and in conformity with the required lines, levels, grades, dimensions and cross sections.

(ii) Composition of mixtures

The asphaltic mix shall be composed of coarse mineral aggregate, fine mineral aggregate filler and asphaltic material. The several mineral constituents shall be sized, uniformly graded and combined in such proportions that the resulting blend meets the grading requirements for the specific type under the contract. To such composite blended aggregate shall be added asphalt within the percentage limits set in the specification for the specific type.

(iii) Job Mix

Before starting work, the Contractor shall submit to the Engineer, in writing, a proposed job-mix for the mixture to be supplied for the project. The formula so submitted shall stipulate for the mixture a single percentage of aggregate passing each required sieve size, a single definite temperature at which the mixture is to be emptied from the mixer and, for mixtures to be laid hot, a single definite temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the general composition and temperature limits.

All mixture furnished to size shall fall within the ranges of tolerance given below:

Passing sieves 10mm and larger	+ or - 5%
Passing sieves between 10mm and 75mm	+ or - 4 %
Passing 75 mm sieve	+ or - 1.5 %
Asphalt	+ or - 0.3 %
Temperature of mixture when emptied from mixer	+ or -10 Degree C
Temperature of mixture at delivery on road	+ or -10 Degree C

Each day samples of the materials and mixture shall be taken and tested as specified in the following British standards or as the Engineer considers necessary for checking the required uniformity of the mixture.

Binders	:	BS 76 and BS 3690
Aggregates	:	BS 812 and BS 1047

Coated macadam : BS 598

When unsatisfactory results or changed conditions make it necessary, the Contractor shall submit a new job-mix to the Engineer for approval.

Should a change in a material be encountered or should a change in a source of material be made, a new job formula shall be submitted and approved before the mixture containing the new material is delivered. Materials will be rejected if they are found to have void or other characteristics, which require, for a balanced mix, an asphalt content greater or less than the specified range.

9.2.10.6.2 Materials

(i) Coarse Mineral Aggregate

Coarse aggregate is material substantially retained on the 3.35mm BS test sieve and shall be crushed rock or crushed gravel. Only type of one coarse aggregate shall be used except by written permission from the Engineer.

Crushed rock, and crushed gravel shall consist of clean, tough, durable material free from vegetable matter, soft particles and other objectionable matter. When gravel is used the clay and silt content shall not exceed 1% by mass of the coarse aggregate when determined in accordance with the sedimentation or decantation methods given in BS 812.

Crushed rock shall be one or more of the types listed below, as classified in BS 812. The Contractor shall if required by the Engineer, inform him of the group or groups to which the aggregate belongs.

- (1) Granite Group
- (2) Basalt Group
- (3) Gabbro Group
- (4) Porphyro Group
- (5) Quartzite Group
- (6) Hornfels Group
- (7) Gritstone Group
- (8) Limestone Group

If it is proposed to use an aggregate of another type other than the groups above, the Contractor shall submit all the facts to the Engineer for his approval.

Coarse Aggregate shall comply with the following:

- Aggregate Impact Volume when tested in accordance with BS 812 of not more than 30 %
- Aggregate Abrasion Value as determined by AASHTO test method T96 of not more than 40.
- Flakiness Index when tested in accordance with BS 812 Part 105. I shall not exceed 35 %.
- When subject to Coating and Stripping Test, AASHTO test method T182, the aggregate shall have a coated area of not less than 95 %.

(ii) Fine Mineral Aggregate

The portion of the aggregate passing a 3.35 mm BS test sieve shall be known as fine mineral aggregate, and shall consist of natural sand, stone screenings, or a combination if stated in the Special Provisions. Fine aggregate shall be composed of clean, hard durable particles, rough surfaced and angular, free from vegetable matter, soft particles, clay balls or other objectionable material. Stone screenings shall be produced from stone meeting the requirements for coarse mineral aggregate in Sub-section 9.2.10.6.2 (i).

When sand is used the clay and silt content shall not exceed 3% by mass of the fine aggregate when determined in accordance with sedimentation or decantation methods given in BS 812.

(iii) Mineral Filter

Mineral filter when required shall consist of limestone dust, dolomite dust, or similar rock dust, Portland cement, dehydrated lime, silica cement or other mineral matter from sources approved by the Engineer. It shall be free from foreign or other objectionable material. It shall be dry and free from lumps and when tested by means of laboratory sieves shall meet the following grading requirements.

B.S. Sieve mm	Percentage by Weight passing
600	100
212	95-100
75	75-100

Mineral filler shall be considered to include any mineral dust naturally present in the asphalt.

(iv) Asphaltic Materials

Asphaltic materials shall conform to the requirements of Sub-section 9.2.10.4.3.

(v) Sources of Supply

Approval of sources of supply of aggregate and mineral filler shall be obtained from the Engineer, prior to delivery of the material. Samples of each shall be submitted as directed at least ten days in advance of its use.

9.2.10.6.3 Composition of Mixtures

The composition of freshly mixed material for coated macadam shall comply, on analysis, with the general requirements given in the following tables.

- (i) Group One - road base material; **Table 9.2.10-3**
- (ii) Group Two - base course material; **Table 9.2.10-4**
- (iii) Group Three - wearing course material; **Table 9.2.10-5**

Table 9.2.10 – 3 Road Base Material

Road base Material : 40 mm nominal size dense road base material.

BS test Sieve Mm mm	Aggregate % by mass passing	Bitumen % by Mass of total mixture	Grade of Binder	Mixing Temperature °C
50	100	3.5 ± 0.6	80/100 pen	120-160
37.5	95-100			
28	70-94			
14	56-76			
6.3	44-60			
3.35	32-46			
300	7-21			
75	2-9			

Table 9.2.10 – 4 Base Course Material

Type	40 mm nominal size single course		40 mm nominal size dense base course		28mm nominal size dense base course		20 mm nominal size dense base course	
Aggregate	Rock/gravel		Rock/gravel		Rock/gravel		Rock/gravel	
% by mass of Total Binder content	3.5 ± 0.6		4.5 ± 0.6		4.7 ± 0.6		4.7 ± 0.6	
Grade of Binder	80/100 pen		80/100 pen		80/100 pen		80/100 pen	
Mixing temp. °C Binder	Min	Max	Min	Max	Min	Max	Min	Max
°C Aggregate	130	165	130	165	130	165	130	165
	120	160	120	160	120	160	120	160
Grading BS test sieve								
mm μ m								
50	100		100					
37.5	90-100		95-100		100			
28	55-90		70-94		95-100		100	
20					71-95		95-100	
10	35-55		56-76		58-82		65-85	
14							52-72	
6.3	20-30		44-60		44-60		39-55	
3.35	10-20		32-46		32-46		32-46	
300	2-10		7-21		7-21		7-21	
75			2-9		2-9		2-9	

Table 9.2.10 – 5 Wearing Course Material

Type	14 mm Open course	10 mm Open course	6mm Medium wearing course	14 mm Dense course	10 mm Dense wearing course
Aggregate	Crushed rock	Crushed rock	Crushed rock	Crushed rock	Crushed rock
Binder content % by mass to total	Min. 4.8 ± 0.5%	Min. 5.3. ± 0.5 %	Min. 5.4 ± 0.5%	Min 5.1 ± 0.5%	Min. 5.3 ± 0.5%
Grade of Binder	80/100 pen	80/100 pen	50/200 pen	80/100 pen	80/100 pen
Mixing temp. °C Binder °C Aggreg.	130 -165 120 -160	130 - 165 120 - 160	Varies 120 - 160	130 - 165 120 - 160	130 - 165 120 - 160
Grading BS test sieve					
mm μ m					
20	100			100	
14	90-100	100		95-100	100
10	55-75	85-100	100	70.-90	95-100
6.3	25-75	30-60	90-100	45-65	55-75
3.35	15-25	15-25	45-65	30-45	30-45
1.18			10-30	15-30	15-30
75	2 - 7	2 - 7	2 - 9	3 - 8	3 - 8

* For light traffic, footways, play grounds and patching.

9.2.10.7 PLANT AND EQUIPMENT

9.2.10.7.1 General

Mixing plant - used by the Contractor shall be modern type batching plant or a continuous mixing plant and shall have the capacity sufficient to supply the paver on the road continuously when spreading the asphaltic mix at normal speed and required thickness.

The plant shall be able to heat the aggregate and the binder to the appropriate temperatures given in the tables and before coating the aggregate shall be adequately dried.

The plant shall be so designed, co-ordinated and operated so the materials, including any added filler, shall be weighed or measured into the mixer and mixed in such a manner that the premix on discharge from the mixer is uniform in composition and all particles of the aggregate are completely coated.

The Contractor shall provide and have at hand not less than ten 25 kilogram standard weights for frequent testing of all weighing scales on the mixing plant. The plant shall, if situated in urban areas or required by the Contract, be equipped with a dust collector so constructed as to waste or return uniformly to the elevator all or any part of the material collected.

The Contractor shall provide a field laboratory.

Safety equipment - Adequate and safe stairways to the mixer platform and guarded ladders to other plant units shall be placed at all points required for accessibility to plant operations. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading space. This space shall be kept free from drippings from the mixing platform. Flexible pipe connections carrying hot asphalt shall be shielded.

The mixing plant and all equipment necessary to operate the plant will be inspected by the Engineer for approval.

9.2.10.7.2 *Temperature limits for Asphaltic Mixtures*

The asphaltic material shall be heated to the temperature as set forth in the tables.

The heating system shall be so designed as to avoid overheating. The mixture shall be delivered to site within 14 degrees C of the temperature set in the job-mix formula.

9.2.10.8 CONSTRUCTION METHODS

9.2.10.8.1 *Weather Limitation*

Asphaltic mixtures shall be placed only when the surface is dry, when the weather is not rainy and when the prepared roadbed is in a satisfactory condition; provided, however that the Engineer may permit, in case of sudden rain the placing of mixture then in transit from the plant, if laid at proper temperature and if the road bed is free from pools of water. Such permission shall in no way relax the requirements for quality and smoothness of surface.

9.2.10.8.2 *Progress of Work*

No work shall be performed when there is insufficient hauling, spreading or finishing equipment, or labour, to ensure progress at a rate not less than 60 % of the capacity of the mixing plant.

9.2.10.8.3 *Hauling Trucks*

Trucks for hauling asphaltic mixtures shall have tight, clean and smooth metal beds that have been sprayed with soapy water, thinned fuel oil, paraffin oil, or lime solution to prevent the mixture from adhering to the beds. The amount of sprayed fluid shall however be kept to the practical minimum. Each load shall be covered with a canvas or other suitable material of such size as to protect the mixture from the weather. Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts or that causes undue delays shall upon

direction of the Engineer be removed from the work until such conditions are corrected. When necessary, in order that the mixture shall be delivered to the site within the specified temperature range, a properly fastened insulating cover shall be used. Loading and transporting shall be such that spreading, compacting and finishing shall all be carried out during daylight hours unless satisfactory illumination is provided by the Contractor.

Each vehicle shall be weighed after each loading at the mixer and a record shall be kept of the gross weight, tare and net weight as well as time of dispatch of each load.

9.2.10.8.4 Pavers

The equipment for spreading and finishing shall be approved mechanical, self powered pavers, capable of spreading and finishing the mixture true to the lines, grades, levels, dimensions and cross sections.

The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly in front of adjustable steering devices and shall have reverse as well as forward travelling speeds. Pavers shall also be equipped with vibrating screeds furnished with suitable burners or heaters.

The pavers shall maintain trueness of grade and confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be adjustable to give the cross section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.

The mixture after spreading and initial tamping by the paver, shall have a smooth surface free of distortions caused by dragging, tearing or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor forthwith. A fully trained and experienced operator shall be in direct charge of the paver. Material remaining in hoppers, conveying and spreading mechanisms, tampers and screeds shall be cleaned off at the end of each working day. Narrow strips remaining alongside paver work shall be hand laid and rolled at the same time as the paver laid work, and allowances shall be made for extra compaction of hand-laid strips. Any defects in the finished surface shall immediately be rectified before any rolling takes place and there must be no unnecessary scattering back by hand of material as paver laid work.

9.2.10.8.5 Rollers General

The type of roller or roller combination to be used shall be nominated by the Contractor for the approval of the Engineer prior to the commencement of work. Irrespective of the type of roller or roller combination, the Contractor shall supply evidence that the roller or roller combination shall have a compaction capacity not less than 1.5 times the spreading capacity of the paver. During construction, should this compaction capacity not be met, an additional and appropriate roller shall be provided immediately to meet this requirement.

9.2.10.8.6 Non Vibratory Rollers

(a) Roller requirements

Generally with each paver, two steel wheeled tandem rollers and one pneumatic tyred roller will be required, except that on projects involving a total of less than 500 tons of material the minimum requirement will be one tandem roller. All rollers shall be self propelled, capable of being reversed without backlash and equipped with power steering, dual controls allowing operation from either the right or left side, water tanks, sprinkler systems and coco-mats to ensure even wetting of rollers or tyres. The Contractor shall supply to the Engineer for each type of roller a calibration chart showing the relationship between depth of ballast and weight and giving the tare weight of the roller. Each roller shall be in good condition and worked by an competent and experienced operator.

Steel wheeled tandem roller shall weigh not less than 8 metric tons and each tandem roller used for final compaction (finish rolling) shall have at least one roller capable of applying a minimum load of 33 N/mm of roller width.

Pneumatic tyred rollers shall be of an approved type having not less than seven wheels smooth tread compactor tyres of equal size and construction capable of operating at inflation pressures up to 850 kN per square metre. Wheels shall be equally spaced along both axle lines and arranged so that tyres on one axle line tract midway between those on the other with an overlap. Each tyre shall be kept inflated to the specified operating pressure such that the pressure difference between any two tyres shall not exceed 35 kN per square metre. Means shall be provided for checking and adjusting the tyre pressures on the job at all times. For each size and type of tyre used the Contractor shall supply to the Engineer charts or tabulations showing the relationship between wheel load, inflation pressure and tyre contact pressure, width and area. Each roller shall be equipped with means of adjusting its total weight by ballasting so that the load per wheel can be varied from 15 N to 25 N. In operation the tyre inflation pressure and the wheel load shall be adjusted as required by the Engineer, to meet the requirements of each particular application. In general the compaction of any course with a pneumatic tyred roller shall be accomplished with contact pressures as high as the material will support.

(b) Procedure

Rolling of the mix shall consist of six separate operations as follows:

- | | |
|------------------------|------------------------------------|
| (1) Transverse joint | (4) Initial or breakdown rolling |
| (2) Longitudinal joint | (5) Second or intermediate rolling |
| (3) Edges | (6) Finish rolling |

The list rolling of all joints and edges, the initial or breakdown rolling and the final or finish rolling shall all be done with the steel wheeled tandem rollers. The second or intermediate rolling shall be done with the pneumatic tyred roller except on small operation as noted above.

The speed of the rollers shall not exceed 4 kilometres per hour for steel wheeled rollers and 6 kilometres per hour for pneumatic tyred rollers and shall be at all times slow enough to avoid displacement of the hot mixture.

9.2.10.8.7 *Vibrating Rollers*

(a) Roller requirements - Generally rollers shall be self propelled tandem rollers, capable of being reversed without backlash, be equipped with water tanks, sprinkler systems which wet the tyres evenly and an automatic vibration control which cuts out the vibratory system before the machine comes to a halt.

The minimum operating weight of the roller shall be 3 tons and minimum drum width 0.75 m, the minimum linear drum applied force 33N/mm and the minimum frequency of vibration 4000 r.p.m (67Hz) operating on both wheels.

Where the Contractor wishes to use a roller or roller combination which meets most but not all of the above requirements, the Engineer may approve the use of such rollers provided they meet the compaction capacity as specified in Sub-Section 9.2.10.7.5 and compact to the density and surface tolerances specified in Sub-section 9.2.10.7.10.

9.2.10.8.8 *Preparation of Existing Surface*

Where local irregularities in the existing surface would otherwise result in a course more than 75mm thick after compaction, the surface shall be regulated using an asphaltic mixture to be approved by the Engineer, and thoroughly tamped or rolled. The mixture used shall be follows:

a) Dense Bitumen Macadam Regulating Courses

i) Less than 15mm thick

Dense bitumen macadam regulating courses less than 15mm thick shall not be used. Material in the subsequent layer shall be increased in thickness as required conditional upon the subsequent layer thickness being within the limits given in Table 1 of BS 4987 : Part 2 for coated macadam materials and the nominal size of the aggregate.

ii) Between 15mm and 35mm thick

For regulating courses between 15mm and 35mm compacted thickness, 10mm or 14mm close graded wearing course material in accordance with BS 4987: Part 1 Clause 7.3 and 7.4 respectively may be used conditional upon the course thickness being not less than 1 1/2 times the nominal size of the aggregate. The binder shall be 100 pen bitumen unless otherwise agreed with the Engineer. The coarse aggregate shall be as shown on the drawings or otherwise agreed with the Engineer.

iii) Between 35mm and 80mm thick

For regulating courses between 35mm and 80mm compacted thickness, 20mm size dense base course in accordance with BS 4987: part 1 Clause 6.5 shall be used. The binder shall be 100 pen bitumen unless otherwise agreed with the Engineer. The coarse aggregate shall be as specified in Clause 10.2 hereafter.

iv) Between 80mm and 125mm thick

For regulating courses between 80mm and 125mm compacted thickness, 28mm size dense road-base in accordance with BS 4987 : Part 1 Clause 5.2 shall be used. The binder shall be

100 pen bitumen unless otherwise agreed with the Engineer. The coarse aggregate shall be as specified in Clause 8.3 above.

- v) Greater than 125mm thick
For regulating courses greater than 125mm thick dense road-base in accordance with BS 4987: Part 1 Clause 5.1 or Clause 5.2 for 40mm and 28mm size aggregate respectively shall be used.

b) Approval of the Engineer

The thickness of the regulating course required and the materials to be used shall be as shown on the drawings or otherwise agreed with and to the approval of the Engineer. Where pre existing roadbed is broken or in the opinion of the Engineer shows instability, the unstable material shall be removed and disposed of as directed by the Engineer and be replaced with the same mixture as specified for the next course, compacted to the standard and elevation of the adjacent surface.

Where the existing surface course is stabilized or asphaltic or Portland cement concrete, and if the edge of the course has become eroded, disintegrated, or broken the edges shall be trimmed back as directed by the Engineer, the debris removed and disposed of, and the space backfilled with an asphaltic mixture or with gravel or similar approved material as directed and then compacted.

The surface upon which the mixture is to be placed shall be swept thoroughly and cleaned of all loose dirt and other objectionable material immediately before spreading the mixture.

Before spreading the mixture upon a Portland cement concrete surface all longitudinal and transverse joints shall be cleaned out and filled with an approved sand asphalt mix. Cracks shall be similarly treated as directed by the Engineer. Wherever, possible the cleaning out shall be to a depth of 40 mm or more and the sand asphalt shall be thoroughly compacted in joints and cracks to a level not more than 3 mm below the surface. A tack coat shall then be applied to the surface.

9.2.10.8.9 Spreading and Finishing

Upon arrival at the point of use, temperature of the mixture shall be checked in both the hauling truck and in the paver hopper and recorded. The mixture shall spread and struck off to the grade, elevation and cross section shape intended either over entire width or over such partial width as may be practicable. The mixture shall be laid upon an approved surface and only when weather conditions are considered suitable by the Engineer.

In narrow base widening, deep or irregular sections, turnouts or driveways where it is impractical to spread and finish the mixture by use of a paver, the Contractor shall use approved spreading equipment or acceptable hand methods as directed by the Engineer.

On areas where in the opinion of the Engineer, the use of spreading equipment is considered impractical the mixture shall be dumped on steel boards then spread, raked and laid by hand to provide the correct weight or uniform thickness of material without segregation. Mixtures shall not be applied faster than they can be properly handled and spread.

The Contractor shall provide suitable means for keeping all small tools clean and free from accumulations of asphaltic material. He shall provide and have ready for use at all times enough

taraulins or covers, as may be directed by the Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped and not spread.

For macadam recipe mixes the maximum thickness of any compacted layer shall not exceed those given in BS 4987.

9.2.10.8.10 *Compaction of Mixture*

General - Immediately after the mixture has been spread and struck off, the surface shall be checked and any inequalities adjusted. The mixture shall then be thoroughly and uniformly compacted by rolling. Each course shall be rolled as soon after being placed as the material will support the roller without undue displacement or cracking.

Rolling shall start longitudinally at the sides and proceed toward the centre of the pavement except that on superelevated curves rolling shall begin at the low side and progress toward the high side. Successive trips of the roller shall overlap by at least one-half of the width of the roller and alternate trips shall not terminate at the same point. For initial rolling the drive roller should be nearest the paver. Any displacements occurring as a result of reversing the direction of the roller or from any other cause shall at once be corrected with rakes and fresh mixture where required. Care shall be exercised in rolling not to displace the line and grade of the edges.

Rolling shall progress continuously as may be necessary to obtain uniform compaction while the mixture is in a workable condition and until all roller marks are eliminated.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened, but excess water will not be permitted.

Heavy equipment or rollers shall not be permitted to stand on the finished surface until it has thoroughly cooled or set.

Any petroleum products dropped or spilled from the vehicles or equipment employed by the Contractor upon any portion of the pavement under construction is cause for the removal and replacement of the contaminated pavement by the Contractor.

Along kerbs, headers, manholes and similar structures and at all places not accessible to the roller, thorough compaction shall be secured by means of hot hand tampers or with mechanical tampers giving equivalent compaction. Each hand tamper shall weigh not less than 10 Kilograms and shall have a tamping face area of not more than 0.03 square metres.

The surface of the mixture after compaction shall be smooth and true to the established crown and grade within the tolerance specified. Any mixture that becomes loose and broken, mixed with dirt or which is defective in any way, shall be removed and replaced with fresh hot mixture, which shall be compacted immediately to conform with the surrounding area. Any area of 1 square metre or more showing an excess or deficiency of asphaltic material shall be removed and replaced. All high spots, high joints, depressions and honeycombs shall be adjusted and corrected as directed by the Engineer.

9.2.10.8.11 Joints

Both longitudinal and lateral joints in successive courses shall be staggered so as not to be one above the other. Longitudinal joints shall be arranged so that the longitudinal joint in the top course shall be at the location of the line dividing the traffic lanes. Lateral joints shall be staggered a minimum of 250 mm and shall be straight.

Longitudinal and transverse joints shall be made in a careful manner so that well bonded and sealed joints are provided for the full depth of the course. No mixture shall be placed against previously rolled material unless the edge is vertical or has been cut back to a vertical face. A brush coat of hot asphalt shall be applied just before additional mixture is placed against the previously rolled material.

Spreading shall be as nearly continuous as possible and rollers shall pass over the unprotected end of freshly laid mixture only when authorized by the Engineer. In all such cases provision shall be made for a properly bonded and sealed joint with the new surface for the full depth of the course as specified above.

Before placing mixtures against them, all contact surfaces of kerbs, gutters, headers, manholes, etc. shall be given a thin, uniform coating of hot asphalt and the joints between these structures and the surface mixture shall be effectively sealed by the subsequent spreading, finishing and compaction operations.

9.2.10.8.12 Surface Test of the Pavement

The surface shall be tested by a crown template and 3 meter straight edge, furnished by the Contractor, applied respectively at right angles and parallel, to the centre line of the road. The Contractor shall designate some employees to use the template and straight edge under the direction of the Engineer in checking all surfaces. The crown template shall conform to the typical cross section shown on the drawings.

The variation of the surface from the testing edge of the crown template and the straight edge between any two contacts with the surface shall not exceed 12.5 mm for bases and 3.5 mm for surfacings.

The edges of the pavement shall be straight and true to the required lines. Any excess material shall be cut off square after final rolling and disposed of by the Contractor at an approved tip.

9.2.10.8.13 Recommended Thickness for Coated Macadam

Table 9.2.10 – 6 Recommended Thickness for Coated Macadam

Group	Description	Nominal size mm	Thickness of compacted course mm	Min. Thickness at any point mm
One Road base	Dense	40	90-150	80
Two Base Course	Single Course	40	75 -105	65
	Dense	40	95 - 140	80
	Dense	28	75 – 100	55
	Dense	20	50 = 80	40
Three Wearing Course	Open	14	40 – 55	35
	Dense	14	40 – 55	35
	Open	10	30 – 35	25
	Dense	10	30 – 35	25
	Medium	6	20 – 25	15

9.2.10.9 ASPHALTIC PRIME COAT

9.2.10.9.1 Description

This work shall consist of the careful cleaning of the surface to be primed and furnishing and applying asphaltic material in accordance with the Specification to the area shown on the Drawings and as directed by the Engineer.

9.2.10.9.2 Materials

(i) Asphaltic Material

Asphaltic material shall be a cut back of the type and grade called for in the Special Provisions or elsewhere in the Contract documents and shall conform to the requirements of Sub-section 9.2.10.3.3.

(ii) Blotting Material

Blotting material shall be approved clean dry sand stone screenings free from any cohesive material. It shall contain no organic matter.

9.2.10.9.3 Construction Methods

(i) Weather Limitations

Prime coat shall be applied at a time when the surface to be treated is dry or slightly damp, when the ambient temperature is above 13 degrees C and rising, or above 16 degrees C if falling and when the weather is dry.

(ii) Equipment

(a) Application to Large Areas

The equipment used by the Contractor shall include a power broom and blower or both, a self-powered pressure asphaltic material distributor, and when necessary, equipment for heating asphaltic material.

The distributor shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 1200 kilograms per mm of tyre width, and shall be so designed, equipped, maintained, and operated that asphaltic material at even heat may be uniformly distributed on variable widths of surface up to 5 metres at readily determined and controlled rates from 0.2 to 9.0 litres per square metre with uniform pressure and with an allowable variation from any specified rate not to exceed 0.1 litre per square metre. Distributor equipment shall include an instrument for measuring the speed of travel accurately at low speeds, the rate of flow of asphaltic material through the nozzles, the temperature of the contents of the tank and the pressure. These instruments shall be so located that the operator can easily read them whilst operating the distributor.

Distributors shall be equipped with a separate power unit for the pump and full circulation spray bars. The spray bars on the distributor shall be controlled by a man riding at the rear of the distributor in such a position that operation of all sprays is in his full view.

(b) Application of Small Areas

The equipment shall be to the approval of the Engineer but shall generally conform to the following:

The equipment used shall be capable of applying the asphalt material within the specified temperature range and concentration in accordance with Table 9.2.10-7 and (iv) Application of Asphaltic Material in this section, respectively.

The distributor shall either have pneumatic tyres and be of such weight so as not to damage the surface to be treated or shall be kept clear of the surface.

(c) Supplementary general requirements to (a) and (b)

The tanks of distributors shall be fitted with accurately calibrated dipsticks or contents gauges.

All measuring equipment on the distributor shall have been recently calibrated and an accurate and satisfactory record of such calibration shall be supplied to the Engineer.

If, after beginning the work, the distribution of asphaltic material is found to be in error the distributor shall be withdrawn from the work and calibrated in a manner satisfactory to the Engineer before proceeding with the work.

The Engineer may require such tests as he considers necessary to check the performance of the distributor. As and when directed by the Engineer, the Contractor shall make the distributor and its equipment available for field testing and shall supply any assistance required for this purpose.

Any distributor, which does not operate satisfactorily or conform to the requirements of the Specification in all respects may be rejected by the Engineer for further use on the road.

(iii) Cleaning Surface

Immediately before applying the asphalt material all loose dirt and other objectionable material shall be removed from the surface with a power broom and blower or both as required. Such cleaning shall continue until the entire surface shows a pattern of exposed large particles well wedged together and free from dust. When so ordered by the Engineer a light application of water shall be made just before the application of asphaltic material.

(iv) Application of Asphaltic Material

Asphaltic material shall be applied by means of a distributor at the rate or rates directed by the Engineer, which will usually be from 0.5 to 1.5 litres per square metre and at a temperature within the range called for in Table 9.2.10-7 for the particular material being used. Any prescribed application shall be divided into two applications when necessary to prevent asphalt flowing off the surface and additional asphaltic material shall be applied where surface conditions indicate it to be necessary, if the Engineer so directs. No further courses shall be applied until the prime coat has set and the solvent evaporated.

When so directed, the prime coat shall be applied in lanes of approximately one half or less of the width of the completed surface. A lane of prime coat shall be applied, allowed to penetrate not less than 4 hours, then covered with blotting material if required and opened to traffic before asphaltic material is applied to the adjacent lane. In covering the first treated lane, a strip at least 200mm wide shall be left uncovered where the two lanes join, to permit a slight overlap of the asphaltic material.

The surfaces kerbs and / or of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred. No asphaltic material shall be discharged into a borrow pit or gutter.

Table 9.2.10 -7 Spraying Temperatures for Asphalt

Spraying Temperature for Asphalt		
Type	Grade	Temperatures °C
Cutbacks	Grade (approx.)	(whirling spray jet)
	(30)	50 – 60
	(70)	65 – 80
	(250)	95 – 115
	(800)	115 – 135
	(1000)	135 – 155
Emulsions ambient temperature or blotter as necessary for uniform spraying and satisfactory penetration.		
Asphalt cement	80 – 100 pen	180 – 200
	200 – 300 pen	165 – 175

Note: slot jet distributors should allow a lower spray temperature.

(v) Maintenance and Opening to Traffic

Traffic shall not be permitted on the primed surface until the asphaltic material has penetrated and dried and, in the opinion of the Engineer, will not be picked up by traffic. Where the Engineer deems it impracticable to detour traffic, the Contractor shall spread the minimum quantity, as determined by the Engineer, of blotting material necessary to avoid picking up, and traffic shall be allowed to use areas so treated. Any areas containing an excess or deficiency of priming material shall be corrected by the addition of sand or asphalt as directed by the Engineer. Such corrections of faulty work shall be rectified before the asphalt concrete is laid.

9.2.10.10 ASPHALTIC TACK COAT

9.2.10.10.1 Description

This work shall consist on furnishing and applying asphaltic material to a previously prepared roadbed in accordance with the specification and to the width and area required by the Engineer.

9.2.10.10.2 Materials

Asphaltic material shall be either rapid curing cut back or rapid setting emulsion of the type and grade called for in the Contract Documents and shall conform to the requirements of Sub-Section 9.2.10.3.

9.2.10.10.3 Construction Methods

(i) *Equipment*

The equipment shall be as specified in Sub-section 9.2.10.8 Asphaltic Prime Coat.

(ii) *Cleaning Surface.*

When, in the opinion of the Engineer, it is necessary, the full width of surface to be treated shall be cleaned with a power broom or power blower to remove loose dirt and other objectionable material. The surface to be treated shall be dry.

(iii) *Application of Asphaltic Material*

Immediately after cleaning the surface, asphaltic material shall be applied by means of a distributor at the rates directed by the Engineer, but not to exceed 0.75 litres per square metre and at the temperature within the range called for in Sub-section 9.2.10.8 for the particular material being used. The tack coat shall be applied only when the surface is dry except with the permission of the Engineer.

The surfaces of kerbs and/or structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred. No asphaltic material shall be discharged into a borrow pit or gutter. The Engineer may direct that emulsions shall be diluted with clean water in order to control the rate of spread.

The surface course shall not be placed over the tack coat until it is in a proper condition of tackiness to receive it. Tack coat shall be applied only so far in advance of surface course placement as is necessary to obtain this proper condition of tackiness. Until the surface course is placed, the Contractor shall protect the tack coat from damage.

9.2.10.11 ASPHALTIC CONCRETE SURFACING

9.2.10.11.1 Description

(i) General

This work shall consist of a surfacing of dense graded asphaltic concrete constructed on a prepared base in accordance with Specification and the lines, levels, grades, dimensions and cross section shown on the Drawings and as required by the Engineer.

All the provisions of Sub-section 9.2.10.5 "General Requirements for Asphaltic Bound Bases and Surfacing" shall form a part of the Specification unless otherwise stated.

The surfacing shall consist of one or two layers of the thickness shown on the Drawings. The top layer shall be denoted as the wearing course and the lower layer as the binder course. Mixtures shall be designed according to the "Marshall Method Mix Design" Asphalt Institute Manual – No 2 – MS-2.

(ii) General Composition of the Mixture

The mixture shall consist of mineral aggregate, and filler if needed, coated with asphalt asphalt cement. The total mineral aggregate shall have a job mix grading within the limits set by Table 9.2.10-8, even allowing for tolerances.

In exceptional cases the Engineer's approval may be given to gradings outside the limits specified in Table 9.2.10-8.

The ratio of total material passing the 75mm sieve to asphalt by weight shall not exceed 1.5 to 1.0, nor be less than 1.0 to 1.0.

In addition to meeting the requirements of the job mix formula in Sub-section 9.2.10.5, laboratory samples shall be prepared using 75 blows. The samples shall be of approved material to the gradation and asphalt content stated and shall have the following characteristics:-

1. Marshall Stability not less than 9.0 kN.
2. Marshall Flow (0.25mm) not less than 8 nor more 18 and also,
3. The ratio $\frac{\text{Marshall Stability (kN)}}{\text{Marshall Flow (0.25mm)}}$ shall not be less than 0.55
4. Air voids in Mix, binder course: 4-7%
5. Air voids in Mix, wearing course 4-6%

6. Voids filled with Asphalt, binder course: 65-80%
7. Voids filled with Asphalt, wearing course 75-80%

The selected job mix shall be from one of the classifications listed below:-

Table 9.2.10 –8 Job Mix Classification

Mix Classification Course		1 Binder	2 Wearing	3 Wearing
Thickness mm	Min.	75	60	45
	Max.	35	30	25
Total % by weight passing including filler				
Sieve Size mm	Sieve Size Mm			
28		100	100	100
20		100	93- -100	75- -95
10		63 – 75	59 – 71	53 – 72
5		44 – 52	38- -46	32- -50
2.36		33 – 41	25 – 33	25 – 43
1.18		27 – 35	20 – 28	19 – 35
	800	22 – 30	15 – 23	14 – 27
	300	14- -22	10 - 18	9 - 18
	150	2- 10	4 – 10	5 – 10
	75	1 - 5	3 – 7	
Asphalt cement content by total weight found by analysis		4.0 – 6.5	4.5 – 6.5	5.0 – 7.0

(iii) Job Mix

Before starting work, the Contractor shall submit to the Engineer in writing, a proposed job mix formula for the mixture to be supplied for the project. The formula so submitted shall stipulate for the mixture a single percentage of aggregate passing each required sieve size a single definite temperature at which the mixture is to be emptied from the mixer, and, for mixtures to be laid hot, a single definite temperature at which the mixture is to be delivered on the road, all of which shall fall within the ranges of the general composition and temperature limits.

All mixture furnished to size shall fall within the ranges of tolerance given below:

Passing sieves 10mm and larger	+ or - 5%
Passing sieves between 10mm and 75mm	+ or - 4 %
Passing 75 mm sieve	+ or - 1.5 %
Asphalt	+ or - 0.3 %
Temperature of mixture when emptied from mixer	+ or -10 Degree C
Temperature of mixture at delivery on road	+ or -10 Degree C

Each day samples of the materials and mixture shall be taken and tested as specified in the following British standards or as the Engineer considers necessary for checking the required uniformity of the mixture.

Binders	:	BS 76 and BS 3690
Aggregates	:	BS 812 and BS 1047
Coated macadam	:	BS 598

When unsatisfactory results or changed conditions make it necessary, the Contractor shall submit a new job-mix formula to the Engineer for approval.

Should a change in a material be encountered or should a change in a source of material be made, a new job formula shall be submitted and approved before the mixture containing the new material is delivered. Materials will be rejected if they are found to have void or other characteristics, which require, for a balanced mix, an asphalt content greater or less than the specified range.

9.2.10.11.2 Materials

(i) Asphaltic Materials

Asphaltic materials shall conform to the requirements of Section 9.2.10.3.4. In the absence of any requirement or permission to the contrary, asphalt cement of 80-100 penetration shall be used.

(ii) Asphaltic Additive

Not necessary

(iii) Coarse Mineral Aggregate

Coarse aggregate is material substantially retained on the 3.35mm BS test sieve and shall be crushed rock, or crushed gravel. Only type of one coarse aggregate shall be used except by written permission from the Engineer.

Crushed rock, and crushed gravel shall consist of clean, tough, durable material free from vegetable matter, soft particles, and other objectional matter. When gravel is used the clay and silt content shall not exceed 1% by mass of the coarse aggregate when determined in accordance with the sedimentation or decantation methods given in BS 812.

Crushed rock shall be one or more of the types listed below as classified in BS 812. The Contractor shall, if required by the Engineer, inform him of the group or groups to which the aggregate belongs.

- (1) Granite Group
- (2) Basalt Group
- (3) Gabbro Group
- (4) Porphyro Group
- (5) Quartzite Group

- (6) Horntels Group
- (7) Gritstone Group
- (8) Limestone Group

If it is proposed to use an aggregate of another type other than the groups above, the Contractor shall submit all the facts to the Engineer for his approval.

Coarse Aggregate shall comply with the following:

- Aggregate Impact Volume when tested in accordance with BS 812 of not more than 30 %
- Aggregate Abrasion Value as determined by AASHTO test method T96 of not more than 40.
- Flakiness Index when tested in accordance with BS 812 Part 105. I shall not exceed 35 %.
- When subject to Coating and Stripping Test, AASHTO test method T182, the aggregate shall have a coated area of not less than 95 %.

The materials shall conform to the requirements of Section 4.12 of the Specification with the additional requirements noted below.

(iv) *Fine Mineral Aggregate*

The portion of the aggregate passing a 3.35 mm BS test sieve shall be known as fine mineral aggregate, and shall consist of natural sand, stone screenings, or a combination if stated in the Special Provisions. Fine aggregate shall be composed of clean, hard durable particles, rough surfaced and angular, free from vegetable matter, soft particles, clay balls or other objectionable material. Stone screenings shall be produced from stone meeting the requirements for coarse mineral aggregate in Sub-section 9.2.10.5.2.1

When sand is used the clay and silt content shall not exceed 3% by mass of the fine aggregate when determined in accordance with sedimentation or decantation methods given in BS 812.

(v) *Mineral Filler*

Mineral filter when required shall consist of limestone dust, dolomite dust, or similar rock dust, Portland cement, dehydrated lime, silica cement or other mineral matter from sources approved by the Engineer. It shall be free from foreign or other objectionable material. It shall be dry and free from lumps and when tested by means of laboratory sieves shall meet the following grading requirements.

B.S. Sieve mm	Percentage by Weight passing
601	100
212	95-100
75	75-100

Mineral filler shall be considered to include any mineral dust naturally present in the asphalt.

(vi) *Combined Mineral Aggregate*

The mineral aggregate when combined in the proportions required by the job-mix formula shall have a Sand Equivalent of not less than 50 as determined by AASHTO test Method T 176.

(vii) *Mixture*

The asphalt shall be extracted from samples in accordance with AASHTO Test Method T 164. After concentration of the extracted asphalt solvent solution to approximately 200 millilitres the contained mineral particles shall be removed in a centrifuge. This removal shall be considered satisfactory when the ash content (by ignition) of the recovered asphalt is not greater than 1% by weight. The asphalt shall be recovered from the solution in accordance with AASHTO Test Method T 170.

Asphalt recovered from samples shall have a penetration of at least 70% of the penetration of the asphalt cement before mixing and ductility of at least 400mm when tested in accordance with AASHTO Test Methods T 49 and T 51 respectively.

9.2.10.11.3 Construction Methods

(i) Construction methods shall conform to the requirements of Sub-section 9.2.10.5 of the Specification subject to the following modifications.

- (a) Heating of asphalt materials – Asphalt cement shall be heated to a temperature between 135 Degree C and 163 Degree C. The Engineer will approve the exact temperature.
- (b) Heating of mineral aggregates – The mineral aggregates shall be heated to a temperature between 135 Degree C and 171 Degree C.
- (c) Heating of mixture – The mixture shall be delivered from the mixer at a temperature within the absolute limits of 135 Degrees C and 170 Degrees C even allowing for tolerances.
- (d) Delivery of mixture – The mixture shall be delivered on the road within $\pm 14^{\circ}\text{C}$ of the job mix formula temperature giving due account of compaction temperatures.
- (e) Compaction – The mixture shall be compacted at a temperature above 105 Degrees C. The density of all samples taken from the compacted surface course shall be not less than 97% of the Marshall Density of the mixture sampled at the plant appropriate to the location.
- (f) Pavement Samples – The Contractor shall after final rolling and before opening the surface to traffic, cut samples from the finished work for testing. Samples shall be not less than 250mm square, except that, for measurement of the field density only, cores with a minimum diameter of 100mm cut by an approved coring machine will be acceptable. Samples shall be taken of the mixture for the full depth of the course from the locations directed by the Engineer.

One sample for density measurement shall be taken for each day or fraction of a day that the plant operates or if the output exceeds 100 tons per day then at the rate of one per 100 tons or part thereof.

Samples for analysis and other tests shall be taken from the surface course when the Engineer so directs and shall in any case be taken whenever a change is made in the job-mix formula.

Where samples have been taken, fresh material shall be placed, thoroughly compacted and finished to the satisfaction of the Engineer.

(ii) *Control and testing*

(a) Unless specified otherwise in the Special Provisions, the Contractor shall provide adequate laboratory accommodation and all then equipment required for sampling and for each of the following tests:

1. Grading analysis of aggregates and filler.
2. Flakiness and Elongation Index of course aggregates.
3. Sand Equivalent of aggregates.
4. Bulk specific gravity of mixed aggregates.
5. Compacted density of mixed aggregates.
6. Compacted density of mix (Marshall Density)
7. Marshall Stability and Flow.
8. Density of compacted surface course.
9. Asphalt extraction.

The Contractor shall be responsible for this sampling and testing and shall provide an adequate number of skilled assistants to do this work. The Engineer may provide an adequate number of skilled assistants to do this work. The Engineer may however, from time to time decide to take the samples and or carry out the test himself.

The Contractor shall keep records of all his tests and copies of these records shall be sent to the Engineer continuously.

(b) The Contractor shall provide the Engineer with the following results and records of tests carried out on each days production together with the exact location of each days production in the finished work.

1. Temperature of mix when sampled at the mixing plant and on the road.
2. Density of laboratory – compacted mix (Marshall Density)
3. Compacted density and percentage compaction of surface course.
4. Marshall Stability and Flow.
5. Asphalt content and aggregate grading of mix.
6. Air voids in mix.

(iii) *Protection of the Pavement*

Sections of the newly finished work shall be protected from traffic of any kind until the mixture has cooled to 50 Degrees C. Traffic shall not normally be permitted on the newly laid surface less than 6 hours after completion of the pavement, except with the approval of the Engineer.

9.2.11 SPECIFICATION FOR VOLUMETRIC TYPE DOMESTIC WATER METERS

9.2.11.1 SCOPE

This specification applies to water meters for the measurement of cold potable water supplied to domestic and small commercial premises in Sri Lanka. It deals with the general, meteorological and technical requirements of volumetric type domestic meters.

The successful bidder shall undertake to supply & deliver domestic water meters for the National Water Supply and Drainage Board (NWSDB), (Purchaser) Sri Lanka from reputed manufacturers in conformance with the specifications and conditions of this contract.

The tender price shall include all labour, machinery and all materials necessary for the proper manufacturer of the goods, for tests at the manufacturers works and for insurance and freight to the port of Colombo and for discharging every requirement and obligation of the contract.

9.2.11.2 GENERAL REQUIREMENTS FOR THE WATER METER MANUFACTURER

The bidder shall furnish particulars of his or his manufacturer's experience in the design, manufacture and supply of water meters.

Manufacturer shall meet all the following minimum pass/fail criteria referred to the manufacturer's general and particular experience, technical capability, financial capacity and quality management systems adopted by the firm as demonstrated by the manufacturer's responses in the forms in Schedule IV of bid. This will be a necessary prerequisite for further evaluation of the offer.

9.2.11.2.1 *General Experience of Water Meter Manufacturer*

- a. Shall have continuous experience in manufacturing of Domestic Water Meters during last 5 Years.
- b. Should have supplied more than 500,000 Nos. Domestic Water Meters within last 60 Months out of which 100,000 Nos. shall be for countries with tropical climatic condition similar to Sri Lanka. Bidder shall also submit documentary proof of the successful operation of the tendered meter in climatic condition similar to Sri Lanka.

This information shall include name & address of the purchaser, make & model, size of the meter, quantity supplied, target and completion dates and certificates of completion from respective purchasers.

9.2.11.2.2 *Quality Management System*

The manufacturer shall possess ISO 9002 accreditation for manufacture of volumetric type domestic water meters for the plant where the manufacturer is done. TQM system shall comply with ISO 9002; 1994 or BS 5750 Part 2 or EN 9002 or an equivalent acceptable to NWSDB.

The certificates valid for current production (years 2001/2002 shall be produced with the offer. Bidder who fails to furnish proof of ISO 9002 certification shall be rejected.

If any of the meter components are obtained from other manufacturers, the bidder shall disclose, names & address of such manufacturer and the plant where such components are manufactured.

If any of the following components are obtained from other manufacturers they shall possess ISO 9002 quality assurance accreditation for the manufacturer of the same for the plant where the manufacture is done.

- i. Working Chamber
- ii. Water Meter Housing
- iii. Counter Assembly and other plastic components.

9.2.11.2.3 Test Certificates and Inspection Standards

Inspection Certificates issued by an independent Inspection Agency/ Agencies for the supplies completed within last 36 months given in Form XX in Schedule IV shall be produced.

9.2.11.2.4 After Sales Services

The manufacturer shall undertake to manufacture and maintain adequate stocks of spares for a minimum period five (05) years from the date of delivery of meters to be supplied under this contract.

9.2.11.2.5 Technical Capability

The Products offered shall conform to specifications stipulated under this contract.

The bidder shall submit all technical literature and any other technical reports containing information with regard to design, manufacture and characteristics of water meters.

9.2.11.3 TECHNICAL REQUIREMENTS

9.2.11.3.1 Definitions

For the purposes of this technical specification, the following definitions apply.

9.2.11.3.1.1 Volumetric Meter

Volumetric meter is a device, fitted into a closed conduit, which consists of chambers of known volume and a mechanism driven by the flow, whereby these chambers are successively filled with water and then emptied. By counting the number of these volumes passing through the device, the indicating device totals the volume flow.

9.2.11.3.1.2 *Velocity Meter*

Velocity meter is a device, fitted into a closed conduit which consists of a moving element set in motion directly by the velocity of the water flow. The movements of the moving element is transmitted by mechanical or other means to the indicating device, which totals the volume flow.

9.2.11.3.1.3 *Woltman Meter*

Woltman meter is a device consisting of a helical blade which rotates about the axis of flow in the meter.

9.2.11.3.1.4 *Single-Jet and Multi-Jet Meters:*

Single/ multi jet type meters are devices consisting of a turbine rotor rotating about the axis perpendicular to the flow of water in the meter. The meter is called a single-jet meter if the jet impinges at a single place on the rotor's periphery, and a multi-jet if the jet impinges simultaneously at several points around the periphery of the rotor.

9.2.11.3.1.5 *Flow-Rate*

Flow rate is the quotient of the volume of water passing through the water meter and the time taken for this volume to pass through the water meter.

9.2.11.3.1.6 *Permanent Flow-Rate (q_p)*

Permanent Flow Rate is defined as the flow-rate at which the meter is required to operate in a satisfactory manner (see 3.1.8) under normal conditions of use. e.g. under steady and /or intermittent flow conditions.

9.2.11.3.1.7 *Overload Flow-Rate (q_s)*

Overload Flow Rate is defined as the flow-rate at which the meter is required to operate in a satisfactory manner (see 3.1.8) for a short period of time without deteriorating. It's value is twice the value of q_p .

9.2.11.3.1.8 *Minimum Flow-Rate (q_{min}):*

Minimum Flow Rate is defined as the lowest flow-rate at which the meter is required to give indications within the maximum permissible error tolerance. It is determined in relation with the numerical value of the meter designation.

9.2.11.3.1.9 *Flow Rate Range*

Range limited by the overload flow-rate, q_s , and the minimum flow-rate, q_{min} in which the meter indications must not be subject to an error in excess of the maximum permissible errors is defined as Flow Rate Range.

This range is divided into two zones called "Upper" and "Lower" Zones separated by the transitional flow-rate.

9.2.11.3.1.10 Transitional Flow-Rate (q_t)

The Transitional Flow Rate(q_t) is defined as the flow rate at which the flow -rate range is divided into two zones, the "Upper zone" and "Lower Zone", each characterized by a maximum permissible error in each zone.

9.2.11.3.1.11 Volume Flow

This is the Volume of water passing thorough the water meter disregarding the time taken.

9.2.11.3.1.12 Indicating Device

Device displaying the volume flow is defined as the Indicating device.

9.2.11.3.1.13 Nominal Pressure (PN)

Numerical designation which is a rounded number for reference purposes.

All equipment of the same nominal size (DN) and designated by the same PN number shall have compatible mating dimensions.

9.2.11.3.1.14 Maximum Admissible Working Pressure (MAP)

For a water meter, MAP is defined as the maximum internal pressure that it can withstand permanently at a given temperature.

NOTE 1. For low temperatures between 0°C and 30°C, the MAP for materials currently used for the bodies of water meters remains constant. For cold water meters PN= MAP.

9.2.11.3.1.15 Nominal Size (DN)

DN is the Numerical designation common to all the components of a pipe system, excluding those designated by their external diameter or by the thread dimension, It is a whole number used for reference only, approximating the constructional dimensions.

9.2.11.3.1.16 Pressure Loss

Pressure loss is the actual pressure loss caused by the presence of a water meter in the pipeline at

a given flow-rate.

9.2.11.3.1.17 Maximum Admissible Temperature (MAT)

For a water MAT is the maximum temperature that a meter can withstand at a given internal pressure.

9.2.11.3.1.18 Meter Designation (N)

Meter designation is a Numerical value, preceded by the capital letter N used to designate the meter in relation to tabulated values of dimensions.

9.2.11.3.2 Technical Requirements for Domestic Water Meters

9.2.11.3.2.1 Operating Conditions

Domestic meters shall be suitable in every respect for operation under following operating conditions

(1) Temperature

The working temperature range shall be suitable for a country with following conditions:

- a. Annual average ambient temperature = 30°C
- b. Maximum ambient temperature = 40°C
- c. Operational altitude (Above MSL) = up to 500 m

(2) Humidity and Immersion

A meter shall be suitable for installation in a pit or basement which may be subjected to flooding. Therefore, meters and their fittings shall be capable of operating normally even when submerged to a depth of 1 m.

(3) Installation and Position

Domestic meters shall be suitable for installation in vertical, horizontal and inclined positions without loss of its required accuracy and counter shall be so positioned that it shall be easy to read in vertical or horizontal or inclined positions.

9.2.11.3.2.2 *Meter Type, Meter Designation and Size of End Connections*

All domestic meters to be supplied under this contract shall be of volumetric or semi positive displacement meters of piston type with threaded end connections.

Single or Multi jet type meters of class C accuracy **will not** be accepted for volumetric type meters.

Meter designation and size of threaded end connections are given in the following table. (Also refer 3.1. for definitions).

Meter Designation	Size of Threaded end connection
N 1.5	G1/2 B
N 2.5	G 3/4 B
N 3.5	G 1 B
N 6	G 1 1/4 B
N 10	G 1 2 B

9.2.11.3.2.3 *Meters Size and Overall Dimensions*

Meter size and hence overall dimensions are in principle linked to the designation of the water meter.

For each meter size there is a corresponding set of overall dimensions. The dimensions are given in *Table and Figure in Annex for water meters at the end of Section 9.2.11.*

H_1+H_2, L_1, L_2+L_3 define the height, length and width respectively of a cuboid within which the water meter can be contained (the cover being at right angles to its closed position).

H_1+H_2, L_2+L_3 are maximum dimensions L_1 is one of the fixed values given the *Table in Annex for water meters at the end of Section 9.2.11* with a specified tolerance of + 0/-2 mm. Set of values applicable for each meter size is given in *Table in Annex for water meters at the end of Section 9.2.11.*

9.2.11.3.2.4 *Threaded Connections*

All meters supplied shall have male threaded end connections and shall be provided with pipe connecting unions threaded to respective BSP size. For threaded end connections, two minimum values a and b are specified in *Table in Annex for Water Meters at the end of Section 9.2.11.* Dimensions a & b are as per the *Figure shown in Annex for Water Meters at the end of Section 9.2.11.*

End connections shall be the same at the water meter inlet and outlet.

9.2.11.3.2.5 *Metrological Classes*

All volumetric or semi-positive displacement meters of the piston type shall comply with the

meteorological properties which correspond to precision class C.

q_{min} and q_t values applicable for precision class C is as follows;

Meter Size (mm)	15	20	25	30	40
Meter Designation N	N1.5	N2.5	N 3.5	N6	N 10
Permanent flow rate m ³ /hr	1.5	2.5	3.5	6	10
q_{min} (L/hr)	15	25	35	60	100
q_t (L/hr)	22.5	37.5	52.5	90	150

9.2.11.3.2.6 Accuracy Class C and Corresponding Maximum Permissible Errors:-

The maximum permissible error in the lower zone from q_{min} inclusive up to but excluding q_t is + or- 5%.

The maximum permissible error in the upper zone from q_t inclusive up to and including q_s is + or- 2%.

The above accuracy levels are applicable to meteorological classes C.

9.2.11.3.2.7 Materials & Construction

The water meters must be manufactured from materials of adequate strength and durability for the purpose for which it is intended. Namely internal and or external installation on domestic or commercial premises in tropical country like Sri Lanka.

The meters must also be manufactured from materials which are resistant to or are protected against normal internal and external corrosion. However, the body of the meter shall be manufactured out of Brass.

The meter body shall be rigid and resistant to deformation that could impair the function of the moving parts.

When used under the conditions for which they are designed, materials in contact with or likely to come into contact with potable water shall not constitute a toxic hazard, shall not support microbial growth and shall not give rise to unpleasant taste or odor, cloudiness or discoloration of the water.

The indicating device of the water meter shall be protected by a transparent window (glass or other material). Further Protection shall be provided by a suitable cover.

9.2.11.3.2.8 *Strainers*

All volumetric type meters shall be provided with an internal strainers or a filter placed up stream of the measuring element.

9.2.11.3.2.9 *Pressure Loss*

The pressure loss through the water meter shall not be greater than 1 bar over the entire flow rate range.

9.2.11.3.2.10 *Indicating Devices*

The meter shall incorporate an indicating device which must give an indication of the volume flow expressed in cubic meters. The device shall consist of a row of a minimum of four in line consecutive digits and can be of mechanical type.(e.g a series of numbered cylindrical drums). This device shall be clearly labeled "M³".

Sub multiple of a cubic meter shall be shown by further in line digits. The discrimination of this subsidiary indicating device shall be to 0.1 liters indicated digitally or by graduations of a movable scale.

The cubic meter and its multiples shall be indicated in black and its sub-multiples in red. The actual or apparent height of the digits shall not be less than 4 mm.

The advance of any digit must be completed while the digit of the immediately next lower value describes the last tenth of its travel. The numbers on the drums must be displaced upwards.

9.2.11.3.2.11 *Anti Tamper Facilities*

Revenue meters of all types are subject to fraud and tampering. The anti tamper facilities and construction of the meter shall deter attempts at tampering and also indicate whether tampering has occurred.

Lead and wire seals shall be used to give local indications of meter removal or dismantling.

9.2.11.3.2.12 *Non-Return Valves*

An internal non-return valve which can not be removed without tampering shall be incorporated within the meter body to prevent the contamination of distribution system and to avoid loss of revenue from the back flow from end users.

9.2.11.3.2.13 *External Magnetic Interference*

If the drive between the metering rotor and the counter is magnetic, then it shall be unaffected by external magnetic interference.

9.2.11.3.2.14 *Marks and Inscriptions*

The water meter must carry on its body, excluding the cover, in an unambiguous, indelible and clearly legible form the following information.

- a. The name or the trade mark of the manufacturer.
- b. The meteorological class, meter designation and pressure loss in bars.

Where the numerical value of the permanent flow rate q_p is not equal to the numerical value of the meter designation N, the value of q_p shall be indicated in the addition to the meter designation N.

- c. The year of manufacturer and serial Number.
- d. An arrow indicating the direction of flow.
- e. The letters "NWS&DB" of height not less than 05 mm shall be engraved into the metal body of the water.

9.2.11.4 **SPARE PARTS**

The bidder shall provide, with his bid a complete itemized priced list of spare parts for all types and sizes of meters quoted. Lot of spares quoted shall include the following spares among others recommended by the manufacturer.

1. Combine counter and reduction gear assembly.
2. Working chamber complete.
3. Top plate assembly.
4. Non return valve.
5. Counter with series.
6. All "O" rings, seals, washers air clips.
7. Lid
8. Hinge pin

Bidder shall quote for 10 complete sets of spare parts for every 100 meters of all types and sizes of meters offered as per the specified lists of spares, given above.

9.2.11.5 **SAMPLES**

9.2.11.5.1 *Submission of Samples*

Successful bidder shall submit 5 (five) sample meters of 15 mm volumetric type complete with end connections and washers for inspection and testing by National Water Supply & Drainage Board for testing and approval.

All samples shall be well packed, sealed and labeled to facilitate identification.

The samples shall truly represent the meters offered to be supplied under this contract in every aspect. No samples will be returned and the cost of providing samples shall be borne by the bidders.

9.2.11.5.2 Testing of Sample Meters

All sample meters will be tested to evaluate meter performance on the NWS&DB water meter test benches at NWS&DB Central Workshop, Maligawa Road, Ratmalana only.

Successful bidder will be notified of the dates and times scheduled for testing samples and successful bidder or his authorised representative will be allowed to witness these tests. No change in time schedule will be allowed.

All sample meters will be opened in the presence of bidder or their representatives and then commence the testing.

All sample meters will be tested with the non-return valve in position and any plea for testing samples without non-return valves will not be accepted.

Following tests will be carried out to evaluate meter performance.

1. **% Error Tests at q_{min} , q_b and q_p**

% Error at all the above flow rates shall be within maximum permissible errors specified.

2. **Non return valve function test**

Non return valve shall withstand a max. pressure of 1 bar.

3. **Magnetic Influence**

All meters with magnetic drives shall not be influenced by a magnet.

4. **Pressure Tests**

Meters shall be able to withstand a working pressure of 10 bar without defects in its functioning, leakage or seepage through walls.

5. **Measurement of Overall Dimensions.**

Overall measurement of the sample meters will be measured.

9.2.11.5.3 Evaluation of Meter Performance

The test results obtained from above tests will be final and following criteria will be applied to evaluate meter performance.

9.2.11.5.3.1 Criteria for Evaluation of Test Performance

- a) All performance tests will carry equal weightage of 1.
- b) At least 3 out of 5 sample meters shall pass each test.
- c) Minimum Overall weight age is 20 out of 30.
- d) Offers that satisfy requirements b and c above will only be considered for further evaluation.

Test	Weightage allocated per pass per sample	Sample size	Max. Possible weightage	Minimum weightage necessary to pass each test
1. %Error Tests				
1.1 q_{min} Test	1	5	5	3
1.2 q_t Test	1	5	5	3
1.3 q_p Test	1	5	5	3
2. Non Return Valve Test	1	5	5	3
3. Magnetic Influence Test	1	5	5	3
4. Pressure test	1	5	5	3
Overall Performance	6	5	30	20

9.2.11.5.3.2 Pressure Loss

Total pressure loss of 5 meters in series will be measured at flow rate of Q_{max} . The average pressure loss per meter at Q_{max} shall be calculated and this figure shall not exceed 1 bar. Samples not conforming to above will be rejected.

9.2.11.5.3.3 Overall Dimensions

In addition to the above , overall dimension of the meters offered shall conform with the values given in the *Table in Annex for water meters at the end of Section 9.2.11.*

9.2.11.6 TECHNICAL LITERATURE

9.2.11.6.1 *Tender Drawings*

The bidder shall submit together with his bid a drawing or drawings showing the salient features of the meters, the materials used, methods of manufacture and tolerances allowed and other details to enable determination and assessment of the meters.

The bidder shall supply a calibration curve (flow rate against % error) for each size and type of meter offered.

9.2.11.6.2 *Service Manuals*

The successful bidder shall submit 3 copies of the Service Manuals for each type of meter to NWSDB at the time delivery of meters.

The manuals shall contain complete list with number, name, drawing of spare parts, information, tools and equipment necessary for dismantling each item for repairing or replacing parts, maintenance instructions including charts showing lubrication, if required, and checking, calibration, testing and procedures.

9.2.11.7 INSPECTION AND TESTING AT MANUFACTURERS WORKS BEFORE SHIPMENT

All goods to be supplied under this contract shall be inspected and tested for conformance to specification, prior to shipment at the bidder's own cost by one of the following inspecting agencies or any other competent authority acceptable to NWSDB. Bidder shall indicate the name of the inspection agency selected with the bid.

- i. Crown Agents of U.K.
- ii. Lloyds Register of U.K.
- iii. Bureau Veritas of France.
- iv. S.G.S. of Geneva, Switzerland

9.2.11.8 APPROVAL

Approval or acceptance of the design or drawings by NWS&DB shall in no way relieve the bidder of any of his obligations or liabilities with regard to the design, materials used, workmanship and the proper execution of the contract.

9.2.11.9 GUARANTEE

All meters shall be guaranteed for performance and accuracy by the bidder for a period of 12 months from the date of delivery in respect of conformation with the specifications and defects in materials and workmanship.

The successful bidder shall warrant to the NWSDB that the meters supplied under this contract will comply strictly with the Contract and shall be first class in every case and shall be free from defects.

The successful bidder further warrants to the NWSDB that all meters and their accessories furnished by the successful bidder under this contract will be new, merchantable of the most suitable grade, and fit for their intended purposes.

Any part of the meters supplied under this contract, which fails or does not give satisfactory performance during this period of warranty, shall be replaced within (10) days from the date the successful bidder has been notified to do so.

All expenses involved in this connection shall be borne by the bidders who should take this into consideration when bidding.

9.2.11.10 PACKING

Each water meter and its accessories namely the a set of seals and 02 Nos. end connections (Union nut + Threaded branch) shall be packed in box. These units shall then packaged or otherwise enclosed or protected for overseas shipment, handling & storage in tropical climate. Suitable special provision shall be made to avoid damage resulting from handling by all carriers.

All packages shall be clearly marked for identification including indication of upper side of packages.

Contract No:.....

1. Delivery of Goods

The goods shall be delivered to the Main Stores at Ratmalana Stores as per Delivery Schedule.

2. Acceptance Certificates

The Engineer shall issue an acceptance certificates for each delivery made according to the schedule given in clause (I) above, on checking to his satisfaction the Goods and test certificates delivered.

3. Documents to be submitted

The following documents shall be submitted by the contractor to the Engineer when making request for payment

i. **On Delivery to Site**

Contractor's invoice showing description of Goods Delivered quantity unit contract price and total amount.

- a. Manufacturer's test certificate.
- b. Manufacturer's warranty.

iii. **On Final Acceptance by the Engineer**

- a. Contractor's request for balance in the form of an invoice.
Copy of Acceptance certificate issued by the Engineer.

The Engineer's Representative shall be the Assistant General Manager (Supplies) of the National Water Supply & Drainage Board whose office is at the Board Head Office, Ratmalana.

Annex for Water Meters

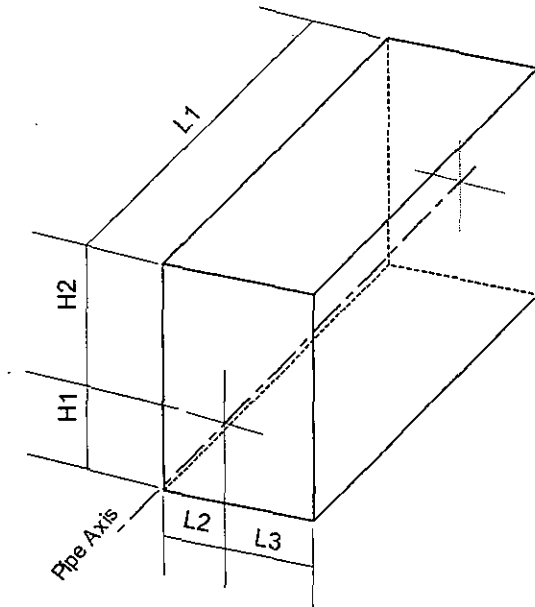


Figure 1 Water Meter Dimensions

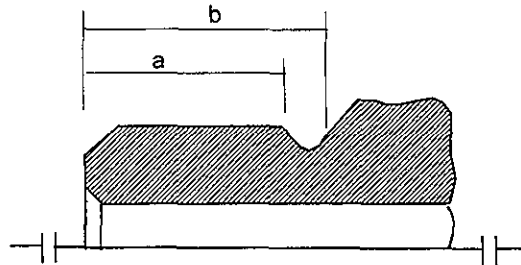


Figure 2 Length of Threaded Connectio and Clearance Length

Meter Designation	N 1.5	N 2.5	N 3.5	N 6	N 10
Meter Size	15	20	25	30	40
Q _p , m ³ /h	1.5	2.5	3.5	6.0	10.0
Meter Thread	G3 / 4B	G 1 B	G 1 1/4 B	G 1 1/2 B	G 2 B
Threaded End Connectors	G1/2 B	G 3/4 B	G 1 B	G 1 1/4 B	G 1 1/2 B
a (min)	10	12	12	13	13
b (min)	12	14	16	18	20
L1 (tolerance + 0 / -2)	165 115 134	190 165	260	260	300
L2 max and L3 max	50	65	85	85	105
H1 max	50	60	65	70	75
H2 max	180	240	260	280	300

All dimensions are in millimeters. Refer Figure 1 and 2 for notation.