ASHGHAL

Interim Advice Note No. 019

Amendments to Sections 5 and 6 of QCS 2010

Revision No. 2

EXW-GENL-0000-PE-KBR-IP-00019

ADVICE

This Interim Advice Note (IAN) provides information and guidance on amendments and additions to Qatar Construction Specifications (QCS) 2010, Sections 5 and 6, namely:

- Section 5 - Concrete, Part 2 Aggregates
- Section 5 - Concrete, Part 16 Miscellaneous
- Section 6 - Roadworks, Part 3 Earthworks
- Section 6 - Roadworks, Part 4 Unbound Pavement Materials
- Section 6 - Roadworks, Part 5 Asphalt Works
- Section 6 - Roadworks, Part 6 Concrete Road Pavements

This Interim Advice Note shall take precedence over these Sections and Parts of QCS 2010. This revision of the Interim Advice Note supersedes the following, previously issued Interim Advice Notes (IAN) which shall be withdrawn:

- The applicable sections and parts of IAN013, Amendments / Additions to QCS 2010, ref. EXW-GENL-0000-PE-KBR-IP-00013, dated 26/04/2012
- IAN019 (Rev 1), Amendments to Earthworks, Unbound pavement Material and Asphalt works of Qatar Construction Specifications, ref. EXW-GENL-0000-PE-KBR-IP-00019, dated 20/06/2012.

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3	30 September 2013	Issued to Expressway Department	AS	AM	MG
2	15 September 2013	Major Amendment	AS	AM	MG
1	20 June 2012	Minor Amendment	AS	AB	MG
0	16 June 2012	Initial Issue	AS	AB	MG
Rev	**Date**	**Reason For Issue**	**Author**	**Chk**	**App**

Contents

1. Foreword

1.1 Interim Advice Notes (IANs) may be issued by Ashghal from time to time. They define specific requirements for works on Ashghal projects only, subject to any specific implementation instructions contained within each IAN.

1.2 Whilst IANs shall be read in conjunction with the Qatar Highway Design Manual (QHDM), the Qatar Traffic Manual (QTM) and the Qatar Construction Specifications (QCS), and may incorporate amendments or additions to these documents, they are not official updates to the QHDM, QTM, QCS or any other standards.

1.3 Ashghal directs which IANs shall be applied to its projects on a case by case basis. Where it is agreed that the guidance contained within a particular IAN is not to be incorporated on a particular project (e.g. physical constraints make implementation prohibitive in terms of land use, cost impact or time delay), a departure from standard shall be applied for by the relevant Consultant / Contractor.

1.4 IANs are generally based on international standards and industry best practice and may include modifications to such standards in order to suit Qatar conditions. Their purpose is to fill gaps in existing Qatar standards where relevant guidance is missing and/or provide higher standards in line with current, international best practice.

1.5 The IANs specify Ashghal's requirements in the interim until such time as the current Qatar standards (such as QHDM, QTM, etc.) are updated. These requirements may be incorporated into future updates of the QHDM, QTM or QCS, however this cannot be guaranteed. Therefore, third parties who are not engaged on Ashghal projects make use of Ashghal IANs at their own risk.

1.6 All IANs are owned, controlled and updated as necessary by Ashghal. All technical queries relating to IANs should be directed to Ashghal's Manager of the Design Department, Infrastructure Affairs.

Signed on behalf of Design Department:

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2. Ashghal Interim Advice Note (IAN) – Feedback Form

Ashghal IANs represent the product of consideration of international standards and best practice against what would work most appropriately for Qatar. However, it is possible that not all issues have been considered, or that there are errors or inconsistencies in an IAN.

If you identify any such issues, it would be appreciated if you could let us know so that amendments can be incorporated into the next revision. Similarly, we would be pleased to receive any general comments you may wish to make. Please use the form below for noting any items that you wish to raise.

Please complete all fields necessary to identify the relevant item			
IAN title:			
IAN number:		Appendix letter:	
Page number:		Table number:	
Paragraph number:		Figure number:	
Description comment: Please continue on a separate sheet if required:			
Your name and contact details (optional):			
Name:		Telephone:	
Organisation:		Email:	
Position:		Address:	

Please email the completed form to:

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Public Works Authority

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We cannot acknowledge every response, but we thank you for contributions. Those contributions which bring new issues to our attention will ensure that the IANs will continue to assist in improving quality on Ashghal's infrastructure projects.

3. Introduction

3.1 This Interim Advice Note takes immediate effect and shall be read in conjunction with:

- **QCS 2010 - Qatar Construction Specifications 2010**
- **IAN 011 - Cycleway Design Guidance**
- **IAN 021 - Cycleways and Footways Pavement Design Guidelines**
- **IAN 016 - Pavement Design Guidelines**
- **IAN 029 - Pavement Standard Details**

This IAN shall apply to pavement construction on relevant Ashghal projects. In the event of conflicts between this IAN and the above documents, this IAN 019 shall take precedence with respect to Ashghal projects.

4. Withdrawn / Amended Standard

4.1 This Interim Advice Note shall take immediate effect and supersedes:

- IAN019 (Rev 1), Amendments to Earthworks, Unbound pavement Material and Asphalt works of Qatar Construction Specifications, ref. EXW-GENL-0000-PE-KBR-IP-00019, dated 20/06/2012.
- The applicable sections and parts of IAN 013, Amendments / Additions to QCS 2010, ref. EXW-GENL-0000-PE-KBR-IP-00013, dated 26/04/2012 or any subsequent revisions.

5. Implementation

5.1 This IAN shall be implemented with immediate effect on projects as follows:

- Relevant Ashghal projects in design stage
- Relevant Ashghal projects in tender stage

5.2 Relevant Ashghal projects in construction stage shall be reviewed by the Supervision Consultant and Contractor and the implications of adoption of this Interim Advice Note discussed with the respective Ashghal Project Manager and Programme Management Consultant (PMC) where applicable. This shall include an assessment on the current design to determine whether it complies with this Interim Advice Note and the practicalities of modifying the design and construction in order to achieve compliance.

5.3 The only exceptions are:

- Projects already in construction, where a significant portion of construction and procurement has already occurred and design modification would not be economic or practicable.

5.4 If in doubt, Consultants / Contractors should seek guidance from their respective Ashghal Project Manager or designated Programme Management Consultant (PMC) on a scheme specific basis.

5.5 Where projects are in construction or final detail design, the impacts of this and related IANs are to be assessed by the designer, construction supervising consultant and Ashghal's Project Management Consultant (PMC) where applicable. If for a significant practical reason, a part of this IAN is not achievable in construction, the particular item and location where the particular condition of IAN cannot be applied must be approved by the Engineer as a departure from the design standard or specifications.

6. Disclaimer

This Interim Advice Note and its recommendations or directions have been provided for application on Ashghal's infrastructure projects within Qatar only and they are not warranted as suitable for use on other roads, highways or infrastructure within Qatar or elsewhere. Should any third party, consultant or contractor choose to adopt this Interim Advice Note for purposes other than Ashghal's infrastructure projects, they shall do so at their own risk.

Attachment A –

Amendments to Sections 5 and 6 of QCS 2010

Amendments to Section 5: Part 2

THE FOLLOWING CHANGES ARE MADE TO QCS, SECTION 5 (CONCRETE), PART 2 (AGGREGATE):

PART 2 AGGREGATE

5.1.2 References

Add a new test as follows:

BS EN 933-9 Tests for geometrical properties of aggregates. Assessment of fines. Methylene blue test

2.2 QUALITY AND TESTING

Delete Table 2.1 and substitute with the following:

Item No.	Requirement	Test Methods			Permissible Limits		
		BS / EN	ASTM	GSO	Combined	Fines	Coarse
1.	Grading	933	C136			Standard	Standard
2.	Material finer than 0.075 mm. Natural, Uncrushed/Crushed	933	C117 & C136			3% max	2% max
	Crushed Rock					5% max	2% max
or	Material finer than 0.063 mm. Natural, Uncrushed/Crushed or used for foundations, retaining structures and structure elements exposed to the weather.					3% max	1.5 % max
	Crushed Rock or used for structure elements not exposed to the weather.					5% max	1.5 % max
3.	Clay lumps and friable particles		C142			2% max	2% max
4.	Lightweight pieces		C123			0.5% max	0.5% max
5.	Organic impurities for fine aggregates		C40			Color standard not darker than plate No. 31	
6.	Water absorption (saturated surface dry)	1097-6	C128/ C127			2.3% max	2.0% max
7.	**Sand Equivalent**	EN 933	D2419		Min 60% *	NA	N.A
8.	Specific gravity (apparent) for normal weight concrete Used for reinforced concrete Used for non-reinforced concrete	1097-6	C128/ C127			2.6 min 2.4 min	2.6 min 2.4 min
9.	**Shell Content:**	933-7				3% max	3% max
10.	**Particle shape:**	933-3	D4791				

	Flakiness index - Used for reinforced concrete - Used for plain or non-reinforced concrete						30% max 40% max
	Elongation index - Used for reinforced concrete - Used for plain or non-reinforced concrete						35% max 45% max
11.	Acid-soluble chlorides:	1744					
	A. Reinforced concrete with SRPC					0.06% max	0.03% max
	OPC and MSRPC					0.06% max	0.03% max
	B. Mass concrete with SRPC					0.06% max	0.03% max
	OPC/MSRPC					0.06% max	0.03% max

Item No.	Requirement	Test Methods			Permissible Limits		
		BS / EN	ASTM	GSO	Combined	Fines	Coarse
	C. Prestressed concrete and						
	steam cured structural concrete					0.01% max	0.01% max
12.	Acid-soluble sulphate2	1744				0.4% max	0.3% max
13.	Loss by magnesium sulphate Soundness (5 cycles) Loss by Sodium Sulphate		C88			15% max 12% max	15% max
14.	Mechanical Strength:						
	10% fines value (dry condition)3	812- 111					150 kN min5
	Aggregate Impact value4	1097-2					25% max
	Loss by Los Angeles abrasion Aggregate Crushing Value	1097-2 812- 110	C131/C 5 35				30% max
15.	Drying shrinkage	1367-4					0.075% max
16.	Potential reactivity:						
	• Of aggregates: alkali-silica reaction alkali-carbonation reaction		C289 C586			Not reactive 6 month expansion 0.10% max	
	• Of cement-aggregate Combination		C227			6 month expansion 0.10% max	

* Provided that ***Methylene Blue Absorption Value*** for the fine material conducted in accordance with BS EN 933-9 or AASHTO TP 57 or CIRIA Special Publication 83/CUR Report 154 is Maximum **5mg/g**

Notes:

1- Use of a fine aggregate failing in the test is not prohibited, provided that:
   a- The discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.
   b- When tested for the effect of organic impurities on strength of mortar, the relative strength at 7 days, calculated in accordance with ASTM C87, is not less than 95 %.
2- Air-cooled blast-furnace slag aggregate shall meet the requirements in BS EN 12620:2002 for acid-soluble sulfate category AS1,0. In accordance with BS PD 6682-1 and BS EN 12620, air cooled blast-furnace slag shall be free from dicalcium disintegration and from iron disintegration when tested in accordance with BS EN 1744-1
3- The limit of 10% fines value (dry condition) is for 20 mm aggregates. Reference BS 812-111.
4- AIV The impact test can be used as an alternative to the Los Angeles test but a correlation with the Los Angeles test should first be established to avoid double testing and ensure mutual recognition of results. The Los Angeles test (reference method) should be used in cases of dispute
5- It is applicable only for 20mm aggregates, for high strength concrete using 10 mm aggregates the 10% fines value will be at least 100 KN

Amendments to Section 5: Part 16

THE FOLLOWING CHANGES ARE MADE TO QCS, SECTION 5 (CONCRETE), PART 16 (MISCELLANEOUS):

PART 16 MISCELLANEOUS

16.1.2 References

Add new tests as follows:

ASTM C150:09, Type V	Standard Specification for Portland Cement, Sulphate Resisting Portland Cement (SRC)
AAHTO T26	Standard Method of Test for Quality of Water to be used in Concrete

16.2.3 CEMENT

Delete paragraph 1 and substitute with the following:

5.5.1.1 The general term 'cement' in this Part means the materials shown below.

Cement	***Complying with***
Sulphate Resisting Portland Cement (SRC)*	ASTM C150:09 Type V.
Portland blast furnace cement	BS 146 or BS EN 197-4
Specification for pozzolanic pulverised-fuel ash cement (grades C20 or below)	BS 6610
SRC: *This type of cement is a type of Portland cement in which the quantity of Tricalcium Aluminates is less than 5%.*	

16.2.4 WATER

Delete paragraph 1 and substitute with the following:

5.5.1.1.1.1.1 Water for use in the making and curing of concrete shall conform to the requirements of AAHTO T26 “Standard Method of Test for Quality of Water to be used in Concrete".

Amendments to Section 6: Parts 3, 4 and 5

THE FOLLOWING CHANGES ARE MADE TO QCS, SECTION 6 (ROAD WORKS), PART 3 (EARTH WORKS):

PART 3 EARTHWORKS

3.1.2 References

Add a new Test 9 as follows:

BS 1377 Test 9 Determination of the soil pH value.

3.3 MATERIALS

3.3.3 Unsuitable Material

Delete paragraph (i) and substitute with the following:

(i) Soil having more than 20% passing the 0.075 mm sieve.

Add a new paragraph (j) as follows:

(j) Soil having a pH value <7 or > 9.

3.3.5 Selected Fill

Delete paragraph (a) and substitute with the following:

(a) The material passing the 0.075 mm sieve shall be less than 20%.
(b) The liquid limit shall not exceed 35% and the plasticity index shall not exceed 10%.

Add a new paragraph (d) as follows:

(d) pH of the soil shall be Min 7- Max 9.

3.3.6 Water

Delete paragraph 1 and substitute with the following:

1 Potable or brackish water shall be used for all earthwork operations, except that only potable water shall be used for compaction of backfill material within five meters from all surfaces of a structure and for the backfill of all service trenches.

3.4 MAIN PLANT FOR EARTHWORKS

3.4.1 General

Delete paragraphs 3, 4 and 5 and substitute with the following:

3 The Contractor shall supply sufficient machinery to enable progress of the Works to the agreed programme.

3.5 EXCAVATION GENERAL

3.5.1 Removal of Unsuitable Soil and Soft Spots

Delete paragraph 6 and substitute with the following:

6 Unsuitable excavated material shall be removed and carted away approved dumping areas, after approval has been received from the relevant Authority and the Engineer.

Delete paragraph 10 and substitute with the following:

10 The Contractor shall probe for voids, using a pattern of holes agreed with the Engineer, beneath all underpasses, structural foundations and where limestone materials are encountered. Where such voids are identified, the Contractor shall submit to the Engineer his proposals for treatment.

3.5.2 Excavating High Level Areas

Delete paragraph 4 and substitute with the following:

4 In all excavations, the groundwater level shall be maintained at least 900mm below the formation level.

3.6 FILLING GENERAL

3.6.4 Contractors Imported Fill

Paragraphs 1 to 9 inclusive shall be deleted and substitute with the following:

1 The Contractor shall source all fill material required for the Works.

2 It shall be the Contractor's responsibility to obtain all permits or permission and make any payments that may be required in acquiring the borrow material.

3 It shall be the Contractor's responsibility to carry out all testing to ensure the imported fill meets the specification.

4 The Contractor's haul and traffic management arrangements shall be subject to approval by the Engineer before commencement of the Works.

3.6.8 Work over Sabka

Delete Table 3.1 and substitute with the following:

Table 3.1 - Definition of Type 1 & 2 backfill materials

Sieve Size (mm)	Percentage Passing	
	Type 1	Type 2
152.400	100	-
127.000	100 – 85	-
101.600	90 – 75	-
50.800	65 – 45	-
38.100	55 – 35	-
19.050	35 – 20	100
12.700	25 – 10	95 – 100
9.525	20 – 5	70 – 100
4.250	-	0 – 55
2.360	-	0 – 10
1.18	-	-
0.075	-	0 – 3

3.7 STRUCTURE EXCAVATION AND FILLING

3.7.3 Dewatering

Delete paragraph 3 and substitute with the following:

3 The Contractor's submitted drawings shall show the arrangement, location and depths of the proposed dewatering system if required. A complete description of the equipment and materials to be used and the procedure to be followed shall be shown, together with the standby equipment, standby power supply, and the proposed location or locations of points of discharge of water. The Contractor shall be required to obtain written approval from the PWA for this discharge.

3.7.4 Excavation for Structures

Add new paragraph 9 as follows:

9 The Contractor may be required to undertake a pattern of rotary percussive probe holes within the footprint of critical structures where there is considered to be a hazard from voids within the rock mass beneath. Details shall be proposed by the Contractor and agreed with the Engineer.

3.7.6 Cofferdams

Delete paragraph 5 and substitute with the following:

5 As an alternative to a cofferdam, the Contractor may propose a wellpoint dewatering system, for approval by the Engineer, to keep structural excavation works dry. Such proposal shall include, but not be limited to, sufficient calculations, sketches and drawings, to justify the wellpoint positions and lengths in addition to pumping capacity required. The use of a wellpoint dewatering system may not preclude the use of support or shoring within the excavation to provide adequate stability and safety to the satisfaction of the Engineer. Where well-point systems are proposed the Contractor shall follow the requirements of Sub-Clause 3.7.3 of Section 6 Part 3.

3.7.7 Backfill Adjacent to Structures

Delete paragraph 1 and substitute with the following:

1 Section 101, Part 2 of this document, "QCS 2010 EXW Amendments", will be referred to for procedures relating to backfilling to highways structures. For all other structures, this Clause 3.7.7 applies.

3.10 TESTING

3.10.1 General

Delete paragraph 1 and substitute with the following:

1 The Contractor shall be responsible for verifying adherence to the specification of moisture content, compaction, thickness California Bearing Ratio and other properties of the materials or workmanship, and shall supply this information to the Engineer for approval before placement of subsequent layers.

3.10.3 California Bearing Ratio

Delete paragraphs 1, 2 and 3 and substitute with the following:

The soaked value of the California Bearing Ratio shall be determined on the top of the specimen compacted statically at the optimum moisture content and 95% of the maximum dry density after soaking for 4 days in accordance with CML 10-97. Both values shall be reported and both shall comply with the minimum requirements outlined in the Qatar Construction Specifications (QCS-2010).

3.10.4 Testing Levels and Evenness of the Formation

Delete paragraphs 1, 2 and 6 and substitute with the following:

1 The Contractor shall be responsible for verifying adherence to the specification of levels, evenness and cross fall and shall supply this information to the Engineer for approval before placement of subsequent layers.

2 The Contractor shall make available to the Engineer a four-metre straight-edge and a crown template of sturdy and approved design and the necessary labour to carry out audit checking as required.

6 These tests shall be taken at a minimum rate of one test per 100 m run and additionally as directed by the Engineer. In the event of any failure, the Contractor shall correct the unevenness of the surface and resubmit the area for approval by the Engineer.

THE FOLLOWING CHANGES ARE MADE TO QCS, SECTION 6 (ROADWORKS), PART 4 (UNBOUND PAVEMENT MATERIALS):

PART 4 UNBOUND PAVEMENT MATERIALS

4.1 GENERAL

4.1.1 Scope

Add new paragraph 3 as follows:

3 Materials: The materials included by the specification are:

a) Crushed Rock/Crushed Gravel subbase and
b) Crushed Rock/Crushed Gravel Road base

4.1.2 References

Add the following tests

Source	Code	Title
ASTM	D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM	D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM|	D 1883	CBR (California Bearing Ratio) of Laboratory-Compacted Soils
ASTM	D 1556	Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM	D 2850	Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils
AASHTO	T 11	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO	T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO	T 89	Determining the Liquid Limit of Soils
AASHTO	T 90	Determining the Plastic Limit and Plasticity Index of Soils
AASHTO	T 96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO	T 104	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
AASHTO	T 180	Standard Method of Test for Moisture-Density Relationship of Soils Using a 4.54kg Hammer
AASHTO	T 191	Density in Place by the Sand-Cone Method
AASHTO	T 193	CBR (California Bearing Ratio) of Laboratory-Compacted Soils
AASHTO	T 267	Determination of Organic Content in Soils by Loss of Ignition
AASHTO	T 290	Determination of Acid Soluble Sulfate
AASHTO	T 291	Determination of Acid Soluble Chloride
AASHTO	T 296	Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression
AASHTO	T 304	Uncompacted Void Content of Fine Aggregate
AASHTO	T 307	Resilient Modulus of Soils and Aggregate Materials
AASHTO	T 327	Micro-Deval Abrasion
AASHTO	T 310	In-place Density and Water Content by Nuclear Methods

4.2 MATERIALS

Delete clause 4.2.2 and substitute with the following

1 Materials shall be so stored and handled as to assure the preservation of their quality and fitness for use in the works. Even after source approval has been given materials may again be inspected and tested before use in the work.

2 Stored material shall be located so as to facilitate prompt inspection.

3 All storage sites shall be restored to their original condition before acceptance of the Works.

4 Handling and stockpiling of aggregates shall at all times be such as to eliminate segregation or contamination of the various sizes and to prevent contamination of materials by dust. Stockpiles shall be kept flat and built in layers not to exceed 3m. The second and subsequence layers shall be constructed so that the aggregate in that layer is not allowed to be pushed over the edge of the proceeding layer. Conveyors used for stockpiling aggregate shall be operated so that the stockpiles are built in layers and the distance from the head pulley of the conveyor to the stockpile never exceeds 3 m. Alternatively, baffle-chutes or perforated chimneys can be used when a stockpile is being built with a conveyor belt. When trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile and their use shall be limited to levelling the deposited material only.

5 The Contractor shall take all necessary protection measures in the storage, handling and stockpiling of materials to prevent contamination of materials by dust. The measures that the Contractor proposes to take shall be subject to the approval of the Engineer.

4.2.4 Fine Aggregate

Delete paragraphs 1-6 and substitute with the following:

1. Fine aggregate (passing the 4.75 mm sieve) shall consist of crushed mineral aggregate and/or natural sand.

2. The fine aggregate shall be clean and free from organic matter, clay-balls and other extraneous or detrimental materials. The ratio of fine aggregates passing the 0.075mm sieve shall not exceed 75% of the portion passing the 0.300mm sieve.

3. The liquid limit shall be a maximum of 25% as determined by AASHTO T 89 and the plasticity index shall be a maximum of 6% as determined by AASHTO T 90.

4. Where the source of fine aggregate does not meet the above requirements, the Contractor may, with the Engineer's approval, add fine aggregate and filler to correct the gradation or to change the characteristics of the material passing the 0.300mm sieve so as to meet the requirements. Such additional material shall be added in a manner which ensures a completely homogeneous material.

5. The aggregate bases shall have a minimum sand equivalent value of 25 % and the aggregate subbase shall also have a minimum sand equivalent value of 25% as determined by ASTM D2419.

6. The aggregate bases and subbases shall have a minimum uncompacted void content of fine aggregate of 45 as determined by AASHTO T 304, Method A.

4.2.5 Coarse / Combined Aggregate

Delete paragraphs 1-7 and substitute with the following:

1 Coarse aggregate (retained on the 4.75 mm sieve) shall consist of crushed stone or crushed gravel with a minimum of 50% by weight having at least one fractured face.

2 The percent of flat and elongated particles, determined using ASTM D4791, with a ratio of longest to shortest dimension of 5:1 should not exceed 10% by weight for each stockpile for the base layers and should not exceed 15% by weight for each stockpile for the subbase layers.

3 The Micro-Deval loss shall be a maximum of 20%for base layers and a maximum of 25 % for subbase layers as determined using AASHTO T327. The Micro-Deval testing can be replaced by the Los Angeles Abrasion Loss with the approval of the Engineer. The Los Angeles Loss shall be a maximum of 30% for base layers and a maximum of 40% for subbase layers as determined by AASHTO T 96. The coarse aggregate shall be hard and durable and free from organic matter, clay and other extraneous or detrimental materials.

4 The loss by magnesium sulphate soundness test shall be a maximum of 12% when determined using AASHTO T 104.

5 The minimum CBR value obtained when preparing samples of aggregate base and aggregate subbase at optimum moisture content and at 100% relative compaction and soaking them for 4 days shall be 80% and 60% respectively as tested according to ASTM D1883. The maximum permitted swell shall be 0.5% and 1.0% respectively.

6 The acid soluble chloride in the combined aggregate shall not exceed 1%, as determined by AASHTO T 291. The acid soluble sulphate in the combined aggregate shall not exceed 0.5% as determined by AASHTO T 290.

4.3 MAIN EQUIPMENT

Delete clause 4.3 and substitute with the following:

4.3.1 General

1 The Contractor shall use equipment and plants that are capable of placement of subgrade, subbase and base that meet these specifications.

2 The Engineer shall have the right to stop the use of any equipment or plant which is not producing, placing or compacting subgrade, subbase or base which meets the specification The Contractor shall immediately comply with such instructions without being entitled to any indemnities or extensions as a result of such instructions.

4.3.2 Paving Machines

1 Paving machines shall be self-propelled and shall be capable of spreading the sub-base and base materials in one operation so as to make it ready for compaction with minimum shaping.

2 The paving machine shall not deform the underlying subgrade or sub-base materials.

3 The paving machines shall be provided with a screed that strikes off and distributes the material to the required width and level.

4 The width of each spread shall not be less than a traffic lane wide.

5 The screed shall be adjustable to the required width being laid.

6 Screed action includes any practical motion that produces a finished surface texture of uniform appearance.

4.3.3 Aggregate Mixers

1 An aggregate mixing plant shall be either of an approved drum or pugmill type with a moisture control system capable of adding water to the aggregate to bring the base to ± 2 % of the optimum moisture content so that the base/subgrade aggregate may be spread without further mixing or processing.

2 Means shall be provided for regulating the flow of material to the aggregate mixer. The various feeds shall be calibrated to allow adjustments to the mix design to be carried out.

4.4 MIX DESIGNS – Title to be replaced with: "ROAD BASE AND SUB-BASE MATERIAL"

Delete paragraph 6 and substitute with the following:

6. The aggregate bases shall conform to the class A. The aggregate sub bases shall conform to the class B or class C as given in Table 4.1.

Table 4. 1: Gradation Table for Aggregates Used in Base (a) and Sub-Base (b)

(a) Road Base- Class A

BS Sieve Size (mm)	Percentage Passing
63	-
50	100
37.5	70-100
25	55-85
20	50-80
10	40-70
5	30-60
2.36	20-50
0.425	10-30
0.075	5-15

(b) **Road Subbase- Class B &C**

BS Sieve Size (mm)	Percentage Passing [Note]	
	Class B (Heavy Traffic)	**Class C** (*Low CBR, Fully and/or Partially Saturated Areas*)
63	-	100
50	-	90-100
37.5	100	60-90
25	70-90	42-77
20	60-90	35-70
10	45-75	25-60
5	35-65	15-40
2.36	25-50	10-26
0.425	15-30	5-15
0.075	0-15	2-9

Note: the selection of subbase class is dependent on the subgrade CBR value, substrata conditions and traffic level.

4.6 SPREADING AND COMPACTION

Delete clause 4.6 and substitute with the following:

1 Before commencing the construction, written approval for the Engineer must be obtained that the subgrade is in compliance.

2 The actual base/subbase moisture content shall be determined at the plant after mixing.

3 If the base/subbase moisture content is less than the optimum moisture content as determined by AASHTO T 180D, the necessary amount of water must be added to obtain a moisture content within ± 2% of the optimum moisture content.

4 Allowance shall be made for the quantity of moisture which may be lost by evaporation in the process of raking, levelling and compacting, depending on atmospheric temperature.

5 The moisture content shall be uniform in all parts of the section where the work is being carried out and in the various depths of the layer thickness.

6 Road base shall be laid by a paving machine with a spreader box. Sub-base may be laid by either a paving machine with a spreader box or end tipped from trucks and spread by grader.

7 Compaction shall start immediately after the material has been laid and as per the approved rolling pattern.

8 Work on the sub-base and road base courses shall not be permitted during rainy weather.

9 Material shall be spread to a thickness that would result in layers not more than 150 mm thick after compaction with a pneumatic roller. When compacting with a vibratory roller do exceed a compacted thickness of 200mm per layer. When compaction of the base or subgrade course results in a wave-like motion due to soft or yielding subgrade the engineer may request excavation below subgrade (EBS) to remove the soft material. The EBS may be filled with Class A or B base aggregate to restore the surface to the plan grade and cross-section.

10 In areas inaccessible to rollers, the sub-base or road base course material shall be tamped thoroughly with suitable mechanical tampers to achieve the required density and finish.

11 Rolling must continue until a relative density of not less than 100 % of the maximum dry density has been obtained as determined by the moisture-density relationship in AASHTO T180D.

12 Care shall be taken so that layers already compacted under the layer being executed are not damaged, or that the formation is not damaged. Any such damage resulting in mixing the various layers constituting the different subgrades and road base courses shall be repaired by the Contractor at his own expense and to the satisfaction of the Engineer.

4.8 PROTECTION OF SURFACE

Delete paragraphs 3 and substitute with the following:

3 The Engineer may request EBS when hauling over completed or partially completed sub-base and road base courses are causing damage.

4.9 QUALITY CONTROL

Delete clause 4.9 – Testing and substitute with the following:

4.9.1 General

1 Prior to proceeding with the mixing of material individual stockpiles shall be tested for compliance to the requirements in Table 4.2.

2 At any stage in the mixing, transportation, spreading or compaction process, the Engineer may instruct that these tests are carried out.

3 Before the application of any prime coat or any other paving course, the aggregate sub-base and road base shall have been tested for compliance with the requirements of this clause on testing and approved by the Engineer.

4.9.2 Compaction

1 The subgrade, sub-base or road base shall be compacted and tested for acceptance in accordance with AASHTO T180D and the in-place density measured by the nuclear density gauge according to AASHTO T310 for density and moisture content, respectively, in the direct transmission model. The nuclear density gage shall be compared and verified by the sand cone method (AASHTO T191, ASTM D 1556). A minimum density of 100 % of the maximum dry density of the material according to AASHTO T180 shall be achieved. Two tests every 500 m2 shall be carried or at least one test during each day of placement unless otherwise directed by the Engineer.

2 Wherever the degree of compaction is found to be less than required, the area of sub-base or road base involved shall be reworked or replaced to meet the density requirement.

4.9.3 Gradation

1 The gradation of the placed material shall be checked by taking samples from an area 0.5 m by 0.5 m from the full depth of the layer for every 1000 m^3 of laid material. The gradation shall be tested in accordance with AASHTO T11 and AASHTO T27. The Engineer may also instruct that the gradation of material shall be checked by taking samples from the mixing plant. The gradation shall be tested in accordance with AASHTO T11 and AASHTO T27.

2 Wherever the gradation is found to be outside the designated limits, the area of sub-base or road base involved shall be scarified, removed or otherwise reworked as directed by the Engineer to provide a gradation in compliance.

4.9.4 Thickness

1 The thickness of the material shall be derived from checking the level by dipping from string lines stretched across the roadway between pins or kerbs. Unless agreed otherwise with the Engineer dipping shall be carried out at intervals of not less than 10m.

2 The thickness of the material shall be derived at the location where the material is removed from the roadway for gradation analysis.

3 Wherever the thickness of compacted aggregate sub-base or road base is found to vary from the thickness specified in the project drawings or specification by more than 10 % the area involved shall be satisfactorily corrected to provide the required thickness constructed to the designated grade level.

4.9.5 Evenness and Level

1 The final surfaces of the sub-base or road base shall be tested by means of a 4 metre long straight edge and no rises or depressions in excess of 10 mm shall appear in the surface.

2 The finished surface shall also be checked by dips or spot levels and shall be constructed to the designated grade levels to within ± 10 mm.

3 Where these requirements are not met, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the course by scarifying to a minimum depth of 75 mm or 4 times the maximum particle size, whichever is greater, reshaping by adding or removing material as necessary, adding water if necessary and re-compacting.

3.9.6 Required Testing

1 The aggregate bases shall conform to the class A and subbase shall conform to class B or C gradation, as given in Table 4.1.

2 The frequency of tests for base and subbase shall be according to Table 4.2.

Table 4. 2: Frequency of Quality Control and Quality Acceptance Tests

Test	Standard	Frequency of Tests
Gradation	AASHTO T 11 and AASHTO T27	1 per 1000 m^3
Liquid Limit	AASHTO T 89	1 per 1000 m^3
Plasticity Index	AASHTO T 90	1 per 1000 m^3
Sand Equivalent	ASTM D2419	1 per 1000 m3
Uncompacted Void Content	AASHTO T 304 Method A	1 per 1000 m^3
Flat/Elongated Particles	ASTM D 4791	1 per 1000 m^3
Los Angeles Abrasion	AASHTO T 96	1 per 1000 m^3
Micro-deval Abrasion	AASHTO T 327	1 per 1000 m^3
Magnesium Sulphate Soundness	AASHTO T 104	1 per 5,000 m^3
California Bearing Ratio	AASHTO T 193 (ASTM D1883)	1 per 5,000 m^3
Acid Soluble Chloride	AASHTO T 291	1 per 5,000 m^3
Acid Soluble Sulphate	AASHTO T 290	1 per 5,000 m^3

4.9.7 Acceptance

1 Acceptance of the subgrade, base, subbase will be based on all quality control tests meeting minimum requirements for materials and placement. Any material not meeting the requirements shall be removed and replaced or reworked until tests indicate that it does meet specifications.

2 The Engineer has the right to perform any verification tests as he/she sees necessary.

Add a new Clause 4.10 as follows

4.10 WET MIX MACADAM (WMM) ROADBASE

4.10.1 This work shall consist of furnishing and placing one or more courses of high quality crushed aggregate, bound by means of carefully controlled moisture content, on a prepared subgrade or sub-base in conformity to the line, level and thickness shown on the drawings or as directed by the Engineer.

4.11 WET MIX MACADAM ROADBASE MATERIAL

4.11.1 The coarse and fine aggregate shall consist of crushed Gabbro rock (each particle shall have a minimum of one crushed face. The aggregate shall conform to the following gradation (Table 4.3):

Table 4.3: Grading for Wet Mix Macadam

SIEVE SIZE (BS)	PERCENT PASSING
50 mm	100
37.5 mm	95 – 100
20 mm	60 – 80
10 mm	40 – 60
5 mm	25 – 40
2.36 mm	15 – 30
0.6 mm	8 – 22
0.075 mm	2 – 8

The particle size shall be determined in accordance with the requirements of BS 1377 Part 2: 1990 (Method 9.2 or 9.3), AMD 9027:1996.

4.11.2 The gradation shall be adjusted as required or as directed by the Engineer within the above limits to ensure the mix has adequate binding properties.

4.11.3 The standards listed in these specifications shall be the latest version at time of use. The latest version may differ from the version listed at time of writing of these General Specifications. Wet Mix road base material shall have physical properties which comply with the following values (Table 4.4):

Table 4.4: Test properties for Wet Mix Macadam

TEST	LIMIT
Sampling ASTM D75: 2009	
Liquid Limit , BS 1377: Part 2: 1990 : Test 4.5, AMD 9027:96	25 % max.
Linear Shrinkage , BS 1377 Part 2: 1990 Method 6.5, AMD 9027:96	3 % max.
Plasticity Index, BS 1377: Part 2: 1990: Test 5.4, AMD 9027:96	6 max.
Aggregate Crushing Value , BS 812: 1990 P 110	30 % max.
Water Absorption , ASTM C128: 2007a / C127 : 2007	2.0 % max.
Flakiness Index , BS EN 933: Part 3, 1997 AMD 14866: 2004	30% max.
Elongation Index , BS 812: 1990 Part 105, Section 105.2	30% max.
Los Angeles Abrasion Loss , ASTM C-131:06 or C-535:09	30 % max.
*Soundness Loss (ASTM C 88:2005) 5 cycles (Magnesium Sulphate)	12 % max
*Organic Matter Content , BS 1377 Pt 3: 1990 Method 3, AMD 9028: 1996)	0.2 % max.
Chloride Content - Acid Soluble, BS 812: 1988 Part 117	1% max.
Sulphate Content- Acid Soluble, BS EN 1744-1:1998	0.5% max.
Sand Equivalent (ASTM D-2419:2009).	45 min
CBR (Remolded Samples after 4 days soaking at 100% of the maximum dry density (BS 1377: Part 4 : 1990: Test 7, AMD 13925: 2005)	100% min
Maximum Dry Density (MDD), BS 1377 Part 4: 1990 (method 3.5 or 3.6, AMD13925-2002)	2.3 min

4.11.4 The moisture content of the Wet Mix Macadam at the time of laying shall be the optimum ± 1 %. Water required to achieve this moisture content shall be added at the mixing plant. Moisture determination shall be in accordance with BS 1377: Part 2: 1990: Test 3.2, AMD 9027:96.

4.11.5 The mixing water should be clear, visually clean and free of matter harmful to the pavement i.e. soluble salts. Sweat water can be used. Water of questionable quality should comply with the chemical limitations listed in Table 3-9. Water shall be sampled in accordance with BS EN 1008:2008 latest edition.

Table 4.5: Chemical requirements for mixing water

ITEM	LIMIT	TEST METHOD
Chloride as CL	250	ASTM D512-04
Sulphate as SO_4	350	ASTM D516-07
Alkali Carbonates and Bicarbonates	500	ASTM D513:2006
Total Dissolved Solids including items 1,2 &3 above	2000	BS 1377 Part 3:Test 1990 AMD 9028(1996)
pH	7-9	ASTM D 1293:2005

4.12 TRANSPORT AND SPREADING WET MIX MACADAM ROADBASE

4.12.1 Transport vehicles carrying the plant mixed material shall have a capacity suited to the output of the mixing plant and the site conditions and be capable of discharging cleanly. Material when mixed shall be removed at once from the mixer transported directly to the point where it is to be laid and protected from the weather both during transit from the mixer to the laying site and whilst waiting tipping. The mixture shall be transported from the plant in vehicles that maintain moisture content and prevent segregation and loss of the fine material

4.12.2 The material shall be placed and spread evenly. The material shall be spread using a paving machine or spreader box operated with a mechanism which levels off the material at an even depth and without delay. Except where otherwise specified, the material shall be laid and compacted in layers of maximum compacted thickness of 150 mm.

4.13 COMPACTION TRIALS OF WET MIX MACADAM ROADBASE

4.13.1 If directed by the Engineer, prior to the commencement of the Wet Mix Macadam Roadbase operations, *the* contractor shall construct trial lengths, not to exceed 50 meters. The materials used in the trials shall be those approved for use as Wet Mix Macadam Roadbase and the equipment used shall be that according to the Contractor's approved schedule of work.

4.13.2 Trial lengths may not form part of the permanent works but may be permitted in the construction of temporary detours of sufficient length.

4.13.3 The objective of these trials is to determine the adequacy of the Contractor's equipment, the loose depth measurements necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.

4.13.4 The Contractor may proceed with the Wet Mix Macadam Roadbase work only after the methods and procedures established in the compaction trials have been approved by the Engineer.

4.14 COMPACTION OF WET MIX MACADAM ROADBASE

4.14.1 The material shall be compacted to a field density equal to 100% of maximum dry density value obtained when tested in accordance with BS 1377: Part 4 : Test 3.7 : 1990, AMD 13925-2002.

Field Density tests shall be carried out in accordance BS 1377: Part 9: 1990: Test 2.2-AMD 8264-1995; AMD 17229-2007

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

4.14.3 Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints.

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

4.14.5 Where directed by the Engineer a Sieve analysis shall be carried out on the material recovered from 5 consecutive field density tests. Where this sieve analysis shows oversize material content of 10 % or greater the area of construction will be removed and the source of the material rejected until further notice. Where considered necessary other areas of work which were carried on using material from the same source shall be tested in a similar manner.

4.15 FINISHING OF WET MIX MACADAM ROADBASE

4.15.1 Immediately prior to the placing of the first layer of the next pavement course on to the Wet Mix Macadam Roadbase, the final layer of Wet Mix Macadam Roadbase shall be at the specified density and to the required grade and section. In order to maintain these requirements while placing the next course, it may be necessary to water and reshape the surface of the Wet Mix Macadam Roadbase. This work shall be at the Contractor's expense.

4.15.2 The surface of the finished Wet Mix Macadam Roadbase will be tested with a three (3) meter straight edge by the Engineer at selected locations. The variations of the surface from the testing edge between any two (2) contacts with the surface shall at no point exceed ten (10) millimeters when placed on or parallel to the centre line, or ten (10) millimeters when placed perpendicular to the centre line of the roadway. The Wet Mix Macadam Roadbase shall be compacted to the thickness and cross sections as shown on the drawings and shall not vary by more than ten (10) millimeters from the required elevation.

All humps and depressions and thickness deficiencies exceeding the specified tolerance shall be corrected by removing the defective work or by adding new material as directed by the Engineer. The straight edge shall not have any supports enabling it to rest on the surface.

4.15.3 Before placing the next construction layer or applying prime coat, the Wet Mix Macadam roadbase shall be mechanically swept then cleaned with compressed air to remove loose material. As soon as possible after cleaning of the surface, the Wet Mix roadbase shall be sealed by the application of a prime coat as specified. Should the surface of the material be allowed to dry out before the seal is applied, it shall be lightly watered and re-compacted immediately prior to spraying with prime coat.

In the event of a section of wet mix roadbase failing to comply, either by level or degree of compaction, and where the full depth of the layer has been allowed to dry out, it shall be removed and replaced at the Contractor's expense, with fresh material. Watering and re-mixing in place will not be permitted.

4.16 MINIMUM TEST REQUIREMENTS FOR WET MIX MACADAM ROADBASE

4.16.1 One sample every 1,000 cu. m. or part of as directed by the Engineer shall be tested for Grading , Plasticity Index, Sand Equivalent value, Maximum Dry Density, CBR and Loss by Abrasion.

4.16.2 Three in-situ density tests shall be made per unit (750 m^2) of each layer of carriageway and three in-situ density test per unit (450 lin.m) of shoulder or as directed by the Engineer.

4.16.3 Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints.

THE FOLLOWING CHANGES ARE MADE TO QCS, SECTION 6 (ROADWORKS), PART 5 (ASPHALT WORKS):

PART 5 Asphalt Works

5.1 GENERAL

5.1.2 References

Add new tests for Performance Graded (PG) Asphalt and Polymer Modified Bitumen (PMB) as follows:

AASHTO M 320	Performance-Graded Asphalt Binder
AASHTO M 323	Superpave Volumetric Mix Design
AASHTO R 28	Accelerated Aging of Asphalt Binder Using a Pressurized Aging Vessel (PAV)
AASHTO R 29	Grading or Verifying the Performance Grade (PG) of an Asphalt Binder
AASHTO T 40	Sampling Bituminous Materials
AASHTO T 44	Solubility of Bituminous Materials
AASHTO T 48	Flash and Fire Points by Cleveland Open Cup
AASHTO T 55	Water in Petroleum Products and Bituminous Materials by Distillation
AASHTO T 240	Effect of Heat and Air on a Moving Film of Asphalt Binder (Rolling Thin-Film Oven Test)
AASHTO T 313	Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
AASHTO T 314	Determining the Fracture Properties of Asphalt Binder in Direct Tension (DT)
ASTM D7173	Standard Practice for Determining the Separation Tendency of Polymer from Polymer Modified Asphalt

5.1.4 Quality Assurance

Insert new paragraphs 5 to 15 as follows:

5 Bituminous paving courses shall consist of coarse aggregate, fine aggregate, filler material, and bitumen binder. Mixture of two different types of rocks, e.g. igneous and sedimentary having different specific gravities in a single fraction shall not be permitted.

6 The Contractor shall provide the Engineer with a complete report on the origin and composition of all stone and/or gravel aggregates to be used in the work (Aggregate Resources Report) within thirty (30) days prior to the scheduled beginning of the crushing and screening operations. All materials shall comply with the specified requirements for the various aggregates.

The Contractor shall provide petro graphic analysis including x-ray diffraction of clay minerals conducted by a competent independent testing laboratory which shall include reports on the suitability of the proposed materials for their use in concrete and asphaltic mixes.

7 The source and manufacture of the aggregates, which shall meet the requirements of the specification, is the responsibility of the Contractor. It is also the Contractor's sole responsibility to manufacture and haul such aggregates at the rates and in the quantities required to complete the work within the specified contract period.

8 Delivery of materials produced from commercial manufacturing process shall be accompanied by the manufacturer's certification and test reports showing the materials comply with the specification for which it is stipulated.

9 All sources of aggregates shall be approved by the Engineer prior to the processing of material from such sources. An individual source of aggregate is deemed to be a particular location within a quarry or borrow pit where material of a constant specific gravity is obtained (with possible variation due to minor changes in characteristics of rock).

10 During the execution of the Works variation in the specific gravity of any individual fraction of aggregates used in the asphaltic mixes by more than 0.020 may be a cause for rejection of mix design in which case the Engineer may ask the Contractor for a new mix design.

11 The test certificate obtained by the Contractor or tests performed by the Contractor at his expense are intended to assist him in his estimate of the location, extent and quantities which will comply with the specification, when properly processed, and will no way obviate the need for future testing by the Engineer.

12 Only material from approved sources shall be processed for incorporation into the work. Approval of specific sources of materials shall not be considered as final approval and acceptance of materials from such sources. The presence of weathered materials discovered in the quarry areas shall be a cause of rejection of the source of materials.

13 After having received approval of specific sources of material the Contractor cannot change these without prior written approval of the Engineer.

14 All processed materials shall be tested and approved before being stored on the Site or incorporated in the Works and may be inspected and tested at any time during the progress of their preparation and use. Questionable materials, pending laboratory testing subsequent approval shall not be unloaded and incorporated with materials previously approved and accepted.

15 If the grading and quality of the material delivered to the Site does not conform to the grading and quality as previously inspected and tested, or does not comply with the specifications the Engineer reserves the right to reject such material at the Site of the work.

5.2 MATERIALS

5.2.1 Fine Aggregate

Delete paragraph 1 and substitute with the following:

1 Fine aggregate is that portion of the mineral aggregate passing the 4.76mm BS Sieve.

Delete paragraph 2 and substitute with the following:

2 Fine aggregate shall consist of crushed hard durable rock and shall be of such gradation that when combined with other aggregates in proper proportions, the resultant mixture will meet the required gradation. The use of wadi, beach or dune sand for asphalt works is not permitted. Fine aggregate including filler shall be obtained from 100% crushed gravel or crushed rock pre-screened to exclude natural uncrushed fine material or weathered unsound fines.

Delete paragraph 3 and substitute with the following:

3 Fine Aggregate shall be non –plastic.

Delete paragraph 6 and substitute with the following:

6 Individual stockpiles of crushed fine aggregate shall have a sand equivalent of not less than 45 for base course and not less than 55 for intermediate and wearing course.

Delete paragraph 7 and substitute with the following:

7 The loss by the magnesium sulphate soundness test, as determined by ASTM C 88, shall be a maximum of 14% for base course and 12% for intermediate and wearing course.

Add a new paragraph 12 as follows:

12 Should a change in a material be encountered or should a change in a source of material be made a new job-standard mix shall be submitted by the Contractor and approved by the Engineer before the mix containing the new material is delivered. Job materials will be rejected if they are found not to have the characteristics required by the approved job Standard Mix.

5.2.2 Coarse Aggregate

Delete paragraph 1 and substitute with the following:

1 Coarse aggregate is that portion of the mineral aggregate retained on the 4.76mm BS Sieve. Coarse aggregate shall consist of crushed natural stones and gravel. Crushed particles shall be cubic and angular in shape and shall not be thin, flaky or elongated. The gradation shall be such that when combined with other aggregate fraction in proper proportions, the resultant mixture will meet the required gradation. Coarse aggregates shall be of uniform quality and free from decomposed stone, shale, etc. Specific Gravity of individual fraction (size) of approved aggregates shall not vary by more than ± 1%.

Delete paragraph 3 and substitute with the following:

3 Coarse aggregate shall be clean and free from organic matter, clay, cemented particles and other extraneous or detrimental material.
The degree of crushing shall be such that (for each stockpile) a minimum of 99% by weight of aggregate shall have at least one fractured face and 85% having at least two fractured faces. No rounded or sub-rounded particles shall be permitted.
The flakiness index of each stockpile shall not exceed 25% for wearing course and 30% for intermediate and base courses, and the elongation index of each stockpile shall not exceed 30% all courses and the average of the elongation index values of all stockpiles shall not exceed 25% for the wearing course.

Delete paragraph 4 and substitute with the following:

4. The loss by the magnesium sulphate soundness test, as determined by ASTM C 88, shall be a maximum of 12% for base course and 10% for intermediate and wearing course.

5.2.5 Polymer Modified Bitumen (PMB)

Add a new Clause 5.2.5 as follows:

1 The bitumen PG76-10 S, H, V, or E specified for use in the asphalt mixes of the *Wearing and Intermediate Courses* shall meet the requirements of AASHTO MP 19 or equivalent ASTM, EN and BS International Standards and Test methods. The bitumen 60/70 Penetration specified for use in the asphalt mix of the Base Course shall meet the requirements of BS EN 12591 and other requirements described in Clause 5.2.4 of QCS.

2 The bitumen shall only be obtained from approved sources.

3 The bitumen shall be prepared by the refining of petroleum. It shall also be uniform in character.

4 Blending of bitumen materials from different refineries will be permitted only with the written approval of the Engineer.

5 The Bitumen Grade PG 76-10 S, H, V and E shall conform to the requirements listed in Table 5.1a below:

Table 5.1a
Bitumen PG76-10 S, H, V and E Specifications

Bitumen PG76-10 S, H, V and E Specifications			
Test	**Standard** [a]		**Specification**
	AASHTO	**ASTM**	
Original Binder			
Average 7 days maximum pavement design temperature, (°C)			< 76
Minimum pavement design temperature, (°C)			>-10
Flash Point Temperature, Minimum (°C)[b]	T48	-	230
Viscosity, Maximum, 3 Pa.a, Test Temperature (°C)[b]	T316[c]	-	135
Dynamic Shear, G*/sinδ, Minimum, 1.00 kPa[e] Test Temperature (°C) at 10 rad/s	T315[d]		76
Rolling Thin Film Oven (T240) or Rolling Thin Film Oven (T179)			
Mass Loss, Maximum, Percent[f]			1%
MSCR, Standard Traffic "**S**" Grade $J_{nr3.2}$,max 4.0 kPa^{-1} $J_{nrdiff,3.2,}$max 75% Test temperature, °C	TP70		76
MSCR, Heavy Traffic "**H**" Grade $J_{nr3.2}$,max 2.0 kPa^{-1} $J_{nrdiff,\ 3.2,}$max 75% Test temperature, °C	TP70		76
MSCR, Very Heavy Traffic "**V**" Grade $J_{nr3.2}$,max 1.0 kPa^{-1} $J_{nrdiff,\ 3.2,}$max 75% Test temperature, °C	TP70		76
MSCR, Extreme Traffic "**E**" Grade $J_{nr3.2}$,max 0.50 kPa^{-1} $J_{nrdiff,\ 3.2,}$max 75% Test temperature, °C	TP70		76
Pressurized Aging Vessel Residue (R28)			
PAV Aging Temperature (°C)[g]			110
Dynamic Shear, "**S**" Grade, G*/sinδ, Max, 5000 kPa[e] Test Temperature (°C) at 10 rad/s	T315		37
Dynamic Shear, "**H**" , "**V**" , "**E**" Grades, G*/sinδ, Max, 6000 kPa[e] Test Temperature (°C) at 10 rad/s	T315		37
Physical Hardening Report			
Creep Stiffness, Stiffness , S, Maximum, 300.0 MPa at 60 seconds m-value, Minimum, 0.300 at 60 seconds Test Temperature (°C)[h]	T313		0
Direct Tension, Failure Strain, Minimum, 1.0% (loading rate of 1.0 mm/min), Test Temperature (°C)	T314		0

a MSCR testing on RTFO residue should be performed at the PG grade based on the environmental high pavement temperature. Grade bumping is accomplished by requiring a lower J_{nr} value while testing at the environmental temperature.

b *Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPP Bind program, may be provided by the specifying agency,* or by following the procedures as outlined in M 323 and R 35, excluding the provisions for "grade bumping".

c This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

d For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be used to supplement dynamic shear measurements of G*/sinδ at test temperatures where the asphalt is a Newtonian fluid.

e G*/sinδ = high temperature stiffness and G* sinδ = intermediate temperature stiffness.

f The mass change shall be less than 1.00 percent for either a positive (mass gain) or a negative (mass loss) change.

g The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures, 90°C, 100°C, or 110°C. Normally the PAV aging temperature is 100°C for PG 58-xx and above. However, in desert climates, the PAV aging temperature for PG 70-xx and above may be specified as 110°C.

h If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The *m*-value requirement must be satisfied in both cases.

6 The Bitumen Grade PG 76-22 S, H, V and E shall conform to the requirements listed in Table 5.1b below:

Table 5.1b
Bitumen PG76-22 S, H, V and E Specifications

Bitumen PG76-22 S, H, V, and E specifications			
Test	**Standard** [a]		**Specification**
	AASHTO	**ASTM**	
Original Binder			
Average 7 days maximum pavement design temperature, (°C)			< 76
Minimum pavement design temperature, (°C)			>-22
Flash Point Temperature, Minimum (°C)[b]	T48	-	230
Viscosity, Maximum, 3 Pa.a, Test Temperature, (°C)[b]	T316[c]	-	135
Dynamic Shear, G*/sinδ, Minimum, 1.00 kPa[e] Test Temperature (°C) at 10 rad/s	T315[d]		76
Rolling Thin Film Oven (T240) or Rolling Thin Film Oven (T179)			
Mass Loss, Maximum, Percent[f]			1%
MSCR, Standard Traffic "**S**" Grade $J_{nr3.2}$,max 4.0 kPa^{-1} $J_{nrdiff,3.2,}$max 75% Test temperature, °C	TP70		76
MSCR, Heavy Traffic "**H**" Grade $J_{nr3.2}$,max 2.0 kPa^{-1} $J_{nrdiff,\ 3.2,}$max 75% Test temperature, °C	TP70		76

MSCR, Very Heavy Traffic "**V**" Grade $J_{nr3.2}$,max 1.0 kPa^{-1}, $J_{nrdiff,\ 3.2,}$ max 75% Test temperature, °C	TP70		76
MSCR, Extreme Traffic "**E**" Grade $J_{nr3.2}$,max 0.50 kPa^{-1} $J_{nrdiff,\ 3.2,}$max 75% Test temperature, °C	TP70		76
Pressurized Aging Vessel Residue (R28)			
PAV Aging Temperature (°C)[g]			110
Dynamic Shear, "**S**" Grade, G*/sinδ, Max, 5000 kPa[e] Test Temperature (°C) at 10 rad/s	T315		31
Dynamic Shear, "**H**" , "**V**" , "**E**" Grades, G*/sinδ, Max, 6000 kPa[e] Test Temperature (°C) at 10 rad/s	T315		31
Physical Hardening Report			
Creep Stiffness, Stiffness , S, Maximum, 300.0 MPa at 60 seconds m-value, Minimum, 0.300 at 60 seconds Test Temperature (°C)[h]	T313		-12
Direct Tension, Failure Strain, Minimum, 1.0% (loading rate of 1.0 mm/min), Test Temperature (°C)	T314		-12

a MSCR testing on RTFO residue should be performed at the PG grade based on the environmental high pavement temperature. Grade bumping is accomplished by requiring a lower J_{nr} value while testing at the environmental temperature.

b *Pavement temperatures are estimated from air temperatures using an algorithm contained in the LTPP Bind program, may be provided by the specifying agency,* or by following the procedures as outlined in M 323 and R 35, excluding the provisions for "grade bumping".

c This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped and mixed at temperatures that meet all applicable safety standards.

d For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be used to supplement dynamic shear measurements of G*/sinδ at test temperatures where the asphalt is a Newtonian fluid.

e G*/sinδ = high temperature stiffness and G* sinδ = intermediate temperature stiffness.

f The mass change shall be less than 1.00 percent for either a positive (mass gain) or a negative (mass loss) change.

g The PAV aging temperature is based on simulated climatic conditions and is one of three temperatures, 90°C, 100°C, or 110°C. Normally the PAV aging temperature is 100°C for PG 58-xx and above. However, in desert climates, the PAV aging temperature for PG 70-xx and above may be specified as 110°C.

h If the creep stiffness is below 300 MPa, the direct tension test is not required. If the creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The *m*-value requirement must be satisfied in both cases.

7 Bitumen grades PG76-10 S, H, V, or E shall be selected in accordance to Table 5.1C. The bitumen shall meet the requirements of TP 70- Figure 2.1 passing % recovery. If traffic speed or the design ESALs warrant, adjust the high-temperature grade for mixtures placed within 100 mm of the surface and placed in any travel lane to meet MP 19 high temperature traffic levels as indicated in Table 5.1c to account for the anticipated traffic conditions at the project site.

Table 5.1c - Binder Selection on the Basis of Traffic Speed and Traffic Level

Design ESALs[a] (Million)	Recommendations for the High-Temperature Grade of the Binder		
	Traffic Load Rate		
	Standing[b]	Slow[c]	Standard[d]
< 0.3	S[e]	S	S
0.3 to < 3	H	S	S
3 to < 10	V	H	H
10 to < 30	E	V	V
≥ 30	E	E	E

[a] *The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.*

[b] *Standing Traffic—where the average traffic speed is less than 20 km/h.*

[c] *Slow Traffic—where the average traffic speed ranges from 20 to 70 km/h.*

[d] *Standard Traffic—where the average traffic speed is greater than 70 km/h.*

[e] *S designates Standard Grade, H designates Heavy Grade, V designates Very Heavy Grade, E designates Extreme Grade under MP 19*

8 The contractor shall submit samples of the bitumen that he proposes to use in the work together with a statement as to its source and properties approved by the Engineer at least 45 days before the asphalt works begins.

9 The PMB binder shall show no separation upon mixing with the modifier either when the binder is blended by the method of injection into the asphalt line/mixer or when the binder is blended on site in continuously agitated tanks. When PMB is tested for storage stability in accordance with ASTM D7173, the difference in softening point between top and bottom samples shall not exceed 5°C.

10 As the performance graded bitumen containing polymer modifiers is susceptible to separation of the modifier, the contractor shall ensure proper circulation or agitation in storage if separation of the modifier is suspected.

11 The PMB shall provide high cohesion when combined with mineral aggregate and shall offer good elastic recovery after relief.

12 PG binder or polymer modifier supplier instructions with regard to the recommended application and storage shall be carefully followed.

13 When the Bitumen or PMB is transported in bulk tankers or in drums, the bulk tankers must have good heating and circulation systems and shall have good functional insulation that can maintain the same temperature. No drop in temperature exceeding 10° C /day shall be allowed.

5.3 PLANT GENERALLY

Delete paragraph 3 and substitute with the following:

3 On first erecting a batching plant and at least once every three months thereafter, the plant shall be calibrated by a calibration service organisation approved by the Central Materials Laboratory.

5.4 ASPHALT MIXING PLANT

5.4.2 Automatic Operation

Delete paragraph 3 and substitute as follows:

3 The use of manual and semi-automatic plants for the production of asphalt is not permitted unless specific approval is given in writing by the Engineer. Plant shall be required to be equipped with the facilities to provide computer printout indicating the quantity of materials used in batch against target setting the hot bin fractions, bitumen content, mixing time and cycle, date and time of production, mix type, total production in a given day. The above printout is to be provided to the Engineer for each production day.

5.4.3 Cold Bins System

Delete paragraph 3 and substitute with the following:

3 The cold bins and loading equipment used shall be compatible to prevent overflow between the bins. Baffle plates shall also be used between bins to prevent overflow of one bin into another. Each cold bin shall include an accurate means for continuously feeding the required amount of mineral aggregate so that uniform production is achieved. The settings on the cold bins shall not be altered from the correct calibrated settings without the approval of the Engineer.

5.4.4 Filler Additive System

Delete paragraph 5 and substitute with the following:

5 When filler is added as a slurry, a minimum of two slurry chambers will be provided. One chamber will be used for proportioning the filler and water into slurry consistency. The second slurry chamber shall contain the mixed slurry and shall be provided with an accurate metering device with well-defined settings to enable easy checking, setting and calibration. Both chambers shall be equipped with continuous mixing paddles or recirculation pumps in order to prevent the slurry mixture from separating.

5.4.6 Dust Collector

Delete paragraph 1 and substitute with the following:

1 The plant shall be provided with a dust collector designed to waste, or to return in a constant and uniform flow to the hot elevator, all or part of the material collected. Before permitting the return of such collected dust, the Contractor will examine its characteristics in relation to the mix requirements and will designate the quantity to be returned. Dust return shall not be permitted without the approval of the Engineer.

Add new paragraph 3 as follows:

3 All plants used for preparation of bituminous mixtures shall consist of an effective filter system to prevent the escape of dust, smoke and any other pollutant to the atmosphere.

5.4.14 Safety Requirements

Delete paragraph 1 and substitute with the following:

1 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 all plant operations. Accessibility to the top of truck bodies shall be provided by means of a platform or other suitable device to enable the Contractor to obtain mixture temperature data. To facilitate handling scale calibration equipment and sampling equipment, a hoist or pulley system shall be provided to raise or lower the equipment from the ground to platform or *vice versa.* All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample 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.

5.4.16 Scales or Meters

Delete paragraph 1 and substitute with the following:

1 All scales and meters shall be calibrated as detailed in Sub-Clause 5.3 of this Part. Production shall not be permitted if the weight batch calibration fails.

5.5 HAULING EQUIPMENT

Delete paragraphs 3 and 5 and substitute with the following:

3 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 be removed from the work until such faults are corrected.

5 The Contractor shall provide an adequate number of trucks of such size, speed and condition to ensure orderly and continuous progress of the work.

5.6 OTHER PLANT

5.6.1 Spreading and Finishing Equipment

Delete paragraphs 2 and 3 and substitute with the following:

2 The pavers shall be self-propelled and equipped with hoppers and distributing screws of the reversing type to place the mixture uniformly in front of adjustable electronic controlled screeds. The pavers shall be so designed to allow a minimum paving width of 2 m and must be capable of paving at least the width of a lane. Paving in widths less than the width of a lane shall require the approval of the Engineer. Tracked pavers shall be used for major roads and tyred pavers shall be used for tight junctions and minor roads.

3 Pavers shall be equipped with such provisions and attachments to suit paving widths specified for road widening as well to as to suit paving on sloped sections. They shall be equipped with fast and efficient steering devices and shall have reversed as well as forward traveling speeds. The operational speed of the pavers shall be adjustable from 3 to 6 m/min.

5.6.2 Rolling Equipment

Delete paragraph 3 and substitute with the following:

3 Pneumatic-tyred rollers shall be self-propelled. The rollers shall be equipped with pneumatic-tyres of equal size and diameter which are capable of exerting varying average contact pressure. Pneumatic-tyred rollers shall be in good condition and with enough ballast space to provide uniform wheel loading as may be required. The Contractor shall furnish to the Engineer charts or tabulations showing the contact areas and contact pressures for the full range of tyre inflation pressures and for the full range of tyre loading for each type and size compactor tyre furnished and used in pneumatic-tyred rollers. The total operating weight and tyre pressure shall be varied by the Contractor to obtain contact pressures which will result in the required asphalt course density.

5.7 BITUMINOUS PAVING COURSES MIX DESIGN

5.7.1 Mix Design Criteria

Delete Table 5.2 and substitute with the following

Table 5.2: Design Criteria for Marshal Design Mix using Standard and Polymer Modified Bitumen (PMB)

Parameter	Mix type	Base Course (BC-TYPE 1)	Intermediate Course (IC-TYPE 1)	Asphaltic Concrete Wearing Course (SC-TYPE 1)	Dense Bitumen Macadam Wearing Course (SC-TYPE 2)
Stability (kN)	Standard	9 minimum	9 minimum	10 minimum	10 minimum
	PMB	14 minimum	14 minimum	14 minimum	14 minimum
Flow (mm)	Standard	2 to 4	2 to 4	2 to 4	2 to 3.6
	PMB	2 to 4	2 to 4	2 to 4	2 to 3.6
Stiffness (=Stability/Flow) (kN/mm)	Standard	4.0 minimum	4.0 minimum	4.0 minimum	3.5 minimum
	PMB	4 minimum	4 minimum	4 minimum	4 minimum
Voids in Mix (Air Voids) (%)	Standard	4 to 8	4.5 to 8	5 to 8	5.5 to 8.5
	PMB	4 to 6.5	4 to 6.5	4 to 6.5	4 to 6.5
Voids in Mineral Aggregate (%)	Standard	13 minimum	14 minimum	14 minimum	14 minimum
	PMB	13 minimum	14 minimum	14 minimum	14 minimum
Voids Filled with Bitumen (%)	Standard	50 to 70	50 to 75	50 to 75	48 to 64
	PMB	60 -75	60 -75	60 -75	60 -75
Voids in Marshall Specimen at 400 Blows per Face at Optimum Binder Content (%)	Standard	3.2 minimum	3.4 minimum	4.0 minimum	4.5 minimum
	PMB	3.0 minimum	3.0 minimum	3.0 minimum	3.0 minimum
Retained Stability (as per CML Test Method 2-97) (%)	Standard	75 minimum	75 minimum	75 minimum	75 minimum
	PMB	75 minimum	75 minimum	75 minimum	75 minimum
(Filler/Bitumen) Ratio	Standard	0.8 to 1.5	0.8 to 1.5	0.75 to 1.35	0.75 to 1.35
	PMB	0.6-1.2	0.6 -1.2	0.6 -1.2	0.6 -1.2

Delete "Recommended Compacted Layer Thickness" Table outlined immediately after Table 5.2, and substitute with the following:

Recommended Compacted Layer Thickness			
Asphaltic Concrete Base Course (BC-TYPE 1)	Asphaltic Concrete Intermediate Course (IC-TYPE 1)	Asphaltic Concrete Wearing Course (SC-TYPE 1)	Dense Bituminous Macadam-DBM Wearing Course (SC-TYPE 2)*
70mm-100mm	50mm-80mm	50mm-60mm	50mm-60mm
**The 'SC-TYPE 2 Wearing Course is coarser than SC-TYPE 1. It is more open texture and it has more air voids in the mix than SC-TYPE 1. It is intended for more heavily-trafficked roads/locations.*			

5.7.2 Mix Design Procedure

Add new paragraph 4 as follows:

4 The job standard mix shall not be used until certification is issued by the *Qatar General Organization for Standards and Metrology (QGOSM).* The assistance of the Engineer or issuance of a certificate to the Contractor for the job standard mix by the QGOM in no way relieves the Contractor of the responsibility of producing a bituminous mix meeting the requirements of the Specification.

5.8.3 Survey and Preparation

Delete paragraph 2 and substitute with the following:

2 When an asphaltic concrete pavement course is to be placed on top of an existing pavement, the Contractor shall determine the required treatment of the existing pavement surface and submit his proposal to the Engineer for approval.

Delete paragraph 4 and substitute with the following:

4 The surface of kerbs, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin and complete coating of tack coat to provide a closely bonded, watertight joint.

5.9 DELIVERY SPREADING AND FINISHING

5.9.1 Delivery of Mixes

Delete paragraphs 5 and 6 and substitute with the following:

5 The mixture at delivery to the paver shall be not more than 163 ºC and not less than 140 ºC. Material which has fallen below minimum temperature of 140 ºC before discharge shall be rejected and immediately removed from site. Delivery temperature shall not exceed the maximum temperature specified for mixing at the plant.

6 Should a significant proportion of the mixture delivered to the paver fail to meet this requirement, or should cold lumps be found in the mixture, the paving operations shall be suspended until measures are taken, to the approval of the Engineer, to ensure compliance.

5.9.2 Spreading and Finishing

Delete paragraph 3 and substitute with the following:

3 The laid material shall be compacted as soon as rolling can be effected without causing undue displacement and while the temperature does not fall below 135ºC. Material still uncompacted and below this temperature shall be rejected.

Add new paragraphs 13, 14 and 15 as follows:

13 The Contractor shall plan the paving such that longitudinal joints occur on the line of future lane markings wherever possible. Paving shall not be allowed in a greater width than 4 m unless otherwise agreed by the Engineer.

14 Asphaltic concrete mixes, except leveling courses shall be laid at a uncompacted thickness such that, after rolling the thickness of the compacted layer shall be:-

Base course	:	Min. 7 cm	Max. 10 cm
Intermediate course	:	Min. 5 cm	Max. 8 cm
Wearing course	:	Min. 5 cm	Max. 6 cm

15 The maximum thickness for layers may be increased slightly when such increase is more adaptable to total pavement thickness and when in the opinion of the Engineer it is not detrimental to placement and rolling conditions.

5.9.9 Finish Rolling

Delete paragraph 4 and substitute with the following:

4 After final rolling, the smoothness, levels, cross falls, density and thickness shall be checked and any irregularity of the surface exceeding the specified limits and any areas defective in texture, density or composition shall be corrected, including removal and replacement of the lot in question if required.

5.9.10 Protection of Laid Courses

Delete paragraph 1 and substitute with the following:

1 The Contractor shall protect all sections of newly constructed pavement from traffic until they have hardened sufficiently to the approval of the Engineer. In heavily trafficked roads during the summer months a minimum period of 7 days must elapse before the newly compacted pavement is opened to traffic. In no case shall traffic be permitted less than 48 hours after completion of asphaltic course unless a shorter period is authorized by the Engineer.

5.11 SAMPLING TESTING AND ACCEPTANCE

5.11.1 General

Delete paragraph 1 and substitute with the following:

1 Each completed asphalt concrete course shall be tested by the Contractor on a lot basis. The Contractor shall submit a testing plan to the Engineer for approval that demonstrates how he shall prove compliance with the requirements for compaction, mix composition, level, evenness and all other requirements of this Section 6. Each lot shall be approved by the Engineer before placing any subsequent asphalt concrete course. In cases where the asphalt course is laid in more than one lift, each lift shall be tested and approved in accordance with the following requirements before placing the subsequent asphalt concrete lift.

5.11.2 Sampling

Delete paragraphs 1 and substitute with the following:

1 The Contractor shall cut and test samples from each completed asphalt course during the progress of the work and before final acceptance. The Engineer may determine the location of the sample. The test results of each lot demonstrating compliance or otherwise with this specification shall be submitted to the Engineer.

Add new paragraphs 6, 7 and 8 as follows:

6 The Contractor shall provide a sample pair of cores to the Engineer at a rate of not less than 1 per lot for audit testing, unless otherwise instructed by the Engineer.

7 The size of a lot shall be as defined by the Contractor's quality system, but shall not be greater than 300 m run of road or 1500 m², whichever is less. The locations of the samples shall be randomly generated however at least one set of samples per lot shall be at joints as defined in QCS Section 6, Part 5, Clause 5.11.2, paragraph 2.

8 Two copies of the density results and related air voids results shall be submitted to the Engineer within 24 hours of compaction of the lot.

5.11.3 Compaction

Delete paragraph 2 and substitute with the following:

2 The density of the compacted mixes shall be related to the daily Marshall Density, which shall be determined by making four standard Marshall Specimens from samples of the mix taken from the mixing plant or paver (provided compacting temperature is retained). The density of each sample shall be determined and compared with mean value. Any individual result which varies from the mean by more than 0.015 gm/cc shall be rejected. Marshall Tests shall be repeated on a daily basis to establish the daily Marshall Density for that particular day's production. The daily Marshall Density shall not vary from the job mix Design Density by more than ± 0.75%.

The field density, as determined from each core sample, shall be a minimum of 98% of daily Marshall Density for the wearing and intermediate courses and a minimum of 97% for the base course.

Delete Paragraphs 4, 5 and 6 and add a new paragraph 4 as follows:

4 Should any bituminous course fail to achieve the specified compaction, at the discretion of the Engineer re-rolling may be allowed subject to the following conditions:

(a) Compaction to be achieved shall be 1% or less.
(b) Only PTR's to be used weighing no greater than 18 tons.
(c) Re-rolling to take place within 72 hours from the time of the initial rolling of the asphalt.
(d) Re-rolling to take place at the time of the day when the asphalt has attained its maximum natural temperature.
(e) Re-rolling to be applied for a maximum of two hours.
(f) Re-rolling to be carried out in the presence of the Engineer's Representative.
(g) The section of the Works in question shall be cored for density determination immediately after the completion of re-rolling.
(h) If after re-testing, the compaction achieved is 0.5% below the specified compaction, the asphaltic material will be accepted in the Works subjected to a reduction to the billed rates. If, on the other hand, compaction is not achieved within 0.5% of specified compaction, the asphaltic material shall be removed and new material to the specification laid at the Contractor's cost.

5.11.5 Thickness and Level

Delete paragraph 2 and substitute with the following:

2 In addition, the variations in the falls to cross sections of the road shall not vary from the required value by more than 0.15%.

Delete paragraph 4 and substitute with the following:

4 If the core so taken is not deficient by more than five (5) millimetres from the specified thickness (individual layer), full payment will be made. If the core is deficient in thickness by more than five (5) millimetres, from the specified thickness of individual layer, two (2) additional cores shall be taken from the area represented and if the average of the three (3) cores is not deficient by more than five (5) millimetres from the specified thickness of respective layer, full payment will be made. If the average thickness of three (3) cores is deficient by more than five (5) millimetres, but not more than ten (10) millimetres, or fifteen (15) per cent (whichever is less) from the specified thickness of total asphaltic pavement, an adjusted unit price as provided in the bill of quantities will be paid for the area represented by these cores.

In calculating the average thickness of each bituminous paving course, measurements, which are in excess of the specified thickness by more than five (5) millimetres will be considered as the specified thickness plus five (5) millimetres, the measurements which are less than specified thickness by more than ten (10) millimetres or fifteen (15) per cent (whichever is less for total thickness), will not be included in the average.

When the measurement of any core is less than specified thickness by more than five (5) millimetres, or fifteen per cent (whichever is less), the actual thickness of the bituminous paving course in this area will be determined by taking additional cores at not less than three (3) metre intervals parallel to the centre-line in each direction from the affected location until, in each direction, a core is found which is not deficient by more than five (5) millimetres, or fifteen (15) per cent (whichever is less). Asphalt areas which are deficient by more than ten (10) mm or 15% (whichever is less – for total pavement thickness) shall be removed and replaced at the Contractor's expense. Exploratory cores for deficient thickness may be used average for adjusted unit price.

Paved cross-section as shown on the Drawings and shall not vary by ± 6 mm for base course and ± 4 mm for intermediate and wearing course from the required elevation.

5.11.6 Evenness of Surface

Delete all paragraphs and substitute with the following:

5.11.6.1 Minor Roads with Posted Speed < 60km/h

1. The rideability of the driving surface of road pavements with posted speed < 60 km/h shall be measured with a 3 m rolling straight edge along any line or lines parallel to the centre line of the pavement on sections of 300 m selected by the Engineer, whether or not it is constructed in shorter lengths.

2. Sections shorter than 300 m forming part of a longer pavement shall be assessed using the number of irregularities for a 300 m length prorated to the nearest whole number.

3. Where the total length of pavement is less than 300 m the measurements shall be taken in 75 m lengths.

4. The number of deviations over the length of the section from the rolling straight edge greater or equal to 4 mm shall be counted.

5. None of the measured deviations or variations shall exceed 6 mm. The rideability of the driving surface of the completed pavement shall be within the relevant limits given in Table 5.3.

Table 5.3 - Rideability of Driving Surface

Section Length (m)	Allowed number of deviations ≥ 4mm
300	20
75	9

6. Any section containing deviations or variations exceeding 6 mm and the tolerances specified in Table 5.3 shall be corrected or removed and replaced in accordance with the instructions of the Engineer and to his satisfaction at Contractor's expense.

5.11.6.2 **Major Roads with posted Speed >=60km/h**

5.11.6.2.1 Data Collection

1. The rideability of the finished Surface (Wearing) course in terms of International Roughness Index (IRI) shall be tested with a certified, calibrated and documented Inertial Profiler meeting the requirements of ASTM E950 –Class 1.

2. The testing method shall be in accordance with ASTM E950 / E950M - 09 "Standard Test Method for Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference". The Bias and Precision shall be as described in ASTM E177.

3. The IRI (quarter-car simulation) shall be calculated according to ASTM E1926 "Standard Practice for Computing International Roughness Index of Roads from Longitudinal Profile Measurements".

4. Calibration checks on the inertial profilers shall be conducted using test methods in accordance with the manufacturer's recommendations, at the beginning of the day of operation and at any other time the operator may suspect changes of system performance since the last calibration.

5. Calibration checks on the inertial profilers and all other quality checks shall be submitted in a method statement to the Engineer for approval, if requested and as to be submitted in the testing report".

6. Profilers shall, at a minimum, measure roughness in two wheel tracks of each lane.

7. Survey speed of the inertial profiler shall be as nearly constant during testing as can be maintained; but not to exceed +/-5 km/h of the selected speed.

8. The selected measuring speed shall be within the range that was utilized when the equipment was most recently approved.

9. The profiler system shall stabilize at the test speed prior to entering the test sections. This requires bringing the profiler vehicle to the desired test speed at least 100 m prior to the beginning of the test location. The start and end point of the test length shall be identified, as well as any features along the test sections such as bridges, culverts, milepost or other pertinent information.

10. Three runs of data collection (both wheel tracks in each lane) shall be conducted for each test section. The coefficient of variation of the overall average IRIs shall be less than or equal to 3% for three runs for the data to be accepted.

11. The processing of the data for IRI shall include calculating the average IRI value for the two wheel tracks. The processed data shall be reported on 25m and 400m calculated using the ***Moving Average*** statistical method.

12. The finished surface (wearing) course when tested for smoothness shall have an IRI (International Roughness Index) not exceeding the following values:

    a) New Construction or Reconstruction (*works include all pavement layers***)**

    - Average value over a 400 metre section $\leq$ 0.90 m/km.

    b) Pavement Rehabilitation (*Works include overlay, Mill and Inlay, or Partial Reconstruction works which include all asphalt layers and part of the aggregate base layer***):**

- ***One layer of asphalt***
    - Average value over a 400 metre section ≤ 1.05 m/km
- ***Two layers or more of asphalt***
    - Average value over a 400 metre section ≤ 1.0 m/km

13. Directional ramps on bridges or interchanges and tunnels of minimum length of 500m and with widely spaced joints of more than 25m shall be tested, unless otherwise instructed by the Engineer, and shall have an IRI (International Roughness Index) not exceeding the following values:

    a) **Flexible Pavement**: Average value over a 400 metre section < 0.90 m/km

    b) **Composite and Rigid Pavement**: Average value over a 400 metre section < 1.20 m/km.

14. Peak individual value over a 25 metre section shall be < 1.5 m/km (Not more than 2 values per 400 metres) - New construction, Reconstruction and Pavement rehabilitation.

15. The amplitude of the longitudinal profile of the road, filtered between (a) 1 metre and 3.3 metres and (b) 3.3 metres and 13 metres shall not exceed the following values:

Filtering Length (m)	Amplitude Tolerance (mm)
1 to 3.3	1.8
3.3 to 13	4.0

16. Any layer containing deviations or variations exceeding the tolerances specified here shall be corrected or removed and replaced in accordance with the instructions of the Engineer and to his satisfaction at Contractor's expense.

17. All humps and depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material as directed by the Engineer at the Contractor's expense.

18. The minimum length of any pavement section to be tested shall be 500m.

19. Individual roughness readings at joints in rigid pavement shall be excluded during processing of the roughness data and shall be ignored in the analysis. Pavement within 20m of Bridge decks or railroad crossings shall also be excluded.

20. Ramps, acceleration and deceleration lanes, loops, U Turn lanes, shoulders, service roads, sides street tie-ins, parking areas and other links (with a length less than the minimum length specified or those constructed of closely spaced joints shall be excluded.

21. The roughness measurements and reporting shall be undertaken at minimum 1 week before opening to the traffic.

22. The minimum length of the rectification work undertaken shall be 100m.

23. All rectified segments shall be re-tested following the completion of rectification work at no additional cost to the client.

5.11.6.2.2 Documentation and Calculation

24. The calculation of the IRI shall be completed using a software provided by the profiler manufacture and must be approved by Ashghal. The following is a list of the calculations that shall be completed for each section and each run:

25. The list of the calculations that shall be completed for each section and each run shall include the followings:

    a) The average IRI for each section (averaging left and right wheel paths) on each run.
    b) The overall average IRI for each run

26. The field report for each test section shall include as a minimum data on the following items:

    a) Date and time of day
    b) Operator, driver, and vehicle identification
    c) Weather condition
    d) Location and description of test section
    e) GPS coordinates
    f) Pavement surface description
    g) Run number
    h) Measuring speed
    i) Direction measured
    j) Lane measured and transverse position
    k) Profile data
    l) Other system-specific measurement options

5.12 PRIME COAT

5.12.2 Materials

Delete paragraphs 2 and 3 and substitute with the following:

2 The application rate shall be between 0.45 to 0.75 kg/m². The exact rate of application, which may be varied to suit field conditions, will be determined by the Engineer following trials to be carried out by the Contractor. The Contractor shall ensure that excessive application of prime coat is avoided.

3 The application temperature for the MC-70 liquid asphalt shall be between 60 °C and 85 °C.

5.12.5 Application

Delete paragraph 1 and substitute with the following:

1 After preparing the road surface in accordance with Sub-Clause 5.12.4, the liquid asphalt shall be applied by means of the distributor at the temperature and rate determined by the Contractor and approved by the Engineer. Hand-spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

5.13 TACK COAT

5.13.2 Materials

Delete paragraphs 1, 2 and 3 and substitute with the following:

1 The material for bituminous tack coat shall be slow setting emulsified asphalt, grade SS-1h (anionic) or CSS–1h (cationic) conforming to the requirements of AASHTO M140 and AASHTO M208 respectively.

5.13.5 Application

Delete paragraphs 1, 2 and 3 and substitute with the following:

1 Immediately after cleaning the surface, the tack coat shall be applied by means of the distributor at the temperature and rate determined by the Contractor and approved by the Engineer. Hand-spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

2 The application rate shall be between 0.15 to 0.38 kg/m². The exact rate of application, which may be varied to suit field conditions, will be determined by the Engineer following trials to be carried out by the Contractor. The Contractor shall ensure that excessive application of tack coat is avoided.

3 The application temperature for the diluted emulsified asphalt shall be between 10 °C and 60 °C. The material should not be applied when the ambient temperature is less than 13 °C or during rain, fog, dust storms or other unsuitable weather.

4 After application the surface shall be allowed to dry to the proper condition of tackiness to receive the following pavement course. Tack coat shall be applied only so far in advance to pavement courses to obtain the proper condition of tackiness and the Contractor shall protect the tack coat from damage during this period.

Add a new clause 5.15.4 (Superpave Asphalt Mix specifications) as follows:

5.15.4 Superpave Asphalt Mix Specifications (QC/QA, Materials, Mixture Design and Equipment)

5.15.4.1 Standards

Source	Code	Title
NCHRP	RP 648	Mixing and Compaction Temperatures of Asphalt Binders in Hot-Mix Asphalt
AI	MS-2	Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types
AI	SP-2	Superpave Mix Design
NAPA	IS 127	Method for Determining Volume of Voids in Compacted Filler or Fines
NAPA	IS 128	HMA Pavement Mix Type Selection Guide
ASTM	C 10	Natural Cement
ASTM	C 50	Sampling, Sample Preparation, Packaging, and Marking of Lime and Limestone Products
ASTM	C 51	Terminology Relating to Lime and Limestone (As Used by The Industry)
ASTM	D 4791	Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM	D 5821	Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM	E 950	Measuring the Longitudinal Profile of Traveled Surfaces with an Accelerometer Established Inertial Profiling Reference
ASTM	E 1926	Computing International Roughness Index of Roads from Longitudinal Profile Measurements
AASHTO	2004	A Policy on Geometric Design of Highways and Streets
AASHTO	M 82	Cut-Back Asphalt (Medium-Curing Type)
AASHTO	M 140	Emulsified Asphalt
AASHTO	M 156	Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures
AASHTO	M 208	Cationic Emulsified Asphalt

AASHTO	MP 19	Performance-Graded Asphalt Binder
AASHTO	PP 28	Superpave Volumetric Design for Hot Mix Asphalt (HMA)
AASHTO	R 11	Indicating Which Places of Figures are to be Considered Significant in Specified Limiting Values / ASTM E 29
AASHTO	R 35	Superpave Volumetric Design for Hot Mix Asphalt (HMA)
AASHTO	R 46	Designing Stone Matrix Asphalt (SMA)
AASHTO	T 2	Sampling of Aggregates
AASHTO	T 11	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO	T 19	Bulk Density (Unit Weight) and Voids in Aggregate
AASHTO	T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO	T 30	Mechanical Analysis of Extracted Aggregate
AASHTO	T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO	T 89	Determining the Liquid Limit of Soils
AASHTO	T 90	Determining the Plastic Limit and Plasticity Index of Soils
AASHTO	T 96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO	T 104	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
AASHTO	T 112	Clay Lumps and Friable Particles in Aggregate
AASHTO	T 164	Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
AASHTO	T 166	Bulk Specific Gravity of Compacted Hot Mix Asphalt Using Saturated Surface-Dry Specimens
AASHTO	T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO	T 195	Determining Degree of Particle Coating of Bituminous-Aggregate Mixtures
AASHTO	T 209	Theoretical Maximum Specific Gravity and Density of Hot-Mix Asphalt (HMA)
AASHTO	T 279	Accelerated Polishing of Aggregates Using the British Wheel
AASHTO	T 283	Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage
AASHTO	T 304	Uncompacted Void Content of Fine Aggregate
AASHTO	T 305	Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures
AASHTO	T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
AASHTO	T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO	T 321	Determining the Fatigue Life of Compacted Hot Mix Asphalt (HMA) Subjected to Repeated Flexural Bending
AASHTO	T 324	Hamburg Wheel-Track Testing of compacted Hot-Mix Asphalt (HMA)
AASHTO	TP 70	Multiple Stress Creep Recovery (MSCR) Test of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
AASHTO	TP 79 &PP60	Standard Method of Test for Determining the Dynamic Modulus and Flow Number for Hot Mix Asphalt (HMA) Using the **Asphalt Mixture Performance Tester (AMPT)**

5.15.4.2 Terminology

5.15.4.2.1 *HMA—hot mix asphalt*

Design ESALs—design equivalent (80 kN) single-axle loads. Design ESALs are the anticipated project traffic level expected on the design lane over a 20-year period. For pavements designed for more or less than 20 years, determine the design ESALs for 20 years when using this standard.

Air Voids (V_a)—the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture, expressed as a percent of the bulk volume of the compacted paving mixture. This term is defined in Asphalt Institute Manual MS-2, *Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types*.

Voids in the Mineral Aggregate (VMA)—the volume of the intergranular void space between the aggregate particles of a compacted paving mixture that includes the air voids and the effective binder content, expressed as a percent of the total volume of the specimen.

Voids filled with Asphalt (VFA)—the percentage of the VMA filled with binder (the effective binder volume divided by the VMA).

Dust-to-Binder Ratio ($P_{0.075}/P_{be}$)—by mass, the ratio between the percent of aggregate passing the 75-µm (No. 200) sieve ($P_{0.075}$) and the effective binder content (P_{be}).

Nominal Maximum Aggregate Size—one size larger than the first sieve that retains more than 10 percent aggregate. This definition applies to the Superpave mix only and differs from the definitions published in other AASHTO standards.

Maximum Aggregate Size—one size larger than the nominal maximum aggregate size. This definition applies to the Superpave mix only and differs from the definitions published in other AASHTO standards.

Reclaimed Asphalt Pavement (RAP)—removed and/or processed pavement materials containing asphalt binder and aggregate.

Primary Control Sieve (PCS)—the sieve defining the break point between fine and coarse-graded mixtures for each nominal maximum aggregate size.

Voids in the Coarse Aggregate (VCA)—the volume between the coarse aggregate particles in SMA. This volume includes dust, fine aggregate, air voids, asphalt binder, and stabilizing additive (if used).

SMA Mortar—a mixture of asphalt binder, filler [material passing the 0.075-mm (No. 200) sieve], and stabilizing additive.

Stabilizing Additive—either cellulose or mineral fiber.

Mix Bulk Specific Gravity (G_{mb})-the ratio of the mass in air of a unit volume of compacted asphalt mixture (including both permeable and impermeable voids) at a stated temperature to the mass in air of an equal volume of water at a stated temperature.

Mix Maximum Specific Gravity (G_{mm})-the ratio of the mass of a given volume of void less HMA at a stated temperature to a mass of an equal volume of water at the same temperature.

Aggregate Bulk Specific Gravity (G_{mb}) - the ratio of the mass in air of a unit volume of aggregate (including the volume of voids that become filled with water during the soaked test) at a stated temperature to the mass in air of an equal volume of water at a stated temperature.

Aggregate Apparent Specific Gravity (G_a)- the ratio of the mass in air of a unit volume of aggregate (excluding the volume of voids that become filled with water during the soaked test) at a stated temperature to the mass in air of an equal volume of water at a stated temperature.

Aggregate Effective Specific Gravity (G_{se}) - the ratio of the mass in air of a unit volume of aggregate (excluding voids permeable to asphalt) at a stated temperature to the mass in air of an equal volume of water at a stated temperature.

5.15.4.3 Submittals

1 The Contractor shall submit for approval a proposed Job Mix Formula (JMF) together with all applicable design data at least one month before beginning the work. The JMF shall submittal shall include the mix description, which shall include the nominal maximum size of the aggregate, the design traffic level and the number of blows used to compact the mix or the number of gyrations if a gyratory compactor is used for mix compaction. The submitted hot mix asphalt (HMA) mix design shall include the JMF showing the gradation of each aggregate and the percentage of that aggregate used in the JMF. The JMF shall show the combined aggregate gradation for each sieve showing a target percentage passing each sieve. The JMF shall show the allowable gradation ranges for each individual sieve size to be used in the mix. The JMF shall show the mixing and compaction temperatures. The JMF shall show the design asphalt content, Pb, at the design air voids, V_a, the bulk specific gravity, G_{mb} the maximum specific gravity G_{mm}, and voids in mineral aggregates, VMA at the design asphalt content. The Engineer will test samples of the materials proposed for use in order to check their quality and to check the proposed mix design. The Contractor shall report all the values obtained in the laboratory design and shall submit these together with a copy of the plotted curves resulting from the tests in an approved form to the Engineer. The Engineer may require verification of the submitted design before giving approval. No asphalt works will be allowed to commence before the Contractor receives written approval from the Engineer for his Job Mix Formula (JMF).

2 The asphalt mix design submission shall include a copy of valid calibration certificates (from a calibration service agency approved by the Qatar General O for Standards and Metrology (QGOSM) for the HMA plant and the relevant laboratory equipment such as but not limited to balances, sieves, compactors, proving rings, ovens and load devices. Approval certificates for mix designs will not be issued if the above requirements have not been complied with.

3 The Contractor shall submit technical information on HMA plant production rate and HMA storage silo's capacity. Additional requirements are provided in Section 5.15.4.16 Asphalt Mixing Plant.

4 The contractor shall submit technical information on the cold milling machine(s) capabilities to remove any existing HMA surface to the required grade and cross section producing a textured surface. Additional equipment requirements are listed in Section 5.15.4.19 Cold-Milling Machines.

5.15.4.4 Quality System

5.15.4.4.1 Definitions

1 **Quality Assurance (QA)**—All those planned and systematic actions necessary to provide confidence that a product or facility will perform satisfactorily in service. [QA addresses the overall problem of obtaining the quality of a service, product, or facility in the most efficient, economical, and satisfactory manner possible. Within this broad context, QA involves continued evaluation of the activities of planning, design, development of plans and specifications, advertising and awarding of contracts, construction, and maintenance, and the interactions of these activities.]

2 **Acceptance—**Sampling and testing, or inspection, to determine the degree of compliance with contract requirements. All acceptance testing will be done by the Public Works Authority (PWA) or its designated laboratory. The Engineer shall produce the Engineer's Acceptance Plan (EAP) which will describe the process of determining the selection of random samples, the type, size and location of where samples are to be taken, the testing as specified in the specification to be conducted on the samples. The EAP shall provide the certification and experience of the Engineer's technicians and equipment.

3 **Quality Control (QC)**—also called process control. Those process control actions and considerations necessary to assess and adjust production and construction processes so as to control the level of quality being produced in the end product. The contractor will prepare a Contractor's Quality Control Plan (CQCP) as part of the process. The CQCP will shall describe the type, size and location of where samples are to be taken, testing to be conducted on the samples and the corrective actions to be taken if the results do not meet or are trending outside the project specifications. The CQCP will include the certifications of the technicians and the equipment used for testing. All quality control testing will be done by the contractor or his designated laboratory according to the CQCP approved by the Engineer.

4

5.15.4.4.2 Contractor Quality Control Plan (CQCP)

1 Before the start of the work, the contractor shall submit a written quality control plan for acceptance. With prior approval, submission of a quality control plan for items of work not immediately scheduled to begin may be deferred. The quality control plan shall include the following:

(a) Process control testing. List the material to be tested by pay item, tests to be conducted, the location of sampling, and the frequency of testing.

(b) Inspection/control procedures. Address each of the following subjects in each phase of construction:

(1) Preparatory phase.

(a) Review all contract requirements.

(b) Ensure compliance of component material to the contract requirements.

(c) Coordinate all submittals including certifications.

(d) Ensure capability of equipment and personnel to comply with the contract requirements.

(e) Ensure preliminary testing is accomplished.

(2) Start-up phase.

(a) Review the contract requirements with personnel performing the work.

(b) Inspect start-up of work.

(c) Establish standards of workmanship.

(d) Provide training as necessary.

(e) Establish detailed testing schedule based on the production schedule.

(3) Production phase.

(a) Conduct sampling and test during construction according to the CQCP to assure compliance with the specifications and to identify and correct deficiencies.

(b) Inspect completed work before requesting Government inspection acceptance.

(c) Provide feedback and system changes to prevent repeated deficiencies.

(c) Description of records. List the records to be maintained.

(d) Personnel qualifications.

(1) Document the name, authority, relevant experience, and qualifications of person with overall responsibility for the inspection system.

(2) Document the names, authority, and relevant experience of all personnel directly responsible for inspection and testing.

(e) Subcontractors. Include the work of all subcontractors. If a subcontractor is to perform work under this Section, details how that subcontractor will interface with the Contractor's and other subcontractor's organizations shall be provided.

2 Modifications or additions may be required to any part of the plan that is not adequately covered. Acceptance of the quality control plan will be based on the inclusion of the required information. Acceptance does not imply any warranty by the PWA that the plan will result in consistent contract compliance. It remains the responsibility of the Contractor to demonstrate such compliance.

3 Do not begin the work until the CQCP covering that work is accepted.

4 Supplement the CQCP as work progresses and whenever quality control or quality control personnel changes are made.

5.15.4.5 Quality Control Laboratory

1 The Contractor shall furnish and maintain a Quality Control (QC) laboratory at the plant site. The laboratory shall be furnished with the necessary space, equipment, and supplies to properly perform all specified testing described in Section 5.15.4.4.5. The laboratory equipment shall be calibrated and meet the requirements of the test methods specified in the PAW laboratory manual. A copy of equipment calibration records shall be kept in the QC laboratory and made available when requested by the Engineer.

2 A cut off saw equipped with a diamond tipped blade shall be furnished. The saw is to be stable so that it may cleanly saw the core samples along the lift line(s). The cores shall be measured for lift thickness and then sawed along the correct lift line to separate the lifts for individual density measurements.

5.15.4.5.1 Contractor Quality Control

1 This work consists of obtaining samples for Contractor quality control testing, performing tests for Contractor quality control, providing inspection, and exercising management control to ensure that work conforms to the contract requirements. Only samples collected and tested according to the CQCP will be allowed for use in Dispute Resolution.

2 **Testing.** Perform testing according to the accepted Contractor Quality Control Plan (CQCP) outlined in Section 5.15.4.4.2. Keep laboratory facilities clean and maintain all equipment in proper working condition. Allow unrestricted access for inspection and review of the facility.

3 **Records.** Maintain complete testing and inspection records by pay item number (pay item characteristics are listed in Table 5.8) and make them accessible to the engineer.

4 For each day of work, prepare an *"Inspector's Daily Record of Construction Operations"* (Form 1413 of Federal Highway Administration (FHWA) of the United States) or an approved alternate form. Detail inspection results including deficiencies observed and corrective actions taken. Include the following certification signed by the person with overall responsibility for the inspection system:

"It is hereby certified that the information contained in this record is accurate and that all work documented herein complies with the requirements of the contract. Any exceptions to this certification are documented as a part of this record."

5 Submit the record and certification described in point 4 above within one working day of the work being performed. If the record is incomplete, in error, or otherwise misleading, a copy of the record will be returned with corrections noted.

6 Maintain linear quality control charts that identify the project number, pay item number, test number, each test parameter, the upper and lower specification limit applicable to each test parameter, and the test results. Use the control charts as part of the quality control system to document the variability of the process, to identify production and equipment problems, and to identify potential pay factor adjustments as shown in Appendix A **If payment factor is implemented by Ashghal,**. The quality control plan will include how the quality control charts are being generated and how they may be accessed.

7 Post control charts in an accessible location and keep them up-to-date. Cease production and make corrections to the process when problems are evident.

8 During production after the JMF has been established through the mix verification program, if any two consecutive quality control test results fall outside the testing limits (Table 5.5 of Section 5.15.4.6.6), production operations shall be terminated and corrective action approved by the Engineer will be taken to bring the production operations back into compliance.

5.15.4.5.2 Minimum Contractor Quality Control Testing

1 The minimum required testing for contractor quality control is as designated in Table 5.4. This is only the minimum required and additional test may be needed for the contractor to completely control bituminous mixing and paving operations.

2 All bituminous mixture samples will be taken and tested according to the CQCP. Only samples taken in a random fashion from the roadway behind the paver before compaction and tested in accordance with the approved procedure will be used for dispute resolution.

3

4 The minimum QC sampling locations must be determined independently from acceptance sampling locations. In addition to the minimum QC sampling and testing required by Table 5.4, additional non-random QC testing maybe included in the CQCP.

Table 5.4: Minimum Required Contractor Q/C Sampling/Testing.

TEST	MINIMUM FREQUENCY	TEST METHOD
Aggregate Stockpile Gradations	1/5000 tonnes	AASHTO T 11, T 27
Field Verification Testing	As needed to establish JMF	Section 5.6
Asphalt Binder Content	1/500 tonnes	AASHTO T 164 or T 308
Aggregate Gradation	1/500 tonnes	AASHTO T 30

5.15.4.6 Suspension of Production

1 The Contractor will suspend production when:

(a) The QC plan is not followed.

(b) Severe segregation or flushing occurs during the paving operations as decided by the Engineer.

(c) The project average lot Percent within Limits (PWL) determined according to Section 5.15.4.7.2 for VMA, binder, air voids or density is below 90.0%.

(d) The sublot acceptance density average is < 93%.

2 The Engineer shall be notified of suspended production.
3 The Engineer shall be notified of what corrective actions will be taken.
4 Resume production when the PWL > 90% to ensure corrective action was successful.
5 Furnish the Engineer with notification in writing of improvements and modifications to the system.

5.15.4.7 Standard procedure to verify that plant produced hot mix asphalt will meet mix design requirements.

5.15.4.7.1 Scope

1 Mix Verification consists of validating that the production facility and the production process used by the contractor will produce the desired JMF and design volumetric properties of the HMA on the first full day of production for each mix type specified in the contract. This verification is done using the actual plant facilities and the actual project materials. Mix verification is included as part of the CQCP.

This practice may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

5.15.4.7.2 Definitions

1 **JMF - Job Mix Formula** is defined as the single point target value for percent passing designated sieve sizes and volumetric properties. The JMF will be verified during first day's production or a trial mix placed and compacted according to the CQCP.

5.15.4.7.3 Summary of method

1 Mix verification includes several steps to assure the plant produced mix will meet the mix design requirements. Prior to the beginning of production, aggregate stockpile samples at the mixing plant shall be tested for gradation and moisture content. The first day of production shall be used for the mix verification process. The first day of production shall be divided into 4 sub-lots. The sub-lots shall be 250 to 500 tons based on the days expected production.

2 The samples taken from the road shall be large enough so that each HMA sample will be approximately 25kg in mass. The Contractor shall adjust the HMA plant operations to bring all characteristics of the SUPERPAVE HMA mix into compliance with the JMF established tolerances per lot (following Table 5.5 of Section 5.15.4.6.6).

3 The Contractor shall employ test data obtained for the plant produced HMA in compliance with the test –strip JMF to establish initial control charts for the HMA production process. The JMF is established according to the procedure in Section 5.15.4.6.7.

4 During Field Verification production of the HMA, the Contractor shall place and compact a minimum of 500 tonnes of HMA produced in compliance with the JMF tolerances in order to establish compaction patterns and verify that the equipment and the processes planned for laydown and compaction are satisfactory.

5 The HMA shall be placed in a trial area (Control Strip) at the thickness required by the pavement cross-section design. The control strip is used to establish compaction patterns and verify that the equipment and the processes planned for laydown and compaction are satisfactory. The Contractor shall employ a density gauge or other approved method of test to establish a compaction pattern that meets the specification criteria for in-place density. The density gauge shall be calibrated using cores from the Control Strip.

5.15.4.7.4 Field Verification Tests for Mix Verification

1 Determine the P_b and combined aggregate gradation of the HMA samples in accordance with AASHTO T 164 or T 308 and AASHTO T 30 respectively. Whichever procedure is chosen at the preconstruction meeting will be used for the rest. Any changes in test procedures must be submitted in writing to the Engineer for approval.

2 Determine the maximum specific gravity (G_{mm}) and maximum density of the HMA samples in accordance with AASHTO T 209.

3 Determine the bulk specific gravity (G_{mb}) of the HMA samples in accordance with AASHTO T 166, at N_{design} gyrations derived in accordance with AASHTO T 312.

4 Determine the air void content (V_a) of the HMA samples in accordance with PP 28 at N_{init} and N_{design} gyrations derived in accordance with AASHTO T 312.

5 Determine the voids in the mineral aggregate (VMA) and the voids filled with asphalt (VFA) of the HMA samples at N_{design} gyrations designated in the plans.

5.15.4.7.5 Change in Aggregate Source

1 Repeat steps 1-5 above if there is a change in aggregate source.

2 If the testing meets the HMA mix specification for mix gradation, P_b, V_a, and VMA, the new aggregate source maybe used.

3 If test results do not meet the HMA mix specifications for mix gradation, P_b, V_a and VMA, a new mix design is required or a field design maybe approved by the Engineer if changes can be made to the JMF so that the HMA mix meets the project specifications and the new aggregate source meets the aggregate specifications.

5.15.4.7.6 Field Testing Procedures

1 The HMA sample shall be brought back to the field lab and split down into the proper size for each type of test specimen according to specified test methods. The time for splitting of mix should be kept to a minimum to avoid excessive loss of heat from the sample.

2 HMA for gyratory specimens should be placed into moulds preheated to the mix compaction temperature as recommended by the bituminous binder suppler or determined using the Asphalt Institute method. Once the mix is placed in the mould it shall be immediately place into a forced draft oven set at the mix compaction temperature as determined by the method described in "*NCHRP Report 648, Mixing and Compaction Temperatures of Asphalt Binders in Hot-Mix Asphalt*- Phase Angle Method or Steady Shear Flow Method.

Once the mix has reached the compaction temperature, it shall be taken from the oven, placed into the gyratory compacter and compacted to the design number of gyrations as specified in AASHTO T 312. The mix shall not be left in the oven for more than two hours during the reheating process. Excessive time in the oven may cause additional aging of the binder. After compaction, the samples should be extracted from mould, allowed to cool to room temperature, and the bulk specific gravity of the sample determined according to AASHTO T 166. Note: The samples moulds should be cleaned after the compacted HMA samples are removed and before putting the moulds back in the oven to reheat.

3 HMA for the determination of G_{mm}, (rice test), AASHTO T 209 shall be split down to the proper test sample size for the aggregate size being used. The Rice test is run on the same mix as sampled for gyratory compacted specimens, the binder content, and gradation. Additionally a 1000g sample is used to determine the moisture content of the mix by drying to a constant weight in 110°C oven. Constant weight is defined as a mass loss of less than 0.1g in 15 minutes.

4 HMA for determination of asphalt binder content and gradation shall be quartered down to the proper test sample size for the aggregate size being tested and placed in the ignition furnace according to AASTHO T 308. When using the ignition furnace, the sample should be weighed before and after placement in the oven. After the binder content is determined, the remaining aggregate is used to determine the washed gradation of the mix sample according to AASHTO T 30.

5 If a dolomitic aggregate is being used in the HMA, a correction factor may be difficult to be used to determine the correct asphalt content as the dolomitic aggregate breaks down in the ignition oven. An alternative method such AASHTO T 164 shall be used to determine the HMA mix asphalt content and gradation

6 The Va, VMA, VFA, Pb, dust to asphalt ratio (F/A), and gradation are determined for each hot mix sample. These results are compared against the JMF field check and mix design requirements.

7 During volumetric calculations the aggregate effective specific gravity (G_{se}) should be calculated. The G_{se} is compared to the aggregate bulk specific gravity (G_{sb}) and the aggregate apparent specific gravity (G_{sa}). As long as the G_{se} is in between the bulk and apparent gravities of the mix aggregate, the bulk gravity used for calculations should be acceptable. If the G_{se} falls outside the aggregate bulk and apparent gravities the aggregate gravities should be retested.

8 For field verification as long as Pb and the Passing No. 200 are within specification, the F/A ratio is not used for control of the mix.

Table 5.5: Tolerances for HMA Plant Production

Mix Property	Tolerance Limit		
	BC	IC	SC
Asphalt Binder Content	±0.30%	±0.20%	±0.20%
Gradation Passing 4.75 mm and larger sieves	±5%	±4%	±4%
Gradation Passing 2.36mm and to 75µm Sieve	±4%	±3%	±3%
Gradation Passing 75µm Sieve	±1.5%	±1.5%	±1.3%
Air Voids (V_a) at N_{design}	±1.0%	±1.0%	±1.0%
Voids in Mineral Aggregate (VMA) at N_{design}	+2%	+2%	+2%
Roadway Density % of AASHTO T 209 or (In-place air voids, Va (%)	92 to 94 % G_{mm} or (6-8%)		
***BC**: Asphalt Base Course, **IC**: Asphalt Intermediate Course, **SC**: Asphalt Surface (Wearing) Course.*			

5.15.4.7.7 Data Analysis

1 The test results from Section 5.15.4.6.4 shall be statistically evaluated following the procedure in Section 5.15.4.7.2 based on the tolerances in Table 5.5, and the targets established in the JMF field check. Based on the results from the PWL for gradation, percent passing 0.075 mm sieve (P 0.075mm), V_a, VMA, and P_b, one of the following actions can be taken; these actions are summarized in Table 5.6 and Figure 5.1:

(a) "GO AS IS" no changes to mix or documentation.

i. The mix as produced by the plant meets approved targets for the gradation, binder content, and void properties with a PWL greater than 85%. Production should start with the JMF targets set to the average results from the verification tests for gradation and void properties

(b) "GO WITH CHANGES" minor JMF adjustments or administrative changes to adjust production targets.

i. The mix as produced by the plant varies to a certain degree from the JMF for binder content, gradation and/or void properties (V_a , VMA) targets, with less than 85% within limits for void properties. Typically there are two different cases that initiate the "GO WITH CHANGES" recommendation.

- In the first case, the test results may indicate the plant produced mix matches the JMF targets for gradation, but not for the VMA targets with PWL of 85%. In this case the change would be to establish new gradation targets using the average results from the mix verification.

- In the second case, the test results indicate that the gradation or the void properties were outside the tolerances in Table 5.5 mix design requirements (PWL less than 85%). The test results, however, indicate a minor adjustment to the gradation and or asphalt content could bring these properties back into design requirements.

ii. When these small adjustments are made to the mix, a second mix verification is required to assure that the modified mix will meet all design requirements.

(c) "REDESIGN"

i. Non-compliance with the JMF requiring new mix design when none of the tests fall within the tolerances set in Table 5.5.

ii. The plant produces the gradations and P_b within the tolerances in Table 5.5 with PWL greater than 85%. But, V_a and VMA of the mix as produced by the plant are ≤50% PWL. When this happens a complete redesign of the mix is required. When the volumetric results are less than 85%, additional field trials maybe attempted. **If payment factor is implemented by Ashghal,** Pay for these additional field trials will be at the calculated PF for the tests from each test section as shown in Appendix A. If three field trials fail to produce PWL values at or above 90%, production should be stopped until a new mix design is completed and verified.

(d) "RECALIBRATE PLANT"

i. P_b and or gradation are outside of acceptable limits and the plant requires recalibration to bring it within limits, (less than 70 % within limits) and therefore requires the plant to be recalibrated to bring it within tolerance. The mix verification is performed again after the plant is within calibration.

Table 5.6: Summary of Actions Based on PWL Results

Action	***Meet Tolerances with PWL > 85%***			***Notes***
	Gradation	***Binder Content***	***Va, VMA***	
GO AS IS	*Yes*	*Yes*	*Yes*	--
GO WITH CHANGES *Establish new gradation*	*Yes*	*Yes*	*No*	*Production V_a average = Design V_a ± 0.5%*

				And *Production VMA average = Design VMA + 1%*
GO WITH CHANGES *Establish new gradation and/or asphalt content*	*No*	*No*	*No*	*Production V_a average = Design V_a ± 0.5%* *Minor adjustment to the gradation and asphalt content could bring the properties back to the design requirements*
Redesign *Stop production until a new mix design is completed and verified*	*No*	*No*	*No*	*Production VMA average ≠ Design VMA ± 1%*
Recalibrate Plant	*No, PWL < 70%*	*No, PWL < 70%*	*No, PWL < 70%*	--

2 When the contractor has an acceptable mix verification in accordance with a or b in Section 5.15.4.6.7, the results from that verification will become the approved JMF for production. If payment factor is implemented by Ashghal**,** the targets established in the approved JMF will be used for determination of pay factors (PF) for general production according to the details outlined in Appendix A..

3 The Contractor shall employ test data obtained for the HMA produced in compliance with the JMF to establish initial control charts for the HMA production process. These charts shall be used to determine if variability has occurred which is due to assignable causes which must be remedied. Control charts shall be refined with test results obtained during the mix verification and first week of routine HMA mix production in accordance with the SUPERPAVE mix design.

4 Mix Verification will be performed for each mix type specified in the contract on the first day of production for that specific mix. The mix verification will remain valid until the contractor's quality control and or the acceptance testing indicates that changes have taken place and the JMF as established by the mix verification will not produce mix meeting acceptance requirements. When testing indicates that the current Mix Verification is no longer valid a new Mix Verification shall be performed for the specified mix.

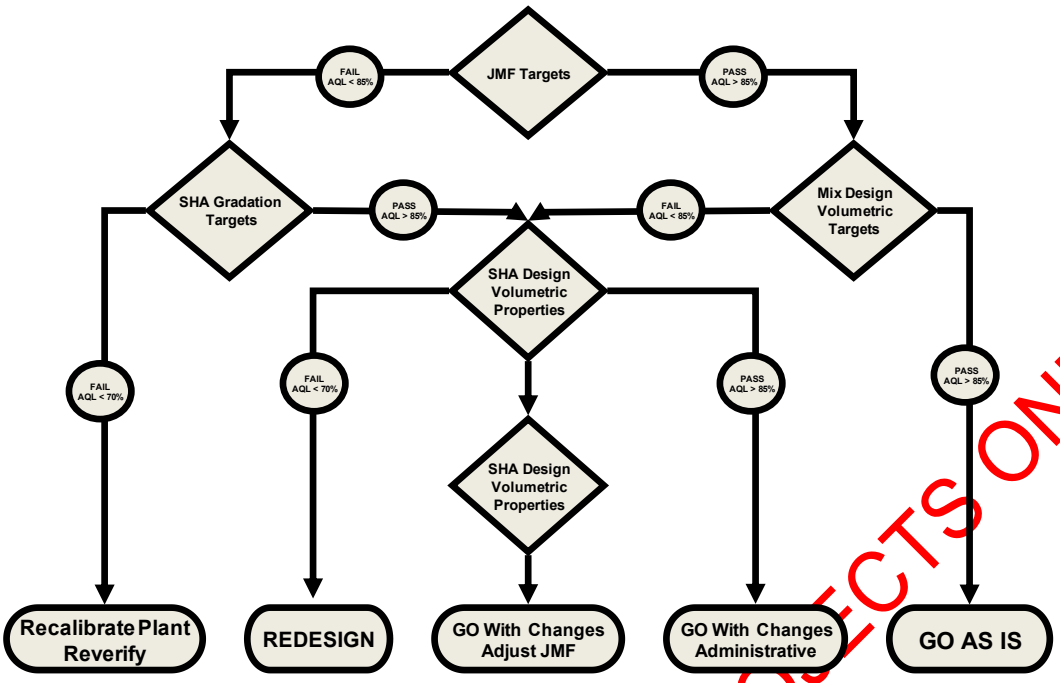

Figure 5.1: Mix verification Decision Tree

5.15.4.7.8 Reporting

1 HMA verification shall be reported on the form shown in Table 5.7.

2 Individual test reports will be recorded as specified in the individual test procedures

Table 5.7: Mix Verification Report Form

Design Parameter	Superpave Criteria	JMF	Avg. Mix Verification
Binder Sp. Gr. (PGXX-YY)			
Stockpile Percentages 1. 2.	 n/a n/a		
Blend Agg. Gravities Bulk, G_{sb} Apparent, G_{sa} % Absorption, H_2O	 ±0.018±0.012 <2.0%		
Consensus Properties Coarse Agg Angularity Fine Agg Angularity Flat & Elongated Sand Equivalent	 --- / --- min --- % min --- % max --- % min		
Optimum Asphalt, P_b	n/a	%	%
Mix Properties Air Voids, V_a VMA at N_{des} VFA at N_{des} $\%G_{mm}$ at N_{ini} = -- $\%G_{mm}$ at N_{des} = -- $\%G_{mm}$ at N_{max} = -- $P_{0.075}/P_{be}$ Rice, G_{mm} Effective, G_{se}	 4.0 % --- % --/-- % -- % max 96 % 98 % max 0.6 to 1.2*--- n/a n/a		
Moisture Sensitivity, AASHTO T 283	80% min	----	
Mixing Temperature Range *	150 - 190 cSt	□C	□C
Compaction Temp. Range *	250 - 310 cSt	□C	□C

** For determining the Laboratory Mixing and Compaction temperatures, the following method shall be followed:*

- Determine the laboratory mixing and compaction temperatures using a plot of viscosity versus temperature.
- Select mixing and compaction temperatures corresponding with binder Viscosity values of 0.17±0.02 Pa.s and 0.28±0.03 Pa. s respectively.
- Note that these viscosity ranges are not valid for modified asphalt binders. The designer should consider the manufacturer's Recommendations when establishing mixing and compaction temperatures for modified binders.
- It is strongly recommended that the maximum binder mixing temperature should never exceed 177 °C.
- The following temperature values can be used as a guide line if the accurate data is not available at Site.

Binder Grade	Plant Binder Storage Temp °C	Plant mixing Temp °C	Site Compaction Temp -behind Paver °C	Min. Temperature a compaction completi °C
PG 76-22	157-166	152-168	155-164 °C	145 °C
PG 76-10	157-166	165-177	158-164 °C	145 °C

5.15.4.8 Statistical Evaluation of work and Percent within Limit

5.15.4.8.1 Statistical Evaluation

1 Statistical evaluation of work is a method of analyzing inspection or test results to determine conformity with the contract requirements.

2 For work evaluated based on statistical evaluation, both the PWA and Contractor assume some risk. The Government's risk is the probability that work of a rejectable quality level is accepted. The Contractor's risk is either the probability that work produced at an acceptable quality level (AQL) is rejected (α) or the probability that the work produced at the AQL is accepted at less than the contract price (α_{100}).

3 Acceptable quality level is the lowest percentage of work within the specification limits that is considered acceptable for payment at contract price. There are 2 categories. Category I is based on an AQL of 95 percent. Category II is based on an AQL of 90 percent. In both cases, the Contractor's risk (α_{100}) is 5 percent and the risk of rejection (α) is significantly lower.

4 As an incentive to produce uniform quality work and to offset the Contractor's risk, a final payment greater than the contract price may be obtained under certain conditions.

5 The quality characteristics to be evaluated, lot size, sampling frequency, sampling location, test methods, specification limits, and category are as follows:

(a) Quality characteristics. The quality characteristics are listed in Table 5.8.

(b) Lot size. A lot is a discrete quantity of work to which the statistical evaluation procedure is applied. A lot for bituminous paving mix normally represents 10,000 metric tonnes of production.

(c) Sampling frequency. The frequency of sampling is listed in Table 5.8. The frequency rate shown normally results in10 samples per lot. If due to production sequencing or other disruptions a full 10,000 tonnes lot is not produced the minimum number required to perform a statistical evaluation is 3. If payment factor is implemented by Ashghal, The maximum obtainable pay factor with 3, 4, or 5 samples is 1.01. A minimum of 8 samples are required to obtain a 1.05 pay factor in accordance with the payment based on acceptance testing results outlined in ***Appendix A.*** If due to the end of production of a specific JMF there are less than 7 samples in a lot those samples may be combined with the samples of the previous lot.

(d) Sampling location. The exact location of sampling will be specified by the Engineer based on random numbers.

(e) Test methods. The test methods used to test the sample are listed in Table 5.8.

(f) Specification limits. The specification limits for the quality characteristics are listed in the contract provisions for the work in question.

Table 5.8: Minimum Frequency for Production Acceptance Sampling/Testing

TEST		MINIMUM FREQUENCY	Pay Factors (refer to Appendix A).
Aggregate Gradation		1/1000 tonnes	
Max. Specific Gravity of Asphalt Concrete (Rice Method)**			
Bulk Specific Gravity of Asphalt Concrete (gyratory)*			
	N_{design}		
Air Voids @ N_{design}			PF
Voids in Mineral Aggregate @ N_{design}			PF
Dust to Binder Ratio			
Asphalt Binder Content			PF
Density, In Place cores		2/1000 tonnes	PF

5.15.4.8.2 Percent within Limits

1 The Variability-Unknown/Standard Deviation Method will be used to determine the estimated percentage of the lot that is within specification limits.

2 The number of significant figures used in the calculations will be according to AASHTO R 11, absolute method.

3 The estimated percentage of work per lot that is within the specification limits for each quality characteristic will be determined as follows:

(a) Calculate the arithmetic mean ($\bar{x}$) of the test values: $\bar{x} = \frac{\sum x}{n}$

where: $\sum$ = summation of

x = individual test value

n = total number of test values

(b) Calculate the standard deviation (s):

$$s = \sqrt{\frac{n\sum(x^2) - (\sum x)^2}{n(n-1)}}$$

where: $\sum(x^2)$ = summation of the squares of individual test values

$(\sum x)^2$ = summation of the individual test values squared

(c) Calculate the upper quality index (Q_U): $Q_U = \frac{USL - \bar{X}}{s}$

where: USL = upper specification limit

Note: The USL is equal to the contract specification limit or the target value plus the allowable deviation.

(d) Calculate the lower quality index (Q_L): $Q_L = \frac{\bar{X} - LSL}{s}$

where: LSL = lower specification limit

Note: The LSL is equal to the contract specification limit or the target value minus the allowable deviation.

(e) From Table 5.9, determine P_U (the estimated percentage of work within the USL). P_U corresponds to a given Q_U. If a USL is not specified, P_U is 100.

(f) From Table 5.9, determine P_L (the estimated percentage of work within the lot within the LSL). P_L corresponds to a given Q_L. If an LSL is not specified, P_L is 100.

(g) Calculate the percent within limits (PWL) which is the total estimated percentage of work within the USL and LSL ($PWL = P_U + P_L - 100$).

(h) Repeat steps 1 through 7 for each quality characteristic listed for statistical evaluation.

Table 5.9: Estimated Percent of Work within Specification Limits

Estimated Percent within Specification Limits (P_U or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L									
	n=3	n=4	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17
100	1.16	1.49	1.72	1.88	1.99	2.07	2.13	2.20	2.28	2.34
99	-	1.46	1.64	1.75	1.82	1.88	1.91	1.96	2.01	2.04
98	-	1.43	1.58	1.66	1.72	1.75	1.78	1.81	1.84	1.87
97	1.15	1.40	1.52	1.59	1.63	1.66	1.68	1.71	1.73	1.75
96	-	1.37	1.47	1.52	1.56	1.58	1.60	1.62	1.64	1.65
95	1.14	1.34	1.42	1.47	1.49	1.51	1.52	1.54	1.55	1.56
94	-	1.31	1.38	1.41	1.43	1.45	1.46	1.47	1.48	1.49
93	1.13	1.28	1.33	1.36	1.38	1.39	1.40	1.41	1.41	1.42
92	1.12	1.25	1.29	1.31	1.33	1.33	1.34	1.35	1.35	1.36
91	1.11	1.22	1.25	1.27	1.28	1.28	1.29	1.29	1.30	1.30
90	1.10	1.19	1.21	1.23	1.23	1.24	1.24	1.24	1.25	1.25
89	1.09	1.16	1.18	1.18	1.19	1.19	1.19	1.19	1.20	1.20
88	1.07	1.13	1.14	1.14	1.15	1.15	1.15	1.15	1.15	1.15
87	1.06	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.11	1.11
86	1.04	1.07	1.07	1.07	1.07	1.06	1.06	1.06	1.06	1.06
85	1.03	1.04	1.03	1.03	1.03	1.03	1.02	1.02	1.02	1.02
84	1.01	1.01	1.00	0.99	0.99	0.99	0.99	0.98	0.98	0.98
83	0.99	0.98	0.97	0.96	0.95	0.95	0.95	0.95	0.94	0.94
82	0.97	0.95	0.93	0.92	0.92	0.92	0.91	0.91	0.91	0.91
81	0.95	0.92	0.90	0.89	0.88	0.88	0.88	0.87	0.87	0.87
80	0.93	0.89	0.87	0.86	0.85	0.85	0.84	0.84	0.84	0.83
79	0.91	0.86	0.84	0.82	0.82	0.81	0.81	0.81	0.80	0.80
78	0.88	0.83	0.81	0.79	0.79	0.78	0.78	0.77	0.77	0.77
77	0.86	0.80	0.77	0.76	0.75	0.75	0.74	0.74	0.74	0.73
76	0.83	0.77	0.74	0.73	0.72	0.72	0.71	0.71	0.70	0.70
75	0.81	0.74	0.71	0.70	0.69	0.69	0.68	0.68	0.67	0.67
74	0.78	0.71	0.68	0.67	0.67	0.65	0.65	0.65	0.64	0.64
73	0.75	0.68	0.65	0.64	0.63	0.62	0.62	0.62	0.61	0.61
72	0.73	0.65	0.62	0.61	0.60	0.59	0.59	0.59	0.58	0.58
71	0.70	0.62	0.59	0.58	0.57	0.57	0.56	0.56	0.55	0.55
70	0.67	0.59	0.56	0.55	0.54	0.54	0.53	0.53	0.52	0.52
69	0.64	0.56	0.53	0.52	0.51	0.51	0.50	0.50	0.50	0.49
68	0.61	0.53	0.50	0.49	0.48	0.48	0.48	0.47	0.47	0.47
67	0.58	0.50	0.47	0.46	0.45	0.45	0.45	0.44	0.44	0.44
66	0.55	0.47	0.45	0.43	0.43	0.42	0.42	0.42	0.41	0.41
65	0.51	0.44	0.42	0.40	0.40	0.39	0.39	0.39	0.38	0.38
64	0.48	0.41	0.39	0.38	0.37	0.37	0.36	0.36	0.36	0.36
63	0.45	0.38	0.36	0.35	0.34	0.34	0.34	0.33	0.33	0.33
62	0.41	0.35	0.33	0.32	0.32	0.31	0.31	0.31	0.30	0.30
61	0.38	0.30	0.30	0.30	0.29	0.28	0.28	0.28	0.28	0.28
60	0.34	0.28	0.28	0.25	0.25	0.25	0.25	0.25	0.25	0.25
59	0.31	0.27	0.25	0.23	0.23	0.23	0.23	0.23	0.23	0.23
58	0.30	0.25	0.23	0.20	0.20	0.20	0.20	0.20	0.20	0.20
57	0.25	0.20	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
56	0.20	0.18	0.16	0.15	0.15	0.15	0.15	0.15	0.15	0.15
55	0.18	0.15	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
54	0.15	0.13	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
53	0.10	0.10	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.08	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.05	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: If the value of Q_U or Q_L does not correspond to a value in the table, use the next lower Q value. If Q_U or Q_L are negative values, P_U or P_L is equal to 100 minus the table value for P_U or P_L.

5.15.4.8.3 Partial and Final Acceptance

1 Maintain the work during construction and until the project is accepted. Damage caused by the Contractor prior to final acceptance of the entire project will be repaired at the Contractor's expense.

2 Partial acceptance. When a separate portion of the project is completed, a final inspection of that portion may be requested. If the portion is complete and in compliance with the contract, it may be accepted. If accepted, the Engineer will relieve the Contractor of further responsibility for maintenance of the completed portion. Partial acceptance does not void or alter any of the terms of the contract.

1 When public traffic is accommodated through construction and begins using sections of roadway as they are completed, continue maintenance of such sections until final acceptance.

2 Final acceptance. When notified that the entire project is complete, an inspection will be scheduled. If all work is determined to be complete, the inspection will constitute the final inspection and the Contractor will be notified in writing of final acceptance as of the date of the final inspection.

3 If the inspection discloses any unsatisfactory work, the Engineer will provide to the Contractor a list of the work that is incomplete or requires correction. Immediately complete or correct the work. Furnish notification when the work has been completed as provided above.

5.15.4.9 Payment based on acceptance testing results and Dispute Resolution

If implemented based on an official notification from ASHGHAL, the Payment based on acceptance testing results and Dispute Resolution Process shall be in accordance to the procedure outlined in ***Appendix A***.

Table 5.10 Not used

Table 5.11 Not used

5.15.4.10 Materials

5.15.4.10.1 Fine Aggregate

1 Fine aggregate is that portion of the mineral aggregate passing the 4.75mm.

2 Fine aggregate shall consist of crushed hard durable rock and shall be of such gradation that when combined with other aggregates in proper proportions, the resultant mixture will meet the required gradation. The use of wadi, beach or dune sand for asphalt works is not permitted.

3 Fine aggregate shall be non-plastic and chemically stable.

4 The source of natural fine aggregate is considered to be the crusher site at which it is produced. Crushed fine aggregate shall be produced by crushing clean coarse aggregate and shall not be thin, flaky or elongated. Sampling of fine aggregate shall be in accordance with AASHTO T 2. Sieve analysis shall be in accordance with AASHTO T 27 and AASHTO T 11.

5 Fine aggregate shall be clean and free from organic matter, clay, cemented particles and other extraneous or detrimental materials.Individual stockpiles of crushed fine aggregate when tested in accordance with AASHTO T 176 shall have a sand equivalent of not less than 45. Individual stockpiles of aggregate containing more than 10 percent by weight of fine aggregate shall be tested for sand equivalent

6 The loss by the magnesium sulphate soundness test, as determined by AASHTO T 104, shall be a maximum of 15 %.

7 The fine aggregate shall have a maximum plasticity index of 1% when sampled from every stockpile. The liquid limit shall be determined according to AASHTO T 89 and the plastic limit shall be determined according to AASHTO T 90.

8 In addition to fine aggregate source specifications of individual stockpiles, the fine aggregate blend should meet the requirement in the mixture design procedure in Section 5.15.4.12.

9 The Contractor shall ensure that the sources of all fine aggregates have been approved by the Municipality concerned.

10 Aggregate imported for a project and stockpiled at the contractor's HMA plant site shall be tested for compliance with aggregate requirements before starting a new project. Or, if a stockpile is being built for a project then the stockpile shall be tested for gradation every 3,000 tonnes. Stockpiles should be tested for magnesium sulphate at least once per project or every 30,000 tonnes or once a year which ever results in more tests.

5.15.4.10.2 Coarse Aggregate

1) Coarse aggregate is that portion of the mineral aggregate retained on the 4.75mm sieve. Coarse aggregate shall consist of crushed natural stones and gravel. Crushed particles shall be cubic and angular in shape and shall not be thin, flaky or elongated. The gradation shall be such that when combined with other aggregate fraction in proper proportions, the resultant mixture will meet the required gradation.

1) The source of crushed aggregate is considered to be the crushing site from which it is produced. Sampling of coarse aggregate shall be in accordance with AASHTO T 2. Sieve analysis shall be in accordance with AASHTO T 27 and AASHTO T 11.

2) Coarse aggregate shall be clean and free from organic matter, clay, cemented particles and other extraneous or detrimental material. The percentage of deleterious materials in each stockpile should not exceed 1.5% as determined using AASHTO T 112.

3) The degree of crushing determined using ASTM D-5821 for each stockpile shall be such that 100% by weight of aggregate having at least one fractured face and 85% having at least two fractured faces.

4) The percent of flat and elongated particles, determined using ASTM D-4791, with a ratio of longest to shortest dimension of 5:1 should not exceed 10% by weight for each stockpile.

5) The loss by magnesium sulphate soundness test, as determined using AASHTO T 104, shall be a maximum of 10 % for aggregate used in wearing and intermediate courses and a maximum of 15 % for aggregate used in base course.

6) The Los Angeles Abrasion Loss, as determined by AASHTO T 96, shall be a maximum of 25 % for wearing course aggregate and 30 % for intermediate and base courses aggregate.

7) The Polished Stone Value, as determined by AASHTO T 279, for coarse aggregates shall be a minimum of 40% for wearing course aggregate used in main lanes. The Polished Stone Value shall be a minimum of 50% for approaches to and across major junctions; gradients steeper than 10%, and approaches to roundabouts, traffic signals, pedestrian crossings, railway level crossings or similar.

8) The average water absorption by the aggregate for all courses shall not exceed 1.5 % except for base course where it shall not exceed 2.0 % when tested in accordance using AASHTO T 85.

9) In addition to course aggregate source specifications of individual stockpiles, the coarse aggregate blend should meet the requirement in the mixture design procedure in Section 5.15.4.12.

10) The Contractor shall ensure that the sources of all coarse aggregates have been approved by the Municipality concerned.

11) Aggregate imported for a project and stockpiled at the contractor's HMA plant site shall be tested for compliance with aggregate requirements before starting a new project. Or, if a stockpile is being built for a project then the stockpile should be tested for gradation every 3,000 tonnes. Stockpiles should be tested for magnesium sulphate at least once per project or every 30,000 tonnes or once a year which ever results in more tests.

5.15.4.10.3 Mineral Filler

1 Mineral filler when separately supplied from an external source shall consist of finely ground mineral matter such as rock dust, hydrated lime, cement or other material which can satisfy the Engineer will produce asphalt mixes of at equal or better quality. It shall be free from organic substances and clay, shall be thoroughly dry and free from agglomerations, shall be non-plastic and shall meet the following grading requirements:

Sieve (mm)	% Mass Passing
0.600	100
0.300	95-100
0.150	90-100
0.075	70-100

2 Hydrated lime shall conform to the definitions given in ASTM C51. Sampling, packaging and marking of hydrated lime shall be in accordance with ASTM C50. Storage and use of the hydrated lime shall at all times be such as to protect the material from the weather.

3 When cement is used as mineral filler, it shall meet the requirements of ASTM C 10.

5.15.4.10.4 Bitumen

1 The bitumen specified for use in the asphalt mixes shall meet the requirements of AASHTO MP 19. The grade specified is designated in Section 5.15.4.12 Bituminous Paving Course Mix Design. The bitumen shall only be obtained from approved sources.

2 When bitumen grades PG76-10 H, V, or E are specified the bitumen will be required to meet the requirements of TP 70 (Figure 2.1 Passing % recovery in ASSHTO TP 70).

3 The bitumen shall be prepared by the refining of petroleum. It shall be uniform in character and shall not foam when heated to 175°C. Blending of bitumen materials from different refineries will be permitted only with the written approval of the Engineer.

4 The prime coat shall be cutback bitumen consisting of a PG 64-22 grade bitumen and kerosene. The residue from the distillation test, carried out to 360° C, shall be a minimum of 55% (by volume), as determined by the difference method.

5.15.4.11 Bituminous Paving Courses Mix Design

5.15.4.11.1 Mix Design Criteria

1 The types of bituminous paving mixes shall be as designated on the project drawings or in the contract documents.

2 Bituminous paving course mix designs shall be performed by the Contractor and verified by the Engineer. A certified technician shall perform the mix design.

3 Laboratory mix design shall be performed in accordance with the Superpave Mix Design Section 5.15.4.12.3.

5.15.4.11.2 Recycled Asphalt Pavement Use

1 Do not use recycled asphalt pavement in the top lift.

2 The percent binder replacement (PBR) of virgin binder with binder from the RAP shall not exceed 35%.

3 Up to and including 25 PBR with RAP may be used in the mix without adjusting the asphalt binder grade. For mixes with over 25 PBR, and up to and including 35 PBR, recycled asphalt pavement decrease the asphalt binder grade one performance level for both the upper and lower grade level of the asphalt binder specified or use an approved blending procedure with a recycling agent. Do not use more than 35 percent recycled asphalt pavement by PBR.

4 For mixture design, use the specific gravity of the new (virgin) asphalt binder as the specific gravity of the asphalt binder in the recycled asphalt pavement. For calculation purposes, estimate the amount of absorbed asphalt from historical records, and use the estimate to back-calculate the bulk specific gravity of the Aggregate properties of the recycled asphalt pavement shall meet all aggregate requirements for virgin aggregates used in the specified mix.

5.15.4.11.3 Specification for Superpave Volumetric Mix Design

5.15.4.11.3.1 Definitions and Scope

1 This specification for Superpave volumetric mix design uses aggregate and mixture properties to produce a hot mix asphalt (HMA) job-mix formula.

2 This standard specifies minimum quality requirements for binder, aggregate, and HMA for Superpave volumetric mix designs.

3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use*.

5.15.4.11.3.2 Bitumen Requirements

1 The bitumen shall be a performance-graded (PG) binder, meeting the requirements of MP 19, which is appropriate for the climate and traffic-loading conditions at the site of the paving project or as specified by the contract documents.

2 The designated high temperature grade for Qatar is 76°C and the designated low temperature grade is -10°C.

If traffic speed or the design ESALs warrant, adjust the high-temperature grade for mixtures placed within 100 mm of the surface and placed in any travel lane to meet MP 19 high temperature traffic levels as indicated in Table 5.12 to account for the anticipated traffic conditions at the project site.

Table 5.12: Binder Selection on the Basis of Traffic Speed and Traffic Level

Design ESALs[a] (Million)	Recommendations for the High-Temperature Grade of the Binder		
	Traffic Load Rate		
	Standing[b]	Slow[c]	Standard[d]
< 0.3	S[e]	S	S
0.3 to < 3	H	S	S
3 to < 10	V	H	H
10 to < 30	E	V	V
≥ 30	E	E	E

[a] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[b] *Standing Traffic*—where the average traffic speed is less than 20 km/h.

[c] *Slow Traffic*—where the average traffic speed ranges from 20 to 70 km/h.

[d] *Standard Traffic*—where the average traffic speed is greater than 70 km/h.

[e] S designates Standard Grade, H designates Heavy Grade, V designates Very Heavy Grade, E designates Extreme Grade under MP 19

5.15.4.11.3.3 Combined Aggregate Requirements

3 *Nominal Maximum Size*—the combined aggregate shall have a nominal maximum aggregate size of 4.75 mm to 19.0 mm for HMA surface courses and no larger than 37.5 mm for HMA subsurface courses. Additional guidance on selection of the appropriate nominal maximum size mixture can be found in the National Asphalt Pavement Association's IS 128.

4 *Gradation Control Points*—the combined aggregate shall conform to the gradation requirements specified in Table 5.13 and when tested according to AASHTO T11 and AASHTO T27. An example of the 0.45 power gradation chart is shown in Figure 5.2.

5 Gradation *Classification*—the combined aggregate gradation shall be classified as coarse-graded when it passes below the Primary Control Sieve (PCS) control point as defined in Table 5.14. All other gradations shall be classified as fine-graded.

6 *Coarse Aggregate Angularity Requirements*—The aggregate shall meet the percentage of fractured faces requirements, specified in Table 5.15, measured according to ASTM D 5821.

7 *Fine Aggregate Angularity Requirements*—the aggregate shall meet the uncompacted void content of fine aggregate requirements, specified in Table 5.15, measured according to AASHTO T 304, Method A.

8 *Sand Equivalent Requirements*—the aggregate shall meet the sand equivalent (clay content) requirements, specified in Table 5.15, measured according to AASHTO T 176.

1 *Flat-and-Elongated Requirements*—the aggregate shall meet the flat-and-elongated requirements, specified in Table 5.15, measured according to ASTM D 4791, with the exception that the material passing the 10.0-mm sieve and retained on the 5.0-mm sieve shall be included. The aggregate shall be measured using the ratio of 5:1, comparing the length (longest dimension) to the thickness (smallest dimension) of the aggregate particles.

Table 5.13 Aggregate Gradation Control Points

Sieve Size	*Nominal Maximum Aggregate Size - Control Points (Percent Passing)*											
	37.5 mm		25.0 mm		19.0 mm		12.5 mm		9.5 mm		4.75 mm	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
50.0 mm	100	—	—	—	—	—	—	—	—	—	—	—
37.5 mm	90	100	100	—	—	—	—	—	—	—	—	—
25.0 mm	—	90	90	100	100	—	—	—	—	—	—	—
19.0 mm	—	—	—	90	90	100	100	—	—	—	—	—
12.5 mm	—	—	—	—	—	90	90	100	100	—	100	—
9.5 mm	—	—	—	—	—	—	—	90	90	100	95	100
4.75 mm	—	—	—	—	—	—	—	—	—	90	90	100
2.36 mm	15	41	19	45	23	49	28	58	32	67	—	—
1.18 mm	—	—	—	—	—	—	—	—	—	—	30	60
0.075 mm	0	6	1	7	2	8	2	10	2	10	6	12

Table 5.14 Gradation Classification

PCS Control Point for Mixture Nominal Maximum Aggregate Size (% Passing)					
Nominal Maximum Aggregate Size	37.5 mm	25.0 mm	19.0 mm	12.5 mm	4.75 mm
Primary Control Sieve	9.5 mm	4.75 mm	4.75 mm	2.36 mm	2.36 mm
PCS Control Point (% Passing)	47	40	47	39	47

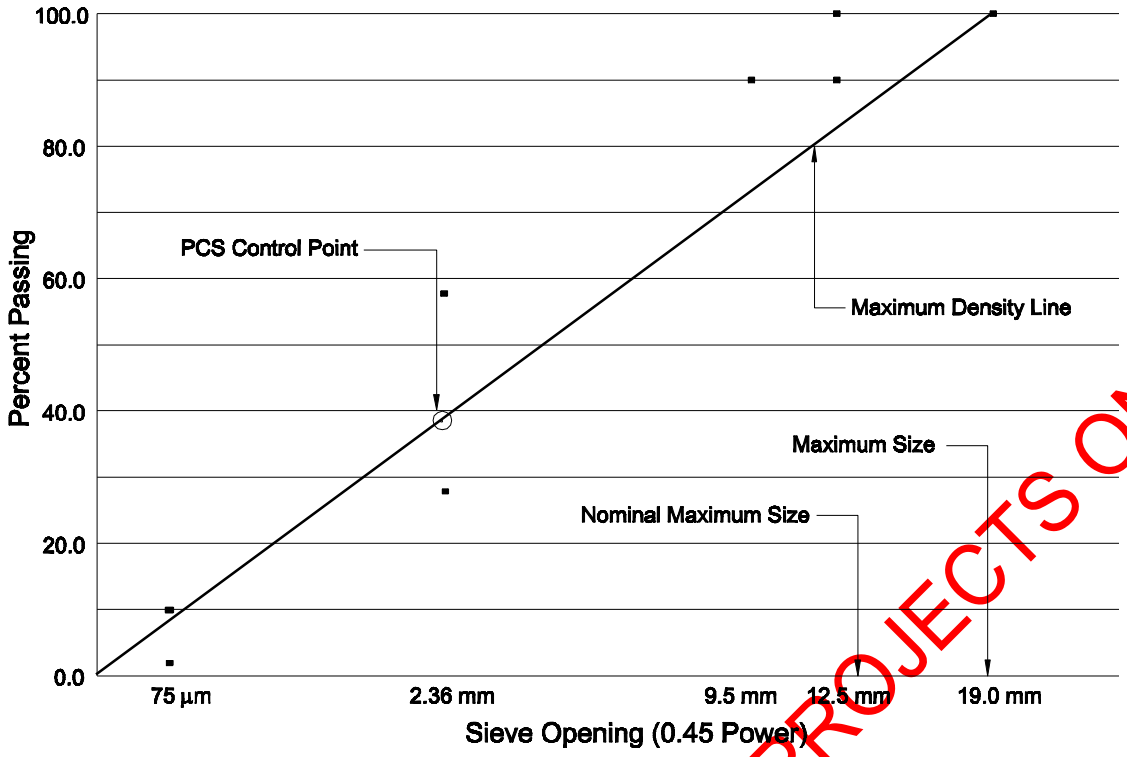

Figure 5.2 Superpave Gradation Control Points for a 12.5-mm Nominal Maximum Size Aggregate Gradation

Table 5.15 Superpave Aggregate Consensus Property Requirements

Design ESALs[a] *(Million)*	*Fractured Faces, Coarse Aggregate,*[c] *Percent Minimum*	*Uncompacted Void Content of Fine Aggregate, Percent Minimum*	*Sand Equivalent of Fine Aggregate, Percent Minimum*	*Flat and Elongated, of Coarse Aggregate*[c] *Percent Maximum*
<10	100/85[b]	45	45	10
10 to <30	100/90	45	45	10
≥30	100/100	45	50	10

[a] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[b] 100/85 denotes that 100 percent of the coarse aggregate has one fractured face and 85 percent has two or more fractured faces.

[c] This criterion does not apply to 4.75-mm nominal maximum size mixtures.

5.15.4.11.3.4 Superpave Design Requirements

The SuperPave Mix design criteria for Asphalt Surface (Wearing) Course (SC), Asphalt Intermediate Course (IC) and Asphalt Base Course (BC) shall be as outlined in Tables 5.16a to 5.16f:

Table 5.16a : Criteria for Superpave Mixtures by Asphalt Course type		
Mix Property	**Criteria**	
	SC and IC	**BC**
Binder Grade	PG grade based on specific project requirements	
Aggregates Properties	See Table 5.16b	
Nominal Maximum Aggregate Size (NMAS)	19.0 mm	Minimum 19.0 mm
$N_{initial}$	9	9
N_{design}	125	125
N_{max}	205	205
$\%G_{mm}$ at $N_{initial}$ (V_a at $N_{initial}$, %)	≤ 89 (≥ 11)	≤ 89 (≥ 11)
$\%G_{mm}$ at N_{design} (V_a at N_{design}, %)	94.5 – 95.5 (4.5 – 5.5)	95.5 – 96.0 (4.0 – 4.5)
$\%G_{mm}$ at N_{max} (V_a at N_{max}, %)	≤ 97.5 (≥2.5)	≤ 98.0 (≥2)
VMA (%) at N_{design}	See Table 5.16c	See Table 5.16c
VFA (%) at N_{design}	65 – 75	60 – 75
Dust Proportion (DP)	0.6 – 1.2 See Note in Table 5.16d	0.6 – 1.2 See Note in Table 5.16d
Plant Produced Mixtures at the Design Binder Content		
Tensile Strength at 25°C (AASHTO T283)	Min. 700 KPa	Min. 700 KPa
Tensile Strength Ratio at 25°C (AASHTO T283)	Min. 80%	Min. 80%
Dynamic Modulus (E*) at Va=7±0.5%, 10 Hz, 45°C (AASHTO TP79 and PP60)	Min. 1,900 MPa On Plant Mixtures	Min. 1,900 MPa On Plant Mixtures
Flow Number (FN) at Va=7±0.5%, 55°C(AASHTO TP79 and PP60)	Min. 740 On Plant Mixtures	Min. 740 On Plant Mixtures
Properties of Mixtures On-Site		
In-place air voids, Va (%)	6 – 8	6 – 8
Mixtures Properties	See Tables 5.16e and 5.16f	See Tables 5.16e and 5.16f

Table 5.16b: Aggregate Properties for Superpave Asphalt Mixtures

Aggregate	Property	Test	Specification
Fine Agg.	Size	ASTM C33/ C136	≤ 4.75 mm
	Plasticity Index-hot bins	ASTM D4318	NP
	Sand Equivalent on Individual Stockpiles	ASTM D2419	≥ 40
	Sand Equivalent on Combined Gradation	ASTM D2419	≥ 45* ≥ 50
	Magnesium Sulfate Soundness (5 Cycles)	ASTM C88	≤ 15%
	Un-compacted Voids	ASTM C1252	≥ 45%
	Water Absorption	ASTM C127	SC/IC: ≤ 1.5% BC: 2.0%
Coarse Agg.	Size	ASTM C33/ C136	> 4.75 mm
	1-Fractured Face	ASTM D5821	100%
	2-Fractured Faces	ASTM D5821	≥ 85%* ≥ 90% ≥ 100%
	Deleterious Materials	ASTM C142	Free
	Flat and Elongated	ASTM D4791	≤ 10%
	Magnesium Sulfate Soundness (5 Cycles)	ASTM C88	SC/IC: ≤ 10% BC: ≤ 15%
	Los Angeles Abrasion Loss	ASTM C131/C535	SC: ≤ 25% IC/BC: 30%
	Water Absorption	ASTM C127	SC/IC: ≤ 1.5% BC: 2.0%
	Polished Stone Value **	AASHTO T279	≥ 45%

**Depending on Design Traffic Level*
***Only for Wearing Course used in Main Lanes*

Table 5.16c: VMA as a Function of Nominal Maximum Aggregate Size

Nominal Maximum Aggregate Size (mm)	Minimum VMA (%)
9.5	15
12.5	14
19.0	13
25.0	12
37.5	11

Table 5.16d: Gradation Classification

NMAS	37.5mm	25.0mm	19.0mm	12.5mm	9.5mm
Primary Control Sieve (PCS)	9.5mm	4.75mm	4.75mm	2.36mm	2.36mm
Percent passing PCS (%)	47	40	47	39	47

NOTE: If the aggregate gradation passes beneath the PCS point specified above, the dust-to-binder ratio range may be increased from 0.6 – 1.2 to 0.8 – 1.6 at PWA's discretion.

Table 5.16e: Sampling/Testing Frequency of Field Mixtures

Superpave PG Full Grade MP19	• Beginning of project • Change in source • 1 test per 50000t of asphalt mix per lift
Superpave PG MSCR at High Temp DSR at Interm. Temp	• 1 test per 10000t of asphalt mix per lift
Field Density – Nuclear Method	• 1 test per paving day per lift • SC: 1 test per 35t of asphalt mix per lift • BC: 1 test per 70t of asphalt mix per lift
Field Density and Pavement Thickness (using cores)	• 1 test per paving day per lift • SC: 1 test per 100t of asphalt mix per lift • BC: 1 test per 200t of asphalt mix per lift
Extracted Gradation And Binder Content	• 1 test per paving day per lift • 1 test per 500t of asphalt mix per lift • Every change in JMF
G_{mm}*	• 1 test per paving day per lift • 1 test per 500t of asphalt mix per lift • Every change in JMF
Va	• 1 test per paving day per lift • 1 test per 500t of asphalt mix per lift
VMA	• 1 test per paving days per lift • 1 test per 500t of asphalt mix per lift
VFA	• 1 test per paving days per lift • 1 test per 500t of asphalt mix per lift
DP	• 1 test per paving days per lift • 1 test per 500t of asphalt mix per lift
Tensile Strength and Tensile Strength Ratio	• 1 test per 10000t of asphalt mix per lift • 1 test per 6 paving days per lift
Dynamic Modulus	• 1 test per 10000t of asphalt mix per lift • 1 test per 6 paving days per lift
Flow Number	• 1 test per 10000t of asphalt mix per lift • 1 test per 6 paving days per lift

**If the measured G_{mm} varies by more than 0.044 from the JMF, the Va, VMA, VFA, and DP shall be measured and compared to the criteria.*
NOTE: sampling/testing shall be completed at the first occurring frequency.

Table 5.16f: Construction Tolerances for Field Mixtures

Mix Property	Tolerance Limit		
	BC	IC	SC
Asphalt Binder Content	±0.30%	±0.20%	±0.20%
Gradation Passing 4.75 mm and larger sieves	±5%	±4%	±4%
Gradation Passing 2.36mm and to 75µm Sieve	±4%	±3%	±3%
Gradation Passing 75µm Sieve	±1.5%	±1.5%	±1.3%
Air Voids (V_a) at N_{design}	±1.0%	±1.0%	±1.0%
Voids in Mineral Aggregate (VMA) at N_{design}	+2%	+2%	+2%

Table 5.17 Superpave Gyratory Compaction Effort

Design ESALs[a] (million)	Compaction Parameters			Typical Roadway Application[b]
	$N_{initial}$	N_{design}	N_{max}	
< 0.3	6	50	75	Applications include roadways with very light traffic volumes such as local roads and city streets where truck traffic is prohibited or at a very minimal level. Traffic on these roadways would be considered local in nature. Special purpose roadways serving recreational sites or areas may also be applicable to this level.
0.3 to < 3	7	65	98	Applications include many collector roads or access streets. Medium-trafficked city streets may be applicable to this level.
3 to < 30	8	80	120	Applications include many two-lane, multilane, divided, and partially or completely controlled access roadways. Among these are medium to highly trafficked city streets.
≥ 30	9	125	205	Applications include the controlled accesses roads and connections to major inter-city routes. Special applications such as truck-weighing stations or truck-climbing lanes on two-lane roadways may also be applicable to this level.

[a] The anticipated project traffic level expected on the design lane over a 20-year period. Regardless of the actual design life of the roadway, determine the design ESALs for 20 years.

[b] As defined by *A Policy on Geometric Design of Highways and Streets*, 2004, AASHTO.

5.15.4.11.4 Standard Specification for Stone Matrix Asphalt (SMA)

5.15.4.11.4.1 Definitions and Scope

1 *Stone Matrix Asphalt* (SMA)—a hot mix asphalt (HMA) consisting of two parts, a coarse aggregate skeleton and a rich asphalt binder mortar. The mixture must have an aggregate skeleton with coarse aggregate-on-coarse aggregate contact (generally referred to as stone-on-stone contact). The coarse aggregate is generally considered to be that fraction of the aggregate retained on the 5.0-mm (No. 4) sieve but may be designated as other sizes.

2 This specification covers the design of Stone Matrix Asphalt (SMA) using the Superpave Gyratory Compactor (SGC). The SMA design is based on the volumetric properties of the SMA in terms of air voids (V_a), the voids in mineral aggregate (VMA), and the presence of stone-on-stone contact.

3 SMA shall be used for the top 50 to 75 mm of bituminous paving courses where the design traffic is over 30 million ESALs. SMA may be used as the surface course of pavements with less than 30 million ESAL's in areas such as roundabouts or other intersection areas where there is likely to be significant stop and go movements.

4 This standard specifies minimum quality requirements for asphalt binder, aggregate, mineral filler, and stabilizing additives for SMA mixture designs.

5 The values stated in SI units are to be regarded as the standard. The U.S. Customary units in parentheses are for information only.

6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use*.

5.15.4.11.4.2 Bitumen Requirements

1 The asphalt binder shall be a performance grade meeting the requirements of AASHTO MP 19 and Section 5.15.4.12.3.2 Bitumen Requirements under Superpave Mix design.

5.15.4.11.4.3 Aggregate Requirements

1 *Coarse Aggregate*—Coarse aggregates shall be 100 percent crushed and conform to the quality requirements of Table 5.15 for design ESAL equal or greater than 30 million.

2 *Fine Aggregate*—Fine aggregates shall be 100 percent crushed and conform to the quality requirements of Table 5.15 for design ESAL equal or greater than 30 million.

3 *Mineral filler* shall consist of finely divided mineral matter such as crusher fines and fly ash. At the time of use, it should be sufficiently dry to flow freely and essentially free from agglomerations. Filler shall be free from organic impurities and have a plasticity index not greater than four.

4 It is recommended that mineral fillers with modified Rigden voids (IS 127) higher than 50 percent not be used in SMA. Experience has shown that fillers exceeding 50 percent excessively stiffen the SMA mortar.

5.15.4.11.4.4 Stabilizing Additive

1 A stabilizer such as cellulose or mineral fiber will be added to the mixture. The dosage rate for cellulose shall be approximately 0.3 percent or more by total mixture mass and sufficient to prevent draindown. For mineral fibers, the dosage rate shall be approximately 0.4 percent by total mixture mass and sufficient to prevent draindown. The maximum draindown will be 0.3 percent by weight of the mix when held at the plant temperature for one hour.

2 If the draindown from the plant-produced samples exceeds the draindown from laboratory-prepared samples, the quantity of the stabilizer should be increased. To maximize durability (through binder volume), fibers also can be added regardless of draindown.

5.15.4.11.4.5 SMA Design Requirements

1 The combined aggregates shall conform to the gradation requirements of Table 5.18. When the bulk specific gravities of the different stockpiles to be used in the mixture vary by more than 0.2, the trial blend gradations shall be based on the volumetric percentage.

2 The designed SMA mixture shall meet the requirements of Table 5.19.

3 For low-traffic-volume roadways or colder climates, target air void contents less than 4.0 percent can be used, but should not be less than 3.0 percent.

4 When aggregates have a Los Angeles Abrasion loss value greater than 30 percent, the desirable number of SGC design gyrations is 75.

5 Experience has shown that binder contents should be from 6.0 to 7.0 percent. Lowering the binder content below 6.0 percent can detrimentally affect the durability of the SMA. When an SMA mix cannot be designed within the minimum binder content requirements of Table 5.19 using the available aggregates, refer to the guidance given on this issue in R 46.

Table 5.18 SMA Gradation Specification Bands

Sieve, mm	Nominal-Maximum Aggregate Size					
	19 mm		12.5 mm		9.5 mm	
	Lower	Upper	Lower	Upper	Lower	Upper
25.0 mm	100					
19.0 mm	90	100	100			
12.5 mm	50	88	90	100	100	
9.5 mm	25	60	50	80	70	95
4.75 mm	20	28	20	35	30	50
2.36 mm	16	24	16	24	20	30
1.18 mm	—	—	—	—	—	21
0.60 mm	—	—	—	—	—	18
0.30 mm	—	—	—	—	—	15
0.075 mm	8.0	11.0	8.0	11.0	8.0	12.0

Table 5.19 SMA Mixture Specifications for Superpave Gyratory Compactor[a]

Property	Requirement
Air Voids,V_a %	4.0
VMA, %	17.0 min.
VCA_{MIX}, %	Less than VCA_{DRC}
TSR	0.80 min.
Draindown at Production Temperature, %	0.3 max.
Asphalt Binder Content, %	6.0 min.
[a] SMA Mixture Specifications refer to specimens compacted in accordance with AASHTO T 312 at 100 gyrations (Note 5).	

5.15.4.11.4.6 Determination of VCA in Coarse-Aggregate Fraction of Mixture

1 For best performance, the SMA must have a coarse-aggregate skeleton with stone-on-stone contact. The course-aggregate fraction is that portion of the total aggregate blend retained on the 4.75-mm (No. 4) sieve for 12.5-mm ($^1/_2$-in.) and 19-mm ($^3/_4$-in.) SMA. For the 9.5-mm ($^3/_8$-in.) nominal-maximum aggregate size SMA, the coarse-aggregate is that portion of the total aggregate blend retained on the 2.36-mm (No. 8) sieve. The condition of stone-on-stone contact within an SMA is defined as the point at which the VCA of the compacted mixture is less than the VCA of the coarse aggregate in the dry-rodded test.

2 The dry-rodded VCA of the coarse-aggregate fraction (VCA_{DRC}) is determined by compacting the stone with the dry-rodded technique in accordance with AASHTTO T 19M/T 19. When the dry-rodded density of the stone fraction has been determined, the VCA_{DRC} can be calculated using Equation 5.1:

$$VCA_{DRC} = \frac{G_{CA}\gamma_w - \gamma_s}{G_{CA}\gamma_w} \times 100 \qquad 5.1$$

where:

G_{CA} = the bulk specific gravity of the coarse aggregate (AASHTO T 85),

γ_s = the unit weight of the coarse-aggregate fraction in the dry-rodded condition [kg/m^3 (lb/ft^3)] (AASHTO T 19/T 19M), and

γ_w = the unit weight of water [1000 kg/m^3 (62.4 lb/ft^3)].

5.15.4.11.4.7 Selection of Desired Gradation

1 After the trial samples have been compacted and allowed to cool, they are removed from the molds and tested to determine their bulk specific gravity in accordance with AASHTO T 166. The uncompacted samples are used to determine the theoretical maximum density in accordance with AASHTO T 209. Using the bulk specific gravity and theoretical maximum density, the V_a, VMA, and VCA of the compacted mixture (VCA_{mix}) can be calculated using Equations 5.2, 5.3, and 5.4:

$$\text{VMA} = 100 - \left(G_{mb}/G_{sb}\right)P_s \qquad 5.2$$

$$\text{VCA}_{\text{mix}} = 100 - \left(G_{mb}/G_{CA}\right)P_{CA} \qquad 5.3$$

$$V_a = 100 \times \left(1 - \left(G_{mb}/G_{mm}\right)\right) \qquad 5.4$$

where:

G_{mb} = the bulk specific gravity of the compacted mixture (AASHTO T 166),

G_{sb} = the bulk specific gravity of the total aggregate,

P_s = the percent of aggregate in the mixture,

G_{CA} = the bulk specific gravity of the coarse-aggregate fraction (AASHTO T 85),

P_{CA} = the percent of coarse aggregate in the total mixture, and

G_{mm} = the theoretical maximum density of the mixture (AASHTO T 209).

2 Of the trial gradations evaluated, the one with the lowest percent of coarse aggregate that meets or exceeds the minimum VMA requirement, and has a VCA_{mix} less than VCA_{DRC}, is selected as the desired gradation. The trial gradation selected, based on the above conditions, is referred to as the optimum gradation.

3 If possible, the selected gradation should have a VMA somewhat higher than the minimum criteria to allow for some reduction in VMA during plant production.

4 The tensile strength ratio (TSR) of the SMA shall be at least 0.80, at 6.0 ± 1.0 percent air voids, when tested in accordance with AASHTO T 283.

5 Draindown sensitivity shall be determined on the SMA mixture in accordance with AASHTO T 305 at the anticipated plant-production temperature and shall not exceed 0.3 percent.

5.15.4.11.5 Performance Tests for Permanent Deformation and Fatigue

1 All asphalt mixtures that will be placed within the top 120mm of the pavement structure shall be tested using AASHTO T 324 “Hamburg Wheel Tracking Test of Compacted Hot Mix Asphalt,” for resistance to permanent deformation.

2 All asphalt mixtures placed in structural layers of the pavement shall be tested using AASHTO T 321 “Determining the Fatigue Life of Compacted Hot Mix Asphalt (HMA) Subjected to Repeated Flexural Bending,” for resistance to fatigue cracking.

3 Performance testing will be done as part of the asphalt mix design and the test results reported with the mix design submission to the engineer.

4 During the mix verification process a random sample of loose mix will be taken and the permanent deformation and fatigue properties of the plant produced mix will be verified.

It is permissible to use tests other than AASHTO T 324 and AASHTO T 321 for the evaluation of permanent deformation and fatigue cracking, respectively. The contractor and consultant has to demonstrate that these proposed methods are based on international standards and experiences and they are consistent with the mechanistic-empirical method

6 Specification limits for performance testing shall be as per the requirements outlined in Table 5.16b.

5.15.4.12 Delivery, Storage and Handling

1 Materials (aggregate, bitumen, fillers, etc) shall be so stored and handled as to assure the preservation of their quality and fitness for use. Materials, even though approved before storage or handling, may again be inspected and tested before use in the Works.

2 Stored material shall be located so as to facilitate their prompt inspection. All storage locations on land not owned by the Contractor shall be restored to their original condition at the Contractor's expense.

3 Handling and stockpiling of aggregates shall at all times be such as to eliminate segregation or contamination of the various sizes and to prevent contamination of materials by dust. Stockpiles shall be kept flat and built in layers not to exceed 3m. The second and subsequence layers shall be constructed so that the aggregate in that layer is not allowed to be pushed over the edge of the proceeding layer. Conveyors used for stockpiling aggregate shall be operated so that the stockpiles are built in layers and the distance from the head pulley of the conveyor to the stockpile never exceeds 3 m. Alternatively, a baffle-chutes or per4forated chimmeys can be used when a stockpile is being built with a conveyor belt.

4 Where trucks are used to construct stockpiles, the stockpiles shall be constructed one layer at a time with trucks depositing their loads as close to the previous load as possible. The use of tractors or loaders to push material deposited at one location to another location in the stockpile shall not be allowed during the construction of the stockpile, and their use shall be limited to levelling the deposited material only.

5 Stockpiles of aggregate located at permanent asphalt plant sites shall be separated by bin walls and shall be constructed on asphaltic or concrete floors. Stockpile locations and procedures at temporary asphalt plant sites shall be as approved by the Engineer.

6 Intermediate storage of hydrated lime and commercial mineral filler for equipment feeding the asphalt plant shall be silos of adequate size to ensure a minimum of one day's continuous operation.

5.15.4.13 Inspection, testing and Control

1 For verification of weights and measures, character of materials and determination of temperatures used in the preparation of the asphalt mixes, the Engineer and the QGOSM shall at all times have access to all portions of the mixing plant, aggregate plant, storage yards, crushers and other facilities used for producing and processing the materials of construction.

2 The Engineer shall have authority to instruct sampling and testing of any material supplied to the site from any source whatsoever in order to establish their compliance and to accept or reject as he deems necessary. Samples shall also be taken from completed work to determine compliance. The frequency of all sampling and testing shall be as designated in the EQAP.

3 The Contractor shall arrange for obtaining specimens of materials, asphalt mixes and samples cut from the paving courses after compaction, including the provision of necessary equipment and plant for obtaining these specimens and samples. This work shall be performed in the presence of the Engineer. The Engineer shall take possession of the samples upon their removal from the roadway unless the Contractor is authorised otherwise

4 In particular, the Contractor shall provide a portable coring machine and bits for taking 150 mm diameter full depth cores of all bituminous paving courses. The coring machine shall be available to the Engineer upon request.

5 Unacceptable Materials that do not conform to the designated requirements shall be rejected and immediately removed from the site of the works unless otherwise instructed by the Engineer. No rejected material, the defects of which have been corrected, shall be used until approval has been given by the Engineer.

5.15.4.14 Plant Generally

1 The machinery and tools used in constructing the various items involved in asphalt works shall be in good working condition and free of oil and fuel leaks. The Contractor shall maintain and preserve them for the whole duration of the work. The Engineer shall approve the machinery and tools before works begin and the Contractor shall supply adequate quantities of such machinery in order to execute the work with due speed and precision. Equipment approved for use shall not be removed from the Site without the approval of the Engineer.

2 If required the Contractor shall furnish the Engineer with the manufacturer's catalogues, specifications and other published data for the equipment and machinery he proposes to use.

3 On first erecting a HMA plant and at least once each three months thereafter, the plant shall be calibrated by a calibration service organisation approved by the QGOSM. Production shall not be permitted if the weigh batch calibration does not comply with the requirements of AASHTO M 156.

5.15.4.15 Asphalt Mixing Plant

5.15.4.15.1 General

1 The hot-mix asphalt (HMA) plant shall be the batch-type, continuous-type, or dryer drum plant meeting the requirements of AASHTO M 156.

2 All asphalt mixing plant used by the Contractor for the preparation of asphalt hot mixes shall have automated controls, so designed, coordinated and operated that they will function properly and produce HMA having uniform temperatures and compositions within the tolerances specified.

3 All HMA plants shall be capable of producing HMA within the specification tolerances for gradation and asphalt binder content.

4 For all types of plants, the ingredients shall be heated and combined in such a manner as to produce HMA which when discharged from the plant will in general vary not more than 20 °F (10 °C) from the JMF mixing temperature.

5 The plant shall be provided with accurate mechanical means for uniformly feeding each aggregate, and RAP if used, in the proper proportions so that uniform production and uniform temperature will be obtained.

6 No laboratory verification or plant trial shall be carried out unless the contractor has a certified laboratory per the Quality Control Section 5.15.4.4.3.

5.15.4.15.2 Cold Bins System

1 The plant shall include a sufficient number of cold storage bins so that there is at least one bin for each different stockpile of material being used.

2 Sufficient bins shall be provided so that <40% of the total aggregate in the JMF comes from a single bin. A minimum of four bins and feeders for aggregate will be required for Drum Mix plants. RAP will be supplied through an additional bin and feeder.

3 The aggregate feeders shall be calibrated to desired volumes and/or weight.

4 The controls of the total quantity of combined aggregates fed to the dryer shall be by a variable speed system.

5 Stockpiles shall be managed so that the gradation, aggregate quality and aggregate source remain constant so that the JMF of the HMA mix design remains constant. Stockpiles may be rehandled or rescreened to meet the JMF as described in the CQCP. Without a written and approved procedure in the CQCP intermixing of material from different stockpiles in one bin or on the ground before putting into the bin is prohibited.

6 The cold bins and loading equipment used shall be compatible to prevent overflow between the bins. Baffle plates shall also be used between bins to prevent overflow of one bin into another. Each cold bin shall include an accurate means for continuously feeding the required amount of mineral aggregate so that uniform production is achieved. The cold bins feeders will be calibrated before production starts and checked as necessary to ensure their continued accuracy. Plant calibration records will kept at the plant and will be available for inspection by the Engineer.

5.15.4.15.3 Filler Additive System

1 An approved filler additive system shall be provided. This system shall uniformly feed the required quantities of filler to the total aggregate.

2 The filler additive system shall be interlocked with the aggregate cold feed system in order to provide continual supply with the aggregate.

3 Filler is being blown into a drum asphalt plant shall be added upstream of the asphalt delivery nozzle so the filler is encapsulated by the asphalt and not drawn into the baghouse or other dust control system.

4 Adequate precautions shall be taken to protect the filler from loss or damage due to the weather; i.e. enclosed storage sheds with concrete flooring and storage silos. The capacity of all components of the filler additive system shall be such as to ensure the continuous application of filler as specified.

5 Filler may be added dry or in slurry form. When added dry, the filler storage silo and the feeder shall have satisfactory means of preventing arching or intermittent flow. A sufficient number of vibrators, augers and the like may be required to ensure the uniform and continuous flow of filler. Both the filler and water additive devices shall have well defined controls to enable easy checking, setting and calibration.

6 When filler is added as a slurry, a minimum of two slurry chambers will be provided. One chamber will be used for proportioning the filler and water into slurry consistency as directed by the Engineer. The second slurry chamber shall contain the mixed slurry and shall be provided with an accurate metering device with well defined settings to enable easy checking, setting and calibration. Both chambers shall be equipped with continuous mixing paddles or recirculating pumps in order to prevent the slurry mixture from separating.

7 The filler system shall adding filler in the form of slurry also include a mixing device. This device shall thoroughly mix the filler, water and total aggregate so that the resultant mixture is uniform in appearance and moisture content. The mixture may then be transferred directly to the asphalt plant drier or stockpiled for later use. Mixed material that remains in the stockpile for more than 30 days may require additional treatment.

5.15.4.15.4 Dryer

1 The aggregate drum (for HMA Batch Plants) drier shall be capable of uniformly drying and heating the aggregate to the moisture and temperature required without leaving any visible burned oil or carbon residue on the aggregate when discharged from the drier.

2 The plant shall be equipped with a revolving cylindrical dryer or dryers capable of heating and drying all of the fine and coarse aggregates to a temperature of 120 to 180 °C.

5.15.4.15.5 Dust Collector

1 The plant shall be provided with a dust collector designed to waste, or to return in a constant and uniform flow to the hot elevator in a batch plant or to the dryer in a drum plant per Section 5.15.4.17, all or part of the dust is collected. The amount of dust allowed to the plant will be controlled by mix specifications for dust to asphalt ratio and mix volumetrics (V_a and VMA).

5.15.4.15.6 Recording Truck Weights

1 Install a digital recorder as part of the platform truck or storage silo scales. Ensure that the recorder can produce a printed digital record of at least the gross or net weights of delivery trucks. Provide gross, tare, and net weights as well as date, time, ticket number, project, and mix type; but not all of this data need be on by the printout system. Ensure that scales cannot be manually manipulated during the printing process. Provide an interlock to prevent printing until the scales come to rest. Size the scales and recorder to accurately weigh the heaviest loaded trucks or tractor-trailers hauling asphaltic mixture. Ensure that recorded weights are accurate to within 0.1 percent of the nominal capacity of the scale.

2 If the digital recorder breaks down, the contractor may manually record weights for up to 2 working days.

5.15.4.15.7 Bitumen Storage

1 Tanks for the storage of asphalt binder shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, hot oil coils, electricity or other approved means so that no flame shall be in contact with the tank. All asphalt lines and fittings shall be steam, electric or hot oil jacketed.

2 Provisions shall be made for sampling the asphalt from the line leading to the weigh bucket or metering device. This sampling port will situated so that the bitumen sampled contains any additives added to the bitumen, such as anti-strip additives.

3 If more than one grade of asphalt binder is required for concurrent operations, an adequate tank shall be provided for each grade.

4 An armored thermometer or pyrometer which will accurately show temperatures between 200 and 400 °F (95 and 205 °C) shall be suitably located in the asphalt line or within the tank. The instrument shall be located so as to indicate to the plant personnel, the temperature of the asphalt binder.

5.15.4.16 Dryer Drum Plant

1 The heated aggregates, mineral filler, asphalt binder, and RAP when used, shall be proportioned by electronic proportioning equipment and mixed to produce a homogenous mixture in which all particles of aggregate are coated uniformly.

2 If a question as to the degree of coating should arise, AASHTO T 195 shall be used.

3 The aggregate and RAP bins shall be designed to prevent overflow of material from one bin to another. Each bin shall be provided with a variable speed belt or apron feeder with adjustable gates which can be locked.

4 Each bin shall have a cutoff system that shall automatically stop the feeding operation when any bin becomes empty.

5 The combined aggregates shall pass over a vibrating scalper that will remove all material and aggregate greater than the nominal top size gradation permitted by the specification for the mixture being produced prior to the aggregates being placed on the weigh belt.

6 The scalper shall be independent of other proportioning or weighing equipment.

7 The dryer drum mixer shall be a revolving cylindrical drum capable of heating, drying, and mixing the combined aggregates, RAP if used, mineral filler when required, and asphalt binder to produce a uniformly coated, homogenous HMA meeting all applicable specifications.

8 The dryer burner shall be equipped with automatic controls.

9 Each aggregate feeder shall have an adjustable feed control, which can be locked, with a master control that will automatically increase or decrease the production rate of each feeder proportionately when the total rate of production is changed. The revolutions per minute (RPM), tons/hour (TPH), etc. of all feeders shall be measured at the tail shaft of the feeder.

10 The feeders shall have an accuracy of ±1.0 percent of the actual quantity of material delivered.

11 The main aggregate proportioning weigh belt shall be electronically interfaced with the asphalt binder, RAP if used, and mineral filler system to proportion the required amount of each material simultaneously to the mixer. The aggregate, and RAP if used, weighing systems shall have an accuracy of ±0.5 percent of the actual material weighed by the belts. The weighing system shall also have a high-low adjustable tolerance indicator that will signal the operator audibly when the actual production rate differs from the preset rate by more than 3.0 percent.

12 Mineral Filler Control. Mineral filler shall be added to the mixer by a variable speed proportioning system interfaced with the aggregate weigh belt that will indicate total dry aggregate combined (aggregates + mineral filler) weight (mass) to the asphalt proportioning system. The mineral filler system shall have an accuracy of ±0.5 percent if the mineral filler is measured by weight (mass), or ±8.0 percent if the mineral filler is measured solely by volume, of the actual material measured by the system.

13 The mineral filler shall be added in the mixing part of the drum at the same point the asphalt binder is added in order that no filler is lost as fugitive dust.

14 The required quantity of asphalt binder shall be proportioned to the mixer via a temperature compensating meter and/or pump that will correct the quantity of asphalt binder to 15 °C), or a system approved by the Engineer. This system shall be electronically interfaced with the combined dry aggregates, RAP if used, and mineral filler.

15 The meter shall have an accuracy of ±0.4 percent of the actual material metered.

16 Aggregate/RAP Moisture Compensators. The moisture compensation devices shall be capable of electronically converting the wet aggregate/RAP weight (mass) to dry aggregate/RAP weight (mass). Other systems will be permitted if approved by the Engineer.

17 Control Console. The following items shall be part of the operator's control console.

18 Aggregate/RAP Feed Controls. The variable speed controls, both total and proportional for each feeder and combined aggregates or RAP if used, shall be indexed in units with a minimum unit of 0.1.

19 The rate in RPM or TPH, etc. shall be displayed by a digital readout for each feeder with a minimum unit of 0.1 RPM or 1 TPH, etc.

20 Aggregate/RAP Weight (Mass) Indicator. The accumulated wet weight (mass) of material in tons (metric tons) that passes over each weigh belt shall be available at the control console with a minimum unit of 0.1 ton (0.1 metric ton). The dry weight (mass) of material, in TPH, passing over each weigh belt shall be displayed by digital readouts with a minimum unit of 1 TPH.

21 Mineral Filler Control. Mineral filler shall be controlled by a variable speed control with a minimum unit of 0.1 and shall be displayed in RPM, or TPH, etc. with a minimum unit of 0.1 RPM or 0.1 TPH, etc.

22 Asphalt Binder Control. The asphalt binder control shall be capable of presetting the actual asphalt binder content directly as a percent of the total weight (mass) of mixture with a minimum unit of 0.1 percent. The asphalt binder rate shall be displayed to a minimum unit of 0.1. A control shall be provided to set the specific gravity or weight/gallon (mass/liter) of the asphalt binder. The temperature of the asphalt binder shall be recorded by a recording pyrometer or thermometer at the console.

23 Aggregate/RAP Moisture Compensators. The compensators shall be part of the operator's console and shall have a minimum unit of 0.1 percent. The control shall be lockable if the moisture setting is not printed as part of the record.

24 HMA Temperature. The temperature of the mixture shall be recorded in °C by a recording pyrometer or thermometer at the console.

25 The plant shall be equipped with a fully computerized system, that will provide the control and documentation and that will record the following data at six minute intervals during production time and print on demand. All readings shall show:

(a) The date, month and year, and time to the nearest minute. Accumulated dry aggregate/RAP in tons (metric tons) to the nearest 0.1 tonnes.

(b) Accumulated mineral filler in revolutions, tons (metric tons), etc., to the nearest 0.1 unit.

(c) Accumulated asphalt binder in gallons (liters), tons (metric tons), etc., to the nearest 0.1 unit.

(d) Aggregate/RAP Moisture Compensators in percent as set at the panel. (Required when accumulated dry aggregate/RAP is printed in Wet Aggregate/RAP Weight (Mass)).

5.15.4.17 Batch Plant

1 Ensure that the plants' control system can coordinate mixture proportioning, timing, and discharge by the operation of a single control. Also provide an automatic batch weighing, cycling, and monitoring system.

2 No laboratory verification or plant trial shall be carried out unless the contractor has a certified laboratory per the Quality Control Section 5.15.4.4.3.

3 Provide adjustable timing devices to control individual component batching and mixing operations. Provide auxiliary interlock cutoff circuits necessary to stop automatic cycling whenever an weighing error exceeding a specified tolerance occurs or when another part of the control system malfunctions.

4 Ensure that the batching system automatic control can stop the cycle in the underweight check position and the overweight check position for each material to check tolerance limits.

5 Ensure that the scale system is equipped with a device that applies pressure to a scale lever to simulate batching operations for tolerance checks.

6 Consistently deliver materials within the full range of batch sizes within the following tolerances:

MATERIAL	PERCENT OF TOTAL MATERIAL BATCH WEIGHT
Coarse aggregate	+1.0
Fine aggregate	+1.0
Mineral filler	+0.5
Asphaltic material	+0.1
Zero return for aggregate	+0.5
Zero return for asphaltic material	±0.1.

7 Unless providing separate tolerance controls for batching mineral filler, reduce aggregate tolerances to +/- 0.5 percent for aggregates delivered before the filler.

5.15.4.17.1 Automatic Operation

1 The plant shall be designed, co-ordinated and operated so as to continually produce an asphalt mix within the job mix tolerances specified.

2 The plant shall be equipped and operated so that the proportioning of the hot aggregate, filler and bitumen, together with the dry and wet mixing cycles are all controlled automatically. Positive interlock shall be provided so that proportioning, mixing and discharge are accomplished by one operation without manual control of the separate phase.

3 The use of manual and semi-automatic plants for the production of asphalt is not permitted unless specific approval is given in writing by the Engineer.

5.15.4.17.2 Batch Plant Equipment

1 Screens - Plant screens shall be capable of screening all aggregates to the specified sizes and proportions. They shall have capacities equal to or greater than the maximum rated capacity of the plant. The screens shall be placed directly above the storage bins for the heated aggregate and shall receive the material coming from the drier. They shall have an operating efficiency such that the aggregate deposited in any bins shall not contain more than 10 % oversize or undersize material. This screen tolerance shall not invalidate the job mix tolerances specified.

2 Hot Bins - The plant shall include at least three storage bins for hot aggregate of sufficient size to supply the asphalt plant when it is operating at full capacity. They shall be arranged to ensure separate and adequate storage of appropriate fractions of the aggregate. Each compartment shall be provided with an overflow pipe that shall be of such size and at such location as to prevent any backing up of material into other bins or against the screens. Bins shall be so constructed that samples can be readily obtained therefrom. An additional dry-storage bin shall be provided for commercial mineral filler and provision shall be made for proportioning this filler into the mix.

3 Recording Batch Weights - Produce an automatic digital record for each batch indicating the proportions of each aggregate component, mineral filler, and asphaltic material.

4 Provide a digital recorder that can print multiple copies of mixture reports that give the total weight of asphaltic mixture and asphaltic material both per load and per batch. Include weights of the individual aggregates and fillers. Reports need not provide tare weight and may use accumulative weights. Ensure that reported weights are accurate within +/- 1 kg/500 kg. Allow sufficient time for the scale to come to rest before printing each weight.

5 The contractor may use mixture storage silos with digital recorder equipped batch plants if the department determines the storage silo output is coordinated with the recorded batch weights.

6 If the recording system breaks down, the contractor may operate the plant without automatic recording for up to 2 working days.

5.15.4.17.3 Bitumen Storage

1 Tanks for storage of bituminous material shall be equipped for heating the material using positive and automatic control at all times, to a temperature within the specified range. The heating shall be accomplished by steam coils, hot oil, electricity or other approved means such that no flame shall come in contact with the bitumen or heating tank.

2 The circulating system for the bituminous material shall be of adequate size to ensure proper and continuous circulation during the entire operating period. Suitable means shall be provided either by steam or hot oil jackets or other insulation for maintaining the specified temperature of the bituminous material in the pipeline, meters, weigh buckets, spray bars, and other containers and flow lines.

3 The storage tank capacity shall be sufficient for at least one day's operation. Circulation return lines to the asphalt storage tanks should be submerged to the same elevation in the storage tanks as the feeder line. (Two or three vertical slots may be cut in the return line above the high level mark to break vacuum when reversing the pump).

4 The Contractor shall provide a sampling outlet in the bituminous material feedline connecting the plant storage tanks to the bituminous material weighing or metering box. The outlet shall consist of a valve installed in such a manner that samples may be withdrawn from the line slowly at any time during plant operation. The location of the sampling outlet shall be readily accessible and free from obstruction. A drainage receptacle shall be provided for flushing the outlet before sampling.

5.15.4.17.4 Thermometric Equipment

1 An armoured thermometer reading from 38 °C to 204 °C shall be fixed in the bituminous feed line at a suitable location near the discharge valve. Similar devices shall be fixed in the heating and storage tanks.

2 The plant shall be further equipped with either an approved dial-scale, mercury-actuated thermometer, an electric pyrometer, or other approved thermometric instruments placed at the discharge chute of the drier and in the hot fines bin so as to register automatically or indicate the temperature of the heated aggregates. For better regulation of the temperature of the aggregates, replacement of any thermometer by an approved temperature recording apparatus may be required by the Engineer and he may further require that daily temperature charts be submitted to him by the Contractor.

5.15.4.17.5 Control of Mixing Time

1 The Plant shall be equipped with electronic controls to govern the time of mixing and to maintain it constant unless changed at the direction of the Engineer.

5.15.4.17.6 Pugmill

1 The pugmill shall include equipment to deliver the bituminous materials in a thin uniform sheet or in multiple sprays over the full length of the mixer.

2 The batch mixer shall be an approved twin pugmill type, capable of producing a uniform mixture within the job-mix tolerances. It shall be so designed as to permit visual inspection of the mix. The mixer capacity shall be not less than 600 kg per batch and shall be so constructed as to prevent leakage of contents.

3 The mixer shall be enclosed and shall have an accurate time lock to control the operation of a complete mixing cycle by locking the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bitumen supply throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between opening of the weigh box gate and the start of application of bitumen.

4 The wet mixing period is the interval between the time the bituminous material is spread on the aggregate and the time the mixer gate is opened. The control of the time shall be flexible and capable of being set at intervals of not more than five seconds throughout cycles up to three minutes. A mechanical batch counter shall be so designed as to register only completely mixed batches. The mixer shall be equipped with a sufficient number of paddles or blades in a suitable arrangement to produce a proper and uniformly mixed batch. The clearance of blades from all fixed and moving parts shall not exceed 19 mm except in the case of aggregates having a nominal maximum size of over 25 mm in which case the clearance shall be so adjusted as to prevent undue breakage of the coarse aggregate during the mixing operation.

5.15.4.17.7 Temporary Storage of Mix

1 Plants may be equipped with skips or elevators for delivering batched mix to hoppers or silos before discharging to hauling units. The skips or elevators shall not be sprayed with diesel or other solvents; where necessary they may be sprayed with a minimum amount of lime water, soap or detergent solution. Hoppers or silos shall be of such design that no segregation or loss in temperature of the mix occurs.

5.15.4.17.8 Safety Requirements

1 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 all plant operations. Accessibility to the top of truck bodies shall be provided by means of a platform or other suitable device to enable the Engineer to obtain mixture temperature data. To facilitate handling scale calibration equipment and sampling equipment, a hoist or pulley system shall be provided to raise or lower the equipment from the ground to platform or vice-versa. All gears, pulleys, chains, sprockets and other dangerous moving parts shall be thoroughly guarded and protected. Ample 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.

5.15.4.17.9 Weigh-Box

1 The plant shall include means for accurately weighing each size of aggregate in a weigh-box or hopper, suspended on scales, ample in size to hold a full batch without hand raking or running over.

2 The weigh-box or hopper shall be supported on fulcrums and knife edges so constructed that they will not be easily thrown out of alignment or adjustment. All edges, ends and sides of weighing hoppers shall be free from contact with any supporting rods and columns or other equipment that will in anyway affect the proper functioning of the hopper.

3 There shall also be sufficient clearance between hoppers and supporting devices to prevent accumulations of foreign materials. The discharge gate of the weigh-box shall be so hung that the aggregate will not be segregated when dumped into the mixer and shall close tightly when the hopper is empty so that no material is allowed to leak into the batch in the mixer during the process of weighing the next batch.

5.15.4.17.10 Scales or Meters

1 Scales or meters used for proportioning aggregates, mineral filler and bitumen shall be accurate to 1 % of the indicated quantity. Scales and meters shall be calibrated before each project and after the HMA plant has been moved. Scales and meters that will not maintain calibration shall be replaced. Scales shall be constructed and located so as to prevent vibration in the dial pointer.

2 Scales for weighing aggregate and mineral filler may be either the beam or springless dial type and shall be of standard make and design. Graduation intervals shall be not more than 0.1 % the nominal scale capacity. Dial scales shall be equipped with adjustable pointers for controlling automatically the weighing of each aggregate and filler. The pointer shall be set close to the dial face to prevent excessive parallax and all dial faces shall be so located that they will be in plain view of the operator at all times.

3 Weighing sequence of hot aggregates shall progress from coarse to fine.

4 Bituminous material shall be automatically proportioned by either weighing or metering. The minimum gradation shall be not more than 1 litre or 1 kg. Bituminous scales and weigh buckets shall be such that the required amount of bitumen is provided in a single weighing and delivered to the pugmill without loss due to overflow, splashing or spillage.

5 Bituminous weigh buckets shall be satisfactorily insulated to prevent loss of heat in the bitumen or accumulation of bitumen in the bucket. Bituminous metering devices shall be rotating positive displacement pumps and shall be capable of providing the designated quantity of material for each batch.

6 All scales and meters shall be approved by the Engineer and shall be checked and calibrated. Production shall not be permitted if the weight batch calibration does not comply with the requirements of AASHTO M 156.

5.15.4.18 Cold-Milling Machines

1 Equipment must consistently remove the HMA surface, in one or more passes, to the required grade and cross-section producing a textured surface. Machines must be equipped with all of the following:

2 Automatically controlled and activated cutting drums,

3 Grade reference and transverse slope control capabilities, and

4 Shall be capable of accurately and automatically establishing profile grades by reference from either the existing pavement or from an independent grade control to provide a milled surface within a tolerance of 5 mm in 5 m when tested with a 5 m straightedge.

5.15.4.19 Hauling Equipment

1 Vehicles used for the transport of aggregates or bituminous mix shall be clean and smooth insulated metal beds and shall be free from dust, screenings, petroleum oil and volatile or other mineral spirits which may affect the material being hauled. The vehicle metal bed shall, if required, be sprayed with a minimum amount of soapy water or lime solution to prevent the bituminous mix from adhering to the bed. After spraying, the truck shall be raised and thoroughly drained and no excess solution shall be permitted. Use of diesel or other solvents to spray in the truck bed is prohibited.

2 Provision shall be made for covering truck loads with canvas or other suitable material of such size that the bituminous mix is fully covered regardless of the outside temperature.

3 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 the instruction of the Engineer, be removed from the work until such faults are corrected.

4 End dump trucks shall be equipped with chains on the tail gates for control when dumping the mix into the paving machine. Hauling trucks shall not be routed over wet or muddy access ways such that tyres accumulate dirt that is deposited on the laying surface.

5 The Contractor shall provide an adequate number of trucks of such size, speed and condition to ensure orderly and continuous progress of the work all to the approval of the Engineer.

5.15.4.20 Paving Equipment

5.15.4.20.1 Spreading and Finishing Equipment

1 The asphaltic mixture shall be fed to the paver by end tipping of the truck or by means of a windrow elevator, pickup machine or material transfer device (MTD) or combination of devices to keep the paver moving. The paving equipment for spreading and finishing the asphaltic mixtures shall be of an approved mechanical, self-powered electronic controlled floating screed type, capable of spreading and finishing the mixture true to line, grade and required crown. The paver shall be capable of producing a finished HMA surface of the required smoothness and texture without segregating, tearing, shoving or gouging the asphaltic mix or deforming the underlying HMA or base layers.

2 The pavers shall be self propelled and equipped with hoppers and distributing screws of the reversing type to place the mixture uniformly in front of adjustable electronic controlled screeds. The pavers shall be so designed to allow a minimum paving width of 2 m, although paving in widths of less than 3 m will require the approval of the Engineer. Tracked pavers shall be used for major roads and tyred pavers shall be used for tight junctions and minor roads.

3 Pavers shall be equipped with such provisions and attachments to suit paving widths specified for road widening as well to as to suit paving on sloped sections. They shall be equipped with fast and efficient steering devices and shall have reverse as well as forward travelling speeds. The paver will be operable I at forward speeds consistent with satisfactory mix laydown, typically from 3 to 6 m/min.

4 The pavers shall employ mechanical devices as equalising runners, straight edge runners, evener arms or other compensating devices to maintain trueness of grade and to 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 designed and operated in such a manner that it will place the material at the required compacted thickness.

5 Electronic screeds shall include automatic feed controls to maintain a constant level of material along the full length of the screed, automatic grade control and automatic slope control. The grade controller shall be activated by:

- a travelling, articulated averaging beam (ski) mounted on one or both sides of the paver not less than 9 m in length. The automatic slope control shall be equipped with a proportioning manual override to enable smooth transition of changing slope rate, or
- Electronic sonic devices to control slope and or grade.

6 Screeds shall be provided with devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring. Pavers shall also be provided with the standard attachable screed extensions. When using the screed in an extended position, auger extensions will be used to keep the augers within 15 cm of the screed end plates. All screeds shall be of the vibrating type or tamping-bar that compact the HMA as it is being placed.

7 The term "screed" includes any cutting, crowning or other physical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving, or gouging.

8 If, during construction, the Engineer determines 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.

5.15.4.20.2 Rolling Equipment

1 Rolling equipment shall consist of vibratory steel-wheeled rollers, dead weight steel-wheeled rollers and pneumatic-tyred rollers as required for proper compaction and finishing of the asphalt surface. Unless otherwise permitted, rollers shall be equipped with reversible or dual controls to allow operation both forward and backward with the operator always facing in the direction of movement.

2 Steel-wheeled rollers shall be two-axle tandem rollers or three-axle tandem rollers. These rollers shall be self-propelled and equipped with power units of not less than four cylinders and under working conditions shall develop contact pressures under the compression wheels of 45 to 65 kg/cm of width. Each two-axle roller shall have a minimum weight of 10,000 kg each and three-axle roller shall have a minimum weight of 13,000 kg. Vibrating steel-wheeled rollers shall have dual drums with a minimum weight of 7000 kg. Vibrating frequency shall be a minimum of 2000 cycles per minute with individual controls for each tandem drum. Rollers shall be in good working condition and shall be equipped with a reversing clutch. Rollers shall be equipped with adjustable scrapers to keep the wheel surface clean and with efficient means of keeping them wet to prevent mixes from sticking. These surfaces shall have no flat areas or projections which will mark the surface of the asphalt courses. The three-axle rollers shall be equipped with a centre axle which may be operated either fixed or floating. The three-axle tandem roller shall be so constructed that when locked in a position for all treads to be in one plane, the roller wheels are held with such rigidity that, if either front or centre wheel is unsupported the other two wheels will not vary from the plane by more than 6 mm. All steel-wheeled rollers shall be in good condition.

3 Equip all rollers with a drum or tire lubricator. Do not lubricate with petroleum or tar products. Use only non-petroleum release agents, soap solutions, and vegetable oil to prevent bitumen from sticking to the tyres.

4 Pneumatic-tyred rollers shall be self-propelled. The rollers shall be equipped with pneumatic tyres of equal size and diameter which in inflated to the same tyre pressure so that a uniform compaction pressure is applied. Pneumatic-tyred rollers shall be in good condition and with enough ballast space to provide uniform wheel loading as may be required.

5 Pneumatic-tyred rollers shall have skirts of heavy rubber placed around the sides of the roller to prevent the tyres from cooling. .

5.15.4.20.3 Liquid Bitumen Distributor

1 The liquid bitumen distributor truck shall be of the pressure type with insulated tanks. The use of gravity distributors will not be permitted. The distributor shall have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 100 kg/cm tyre width.

2 Spray bars shall have a minimum length of 2.4 m and shall be of the full circulating type. Spray bar extensions shall also be of the full circulating type. The spray bar shall be adjustable to maintain a constant height above the surface to be treated.

3 The spray bar nozzles shall be slotted and shall be of such design so as to provide a uniform unbroken spread of bituminous material on the surface. The valves shall be operated by levers so that one or all valves may be quickly opened or closed in one operation. The distributor shall be equipped with a hose and nozzle attachment to be used for spotting areas inaccessible to the distributor. The distributor and booster tanks shall be so maintained at all times as to prevent dripping of bituminous material from any part of the equipment.

4 The distributor shall be equipped with devices and charts to provide for accurate and rapid determination and control of the amount of bituminous material being applied and with a tachometer of the auxiliary wheel type reading speed in m/min. The spreading equipment shall be provided with a separate power unit for the pump or a variable displacement pump driven by a hydrostatic transmission so that a uniform application of bituminous material, in controlled amounts, may be made ranging from 0.15 to 5.0 kg/m^2. The distributor shall have satisfactory heating equipment and thermometers in order to provide the full range of application temperatures for the bituminous material being used.

5 Before commencing the work and as required by the Engineer, the liquid bitumen distributor shall be checked and calibrated such that the rate of transverse spread or longitudinal spread shall not vary more than 10 % from the required rate of application.

5.15.4.21 Production of Bituminous Paving Courses

5.15.4.21.1 Weather Limitations

1 Production and spreading of asphaltic Concrete mix shall not be permitted when the ambient temperature is less than 8 °C, nor during rain, fog, dust-storms or other unsuitable weather.

5.15.4.21.2 Equipment Required

1 The equipment required for construction of the asphaltic concrete courses shall include but not be limited to all equipment mentioned in this document, together with such miscellaneous equipment and tools as required for the satisfactory preparation and performance of the work.

2 All equipment shall be checked, calibrated and approved by the Engineer before use. The equipment shall be satisfactorily maintained and shall be used in an approved manner.

3 Adequate equipment and labour shall be used so that there is continual production and distribution of the asphalt course being constructed.

5.15.4.21.3 Survey and Preparation

1 The area to be paved shall be true to line and grade and shall have a properly prepared surface before the start of paving operations.

2 When an asphaltic concrete pavement course is to be placed on top of an existing pavement, the existing pavement surface shall be prepared as designated by the Engineer.

3 Priming or tacking of surfaces to be paved shall be carried out as designated.

4 The surface of kerbs, vertical faces of existing pavements and all structures in actual contact with asphalt mixes shall be painted with a thin and complete coating of tack coat as instructed by the Engineer to provide a closely bonded, watertight joint.

5 All openings or structures in the road for water, drainage and other specified utilities shall be constructed and their positions and levels determined before the start of paving operations.

5.15.4.21.4 Heating of Bitumen

1 The bituminous binder shall be heated to a temperature of between 150 to 165 degrees centigrade. Polymer modified binders may require higher temperatures to allow for proper pumping and coating of the aggregate. Temperatures of up to 177 degrees centigrade may used with the suppliers recommendation

2 Bitumen shall not be used if foaming occurs or heated above 177 °C at any time.

5.15.4.21.5 Heating of Mineral Aggregate

1 The aggregate shall be thoroughly dried and heated so that their temperature is 165 to 180 degrees centigrade and within ± 8 °C of the temperature needed to satisfy the viscosity requirements of the asphalt cement.

2 In no case shall the materials be introduced into the pugmill with a temperature, including the 8 °C tolerance permitted, of more than that what the binder supplier recommends for mixing or for non-performance graded binders a temperature at which the bitumen has a viscosity of 75 seconds Saybolt-Furol.

3 The moisture content of the heated and dried materials measured using AASHTO T-85 shall not exceed 1%.

4 The quantity of materials fed through the drier shall in all cases be held to an amount which can be thoroughly dried and heated within the limits specified.

5 The heated materials shall be screened into sizes such that they may be combined into a gradation meeting the requirements of the Job Mix Formula and the hot aggregate storage bins shall be such as to minimise segregation and loss of temperature of aggregate.

6 Hot bins shall be drawn and cleaned of material at the end of each day's operation.

5.15.4.21.6 Proportioning and Mixing

1 The heated ingredients together with the mineral filler and bitumen shall be combined in such a manner so as to produce a mixture which complies with the requirements of the Job Mix Formula. Plant settings, once established, shall not be changed without the approval of the Engineer.

2 Mineral filler, in a cool dry state, shall be proportioned into the mixer either with the aggregate or after the introduction of the bitumen to avoid loss of fines that may occur in dry mixing as a result of turbulence in the mixer.

3 In batch type plants a dry mixing period of not less than four seconds shall precede the addition of the bitumen to the mix. Excess wet mixing shall be avoided. Wet mixing shall continue as long as it is necessary to obtain a thoroughly blended mix but shall not exceed 75 seconds nor be less than 30 seconds.

4 The Contractor shall propose the length of time for both dry and wet mixing for the approval of the Engineer. Approval of the lengths of time for mixing shall not relieve the Contractor of his responsibilities and obligations under the Contract.

5 Once approved, mixing times shall not be altered unless so ordered or further approved by the Engineer.

6 When recycled asphalt pavement material is incorporated into the mixture, modify plants according to the plant manufacturer's recommendations to process reclaimed material. Modify batch plants so the recycled asphalt pavement is introduced into the mix after bypassing the dryer. Design the cold feed bin, conveyor system, and special bin adjacent to the weigh hopper, if used, to avoid segregation and sticking of the recycled asphalt pavement material. Heat aggregate to a temperature that will transfer sufficient heat to the recycled asphalt pavement material to produce a mix of uniform temperature within the range specified in the approved job-mix formula.

5.15.4.22 Delivery Spreading and Finishing

5.15.4.22.1 Delivery of Mixes

1 Sufficient plant capacity, haul vehicles and storage shall be provided so that adequate supplies of mixture are delivered to site to ensure that continuous paving can be achieved.

2 The dispatching of the hauling vehicles to the job site shall be so scheduled that all material delivered may be placed in daylight, unless the Engineer has approved the use of artificial light. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

3 All precautions shall be taken to protect the mix from the weather during transit and while waiting to discharge.

4 Hauling vehicles shall not be permitted to carry out tight turns on the laying surface.

5 The mixture at delivery to the paver shall be within 14 °C of the Job Mix Formula temperature and above an absolute minimum temperature of 158 °C. Material which has fallen below the minimum temperature of 158 °C before discharge shall be rejected and immediately removed from site. Delivery temperature shall not exceed the maximum temperature specified for mixing at the plant

6 Should a significant proportion of the mixture delivered to the paver fail to meet this requirement, or should cold lumps be found in the mixture, the Engineer shall order that paving operations be suspended until measures are taken, to the approval of the Engineer, to ensure compliance.

5.15.4.22.2 Spreading and Finishing

1 Prior to the commencement of delivery of the mix the Contractor shall have the option to erect and maintain an approved reference guide wire for controlling the levels of the laid mix. The reference guide wire shall be supported at intervals of not more than 5m. The level of the pavement may also be controlled by a 9-m ski with electronic sensor controls to control slope or grade.

2 The mix shall be laid upon an approved surface and only when weather conditions are suitable and as designated. Upon arrival at the point of use, the asphalt mix shall be spread and struck off to the grade, elevation and cross-section shape intended, either over the entire width or over such partial width as may be required. If the material does not conform to the requirements, it shall not be used and shall be discarded.

3 The laid material shall be compacted as soon as rolling can be effected without causing undue displacement and while the temperature does not fall below 145 °C. Materials still uncompacted and below this temperature shall be rejected.

4 The Contractor shall supply accurate calibrated thermometers suitable for measuring the inner and surface temperature of the material. The material temperature shall be checked immediately before rolling and at least every 30 minutes thereafter during forward progress. A record of these temperatures shall be passed to the Engineer at the end of each days work.

5 While paving is in progress, the output of the batching plant shall be exclusively reserved for the operations and no mixture shall be supplied to other sites or projects.

6 If during laying, the paver is repeatedly delayed because of lack of mixture or if the paver stands at one location for more than thirty minutes (for any reason), a transverse joint shall be constructed. Paving shall not recommence until the Engineer is satisfied that paving will proceed uninterrupted and until at least four loaded vehicles have arrived at the paving site.

7 The asphalt course shall be constructed to proposed levels and shall be homogeneous, providing after compaction an even surface free from undulations, rises or depressions and within the tolerances stipulated.

8 In no case shall construction of a new asphaltic concrete course begin until the previously laid course has been tested and approved with a rolling straight edge.

9 When the same asphalt course is to be laid in more than one layer the second layer shall be placed as soon as practicable after the first layer has been finished, rolled and cooled, and the Engineer may at his discretion request cleaning of the first layer and the application of a tack coat thereon if he so deems necessary.

10 Transverse joints in succeeding layers shall be offset at least 2 m. Longitudinal joints shall be offset at least 300 mm, unless a wedge-joint is being used. Then the notches of successive layers shall be aligned..

11 The use of motor grader or hand spreading of the asphalt mix shall not be permitted except in places where it is impractical to use pavers and shall be only with the specific permission of the Engineer. The asphalt mix shall comply with all conditions regarding trueness of level, thickness, and homogeneity of the mix.

12 Automatic electronic screed controls shall be required on all pavers and shall be used with a 9 m long articulated averaging beam or grade wire or sonic control as approved by the Engineer.

5.15.4.22.3 Compaction of Mixes

1 At least three rollers shall be available at all times, one self-propelled pneumatic-tyre and two self-propelled steel-wheeled. If payment factor is implemented by Ashghal, as many rollers shall be used by the Contractor as necessary to provide specified asphalt course density and surface characteristics so that a PF of 0.9 or higher is maintained (Refer to Appendix A).

2 Before beginning construction of the permanent works, unless otherwise agreed with the Engineer, the Contractor shall carry out compaction trials for each type and thickness of asphaltic course to establish an approved compaction procedure which shall then be used as a minimum requirement for the compaction of the permanent works unless otherwise directed or agreed by the Engineer.

3 The compaction trials shall involve all procedures specified for the permanent works including testing as specified for the asphaltic course under consideration and any equipment, processes or procedures proposed by the Contractor which are not designated. If payment factor is implemented by Ashghal, Construction of the permanent works shall not commence until a compaction trials provide a density meeting a PF of 0.9 or higher determined according to the PF calculation procedure outlined in Appendix A .

4 Immediately after the asphalt mix has been spread and struck off, the surface shall be checked and any irregularities adjusted and then compacted thoroughly and uniformly by rolling.

5 To prevent adhesion of the mix to steel-wheeled rollers, the wheels shall be kept properly moistened with water, liquid soap, vegetable oil and other non-petroleum release agents.

6 After the longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides of the road and shall gradually progress towards the centre. On superelevated sections, rolling shall begin on the low side and progress to the high side, overlapping on successive trips by at least one-half the width of tandem rollers and uniformly lapping each proceeding track. The rollers shall move at a slow but uniform speed with the drive wheels nearest the paver. The speed shall not exceed 4-5 km/h for steel-wheeled rollers or 8 km/h for Pneumatic-tyred rollers. The operating speed shall be approved by the Engineer.

7 The line of rolling shall not be changed suddenly or the direction of rolling reversed suddenly. If rolling causes displacement of the material, the affected areas shall be loosened at once with hand tools and restored to the original grade of the loose material before being rerolled. Heavy equipment or rollers shall not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

8 When paving in a single width, the first lane placed shall be rolled in the following order:

(a) transverse joints
(b) longitudinal joints
(c) outside edge
(d) initial or breakdown rolling, beginning on the low side and progressing towards the high side
(e) intermediate rolling
(f) final rolling.

9 When paving in echelon, 50 mm to 100 mm of the edge which the second paver is following shall be left unrolled. When paving in echelon the edges between the first and the second paver shall not be exposed more than 15 minutes or more than 50m by distance without being rolled. Particular attention shall be given to the construction of the transverse and longitudinal joints in all courses.

5.15.4.22.4 Transverse Joints

1 Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be checked with a straightedge to assure smoothness and true alignment. Joints shall be formed with a bulkhead, such as a board, to provide a straight line and vertical face.

2 If the joint has been distorted by traffic or by other means, it shall be trimmed to line and the face shall be painted with thin coating of emulsified asphalt before the fresh material is placed against it. To obtain thorough compaction of these joints the material placed against the joint shall be tightly pushed against the vertical face with a steel-wheeled roller.

3 The roller shall be placed on the previously compacted material transversely so that not more than 150 mm of the rear rolling wheel rides on the edge of the joint. The roller shall be operated to pinch and press the mix into place at the transverse joint. The roller shall continue to roll along this line, shifting its position gradually across the joint, in 150 to 200 mm increments, until the joint has been rolled with the entire width of the roller wheel. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

4 Transverse joints should have be rolled so that the deviation under a 3m straightedge laid perpendicular across the joint is 5mm or less.

5.15.4.22.5 Longitudinal Joints

1 Longitudinal joints shall be rolled directly behind the paving operations. The first lane placed shall be true to line and grade and have a vertical face. The steel-wheeled roller should overlap (hangover) the unsupported edge by 150mm on the first pass on each side of the lane.

2 The steel-wheel roller should make the first pass down the lane being placed against the cold lane 150mm away from the joint. Then on the second pass on the longitudinal joint the roller shall be shifted over so that no more than 150mm of the roller wheel rides on the cold (previously placed lane).. The rollers shall be operated to pinch and press the fine material gradually across the joint. Rolling shall be continued until a thoroughly compacted, neat joint is obtained.

3 When the abutting lane is not placed in the same day, or the joint is distorted during the day's work by traffic or by other means, the edge of the lane shall be carefully trimmed to line, cleaned and painted with a thin coating of emulsified asphalt before the adjacent lane is placed.

4 The longitudinal joints in the surface course shall be along the same line as the traffic lane markers.

5.15.4.22.6 Paving Edges

1 The edges of the asphalt course shall be rolled concurrently with or immediately after rolling the longitudinal joint.

2 Care shall be exercised in consolidating the course along the entire length of the edges. The steel-wheeled roller should overlap (hangover) the unsupported edge by 150mm on the first pass.

5.15.4.22.7 Breakdown Rolling

1 Breakdown rolling shall immediately follow the rolling of the longitudinal joints and edges. Rollers shall be operated as close to the paver as possible to obtain adequate density without causing undue displacement. In no case shall the mix temperature be allowed to drop below 145 °C before breakdown rolling.

2 If the breakdown roller is steel wheeled, it shall be operated with the drive wheel nearest the finishing machine. Pneumatic-tyre rollers may be used as breakdown rollers.

5.15.4.22.8 Intermediate Rolling

1 Pneumatic-tyred rollers or Steel wheeled rollers shall be used for the intermediate rolling.

2 The intermediate rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still hot. Rollers shall be used continuously after the initial rolling until all of the mix placed has been thoroughly compacted. Turning of rollers on the hot paving mix which causes undue displacement shall not be permitted.

5.15.4.22.9 Finish Rolling

1 The finish rolling shall be performed with two-wheeled steel or three-axle tandem rollers unless otherwise permitted by the Engineer. Finish rolling shall be accomplished while the material is still warm enough for the removal of roller marks.

2 All rolling operations shall be conducted in close sequence.

3 In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by manual or mechanical tampers of such design as to give the desired density.

4 After final rolling, the smoothness, levels, cross falls, density and thickness shall be checked and any irregularity of the surface exceeding the specified limits and any areas defective in texture, density or composition shall be corrected as directed by the Engineer, including removal and replacement as directed by the Engineer.

5.15.4.22.10 Protection of Laid Courses

1 Sections of the newly finished work shall be protected from traffic of any kind until the mix has been properly compacted and cooled. In no case shall traffic be permitted less than 24 h after completion of the asphalt course unless a shorter period is authorised by the Engineer.

5.15.4.23 Cold Planning

1 The cold planning plant shall approved by the Engineer as per Section 5.15.4.19.

2 Cold planning plant shall have sufficient power, traction and stability to maintain the required depth of cut and slope. The control of the depth of cut and the slope shall be by an automatic system based on reference wires.

3 Cold planning shall be carried out to straight cross falls to the designated thickness. Planning shall be to a tolerance of ± 5 mm of the designated amount. The average thickness of planning achieved shall be at least the thickness designated.

4 In areas where there is severe deformation of the existing pavement, it may be necessary to vary the depth of planning.

5 Existing kerbs, gullies, manholes and other features shall not be disturbed by the planning process. This may require the use of smaller plant or removal by hand tools.

6 Any joints at the edge of planed areas shall be cut vertically and straight using asphalt saws.

7 Cold planning shall be carried out in a longitudinal direction.

8 After planning the prepared surface shall be thoroughly brushed and suction swept by mechanical means to the satisfaction of the Engineer. The surface shall be free from gouges, ridges, continuous grooves and shall have a reasonably uniform finish.

9 Cold planning shall be performed so that at the end of a day's work the termination line does not present a hazard to traffic that may use the road.

10 Any cracks noted in the pavement shall be blown clean with compressed air. The Engineer will inspect the planed surface and may instruct that further work is carried out for treating cracks in the pavement.

5.15.4.24 Prime Coat

5.15.4.24.1 General

1 The work shall consist of furnishing and applying liquid asphalt and blotter material, if required, to a previously prepared and approved subgrade or granular base/sub-base course as designated and to the full designated width.

2 Prime coat shall not be applied when the ambient temperature is less than 13 °C nor during rain, fog, dust storms or other unsuitable weather.

3 The prime coat shall be a cutback bitumen consisting of a 60/70 penetration grade bitumen and kerosene. The residue from the distillation test, carried out to 360 °C, shall be a minimum of 55 % (by volume), as determined by the difference method.

5.15.4.24.2 Materials

1 Liquid asphalt for use in asphalt works shall be MC-70 medium curing cutback asphalt in accordance with AASHTO M82.

2 The application rate shall be between 0.45 to 0.75 kg/m^2, or as directed by the Engineer. The Contractor shall ensure that excessive application of prime coat is avoided.

3 The application temperature for the MC-70 liquid asphalt shall be between 60 °C and 85 °C as directed by the Engineer.

5.15.4.24.3 Equipment Required

1 The equipment used by the Contractor shall include a liquid bitumen distributor as described in clause 5.15.4.21.3.

2 If the surface is covered in wind-blown dust or fine aggregate then a power broom shall be provided. The power broom shall be self-propelled and equipped with a cylindrical, rotating nylon bristle brush of not less than 760 mm in diameter and not less than 1800 mm in length. The brush shall be capable of being angled to the right and left with adjustable ground pressure. Where necessary for the proper preparation of the surface, motor graders, rollers and water trucks shall also be provided.

5.15.4.24.4 Surface Preparation

1 Immediately before applying the prime coat, all loose dirt, earth and other objectionable material shall be removed from the surface with a power broom of approved design and/or a power blower as required, and any ruts, soft spots or unacceptable irregularities in the surface shall be repaired in accordance with the instructions of the Engineer. If the Engineer so requires, the surface shall be lightly bladed and rolled immediately before the application of the prime coat, in which case brooming or blowing may not be required.

2 The Engineer may direct that a light application of water be made just before the application of liquid asphalt to facilitate penetration.

3 Priming will not be permitted when there is free water present on the surface.

5.15.4.24.5 Application

1 After preparing the road surface as above, the liquid asphalt shall be applied by means of the distributor at the temperature and rate directed by the Engineer. Hand-spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

2 The surface of structures, kerbstones and other appurtenances adjacent to areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

3 The prime coat shall usually be applied to 1/3 or 1/2 of the road width at a time. When applied in two or more lanes, there shall be a slight overlap of asphalt material along adjoining edges of the lanes. It should be noted that no overlapping is allowed at the transverse joints and that thick paper shall be used at the joint to protect the previous application and the joining application shall begin on the paper. The paper used shall be removed and satisfactorily disposed of by the Contractor after use. Care shall be taken that the application of bituminous material at the junctions of spread is not in excess of the specified amount. Excess bituminous material shall be removed from the surface.

5.15.4.24.6 Maintenance and Traffic

1 Traffic shall not be permitted on the primed surface until the asphaltic material has penetrated and dried and, in the judgement of the Engineer, will not be picked up under traffic. If it becomes necessary to permit traffic before that time, but in no case sooner than 48 hours after the application of the asphaltic material, blotter material (rock screening, Minus 5mm to 0) shall be applied as directed by the Engineer and traffic shall be permitted to use the lanes so treated.

2 Blotter material shall be spread from trucks operated backward so that the wheels will not travel in uncovered wet asphaltic material. When applying blotter material to an asphalt treated lane that adjoins a lane that has not been treated, a strip at least 200 mm wide along the adjoining edge shall be left devoid of blotter material in order to permit an overlap of asphalt material.

3 The Contractor shall maintain the primed surface in good clean condition and before the application of the next course, any surface irregularities shall be corrected and all excessive blotter material, dirt or other objectionable materials shall be removed.

5.15.4.25 Tack Coat

5.15.4.25.1 General

1 This work shall consist of furnishing and applying diluted emulsified asphalt to a previously prepared base or road surface, to provide bond for a superimposed course to the full designated width.

2 Tack coat shall not be applied when the ambient temperature is less than 13 °C nor during rain, fog, dust storms or other unsuitable weather.

5.15.4.25.2 Materials

1 Emulsified asphalt for use in asphalt works may be CSS lh or CRS-2 cationic emulsified asphalt in accordance with AASHTO M208 or SS lh anionic emulsified asphalt in accordance with AASHTO M140 unless otherwise designated or approved by the engineer.

2 Emulsified asphalt shall be of the slow-setting cationic or anionic type of the CSS-lh or SS-lh grades respectively and shall conform to the designated requirements.

5.15.4.25.3 Equipment Required

1 The equipment used by the Contractor shall include an asphalt distributor as well as a power broom and a power blower. Power broom shall be self-propelled and equipped with a cylindrical, rotating nylon bristle Brush of not less than 760 mm in diameter and not lees than 1800 mm in length. The brush shall be capable of being angled to the right and left with adjustable ground pressure. In addition, the Contractor shall supply and use efficient and approved equipment for diluting the emulsified asphalt with water.

5.15.4.25.4 Surface Preparation

1 The full width of the surface to be treated shall be cleaned with a power broom or power blower to remove dust, dirt or other objectionable materials. All faulty or unsuitable patches, excess cracks or joint filler and all surplus bituminous material shall be corrected in accordance with the instructions of the Engineer. The surface shall be dry when treated.

5.15.4.25.5 Application

1 Immediately after cleaning the surface, the tack coat shall be applied by means of the distributor at the temperature and rate directed by the Engineer. Hand spraying of restricted, inaccessible areas is permitted, subject to the approval of the Engineer.

2 The diluted emulsion shall be applied at a rate between 0.15 to 0.38 kg/m^2 as specified by the Engineer. The Contractor shall ensure that excessive application of tack coat is avoided.

3 The application temperature for the diluted emulsified asphalt shall be between 10 °C and 60 °C as directed by the Engineer.

4 The surface of structures, kerbstones and other fixed objects adjacent to areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

5.15.4.25.6 Maintenance and Traffic

1 After application, the surface shall be allowed to dry until it is in a proper condition of tackiness to receive the superimposed course. Tack coat shall be applied only so far in advance of the superimposed course placement as is necessary to obtain this proper condition of tackiness.

2 Until the superimposed course is placed, the Contractor shall protect the tack coat from damage.

3 If the tack coat is unavoidably damaged by rain or dust, it shall be allowed to dry, shall be cleaned again by a power broom or power blower and, if required by the Engineer, a subsequent light application of tack applied to the surface. Where, in the opinion of the Engineer, a tack coat is not necessary between layers of freshly placed courses, he may give instructions in writing to omit the tack coat. Any cleaning required in these areas shall be carried out before the application of the next course.

Amendments to Section 6: Part 6

THE FOLLOWING CHANGES ARE MADE TO QCS, SECTION 6 (ROADWORKS), PART 6 (CONCRETE ROAD PAVEMENT):

PART 6 CONCRETE ROAD PAVEMENT

1.5 REQUIREMENTS FOR CEMENT BOUND MATERIALS

1.5.1 General requirements of Cement Bound Materials

Delete paragraph 2 and substitute with the following:

2. Cement Bound Material shall be tested in accordance with this specification for the requirements of Table 6.6.

Delete paragraph 3 and substitute with the following:

3. Cement and water shall comply with the requirements of the Section 5, Part 16,Clause 16.2.3. and Clause 16.2.4. Aggregates shall comply with the requirements of the Section 6, Part 4- Unbound Pavement Material Clauses 4.2.4, 4.2.5 and 4.4.

Delete Table 6.5 and substitute with the following:

Table 6.5: Cement Bound Material (CBM) Field Requirements

Category	Mixing Plant	Method of Batching	Moisture Content	Minimum Compaction
CBM1	Mix in Place or Mix in Plant	Volume of mass	Note 1	Note 2
CBM2	Mix in Plant	Volume of mass	Note 1	Note 2
CBM3	Mix in Plant	mass	Note 1	Note 2
CBM4	Mix in Plant	Volume of mass	Note 1	Note 2
Note 1: To suit the requirements for strength surface, level regularity and finish				
Note 2: The average in situ density should be not less than 95% of the refusal density.				

Delete Table 6.6 and substitute with the following

Table 6.6: Cement Bound Material (CBM) Specimen Requirements

			7 days cube strength	
Category	**Curing Test**	**Compressive Strength Test**	**Average (MPa) (Note1)**	**Individual (MPa) (Note 2)**
CBM1	BS 1924 Part 2, 1990	BS 1924 Part 2, 1990 or BS 1881 Part 116	2.0-4.0	2.0-4.0
CBM2	BS 1924 Part 2, 1990	BS 1924 Part 2, 1990 or BS 1881 Part 116	4.0-7.0	4.0-7.0
CBM3	BS 1881-116:1983 or BS EN 12390-3:2002	BS 1881 Part 116 or BS EN 12390-3:2002	7.0-10.0	7.0-10.0
CBM4	BS 1881-116:1983 **(Note 3)**	BS 1881 Part 116 or BS EN 12390-3:2002	10.0-15.0	10.0-15.0
Note 1: The average strength of 5 cubes shall be within the stated range.				
Note 2: The strength of any individual cubes shall be within the stated range				
Note 3: This test is replaced by BS EN 12390-3:2002 but it remains applicable				

6.5.12 Testing of Cement Bound Materials

Delete paragraph 3 and substitute with the following:

1 Samples shall be provided in accordance with BS 1924: Part 1: 1990 Clause 5 from the laid cement bound material before compaction. One group of five samples shall be provided from five locations equally spaced along a diagonal that bisects each 800 m^2 or part thereof laid each day. The number of groups may be increased if required by the Engineer.

Appendix A

The following section A.1 through A.3 inclusive shall not be used until a written notification from Ashghal is issued

A.1 Payment (value of work) based on acceptance testing results

1 Payments are based on Quality Acceptance conducted by PWA or its representative. Contractor quality control results shall not be used for payment

2 The acceptance will be based on a statistical basis described in Section 5.15.4.8

3 The specification limits for the determination of the statistical analysis are set in Table 5.7.

4 The acceptance quality characteristics and minimum sampling frequency are described in Table 5.8.

5 Acceptance samples will be taken on random basis from behind the paver before compaction.

6 Use Table A-1 to determine the pay factor for each quality characteristic using the total number of test values and the total estimated percent within limits from Section 5.15.4.8.2.

7 Payment for each lot will be determined by multiplying the contract unit bid price per tonne of bituminous mixture for the specific mix type by the material pay factor. The material pay factor is calculated as follows:

$PF_{Volumetric}$ = *Pay factor for bituminous paving course. $PF_{Volumetric}$ is the lowest single pay factor determined for the acceptance quality characteristics in Table 5.8 (asphalt binder content, air voids, VMA, and core density for the specified lot).*

8 Pavement thickness will be verified by measuring the thickness of density cores. If lower lifts of the pavement do not meet the minimum thickness as set in the plans, subsequent lifts will be increased to make up the overall pavement thickness required. The final pavement thickness shall be no less than 10 mm of required thickness. For sections of pavement where the thickness is less than 10 mm of the required thickness the contractor will remove a minimum of 50 mm and replace the mix to bring the pavement up to the required thickness. If due to grade restrictions such as curb and gutter extra thickness cannot be added to the surface the full bituminous section will be removed and replace to meet the required thickness. No payment will be made for any material that has to be removed and replaced due to inadequate pavement thickness placed by the contractor.

Table A-1: Minimum Required Percentage of Work within Specification Limits for a Given Pay Factor (PU + PL) – 100

Pay Factor I	*n=3*	*n=4*	*n=5*	*n=6*	*n=7*	*n=8*	*n=9*	*n=10 to n=11*	*n=12 to n=14*	*n=15 to n=17*
1.05						100	100	100	100	100
1.04					100	99	97	95	96	96
1.03				100	98	96	84	92	93	93
1.02				99	97	94	91	89	90	91
1.01	100	100	100	98	95	92	89	87	88	89
1.00	69	75	78	80	82	83	84	85	86	87
0.99	66	72	76	78	80	81	82	83	84	85
0.98	64	70	74	76	78	79	80	81	82	84
0.97	63	68	72	74	76	77	78	79	81	82
0.96	61	67	70	72	74	75	76	78	79	81
0.95	59	65	68	71	72	74	75	76	78	79
0.94	58	63	67	69	71	72	73	75	76	78

0.93	57	62	65	67	69	71	72	73	75	76
0.92	55	60	63	66	68	69	70	72	73	75
0.91	54	59	62	64	66	68	69	70	72	74
0.9	53	57	61	63	65	66	67	69	71	72
0.89	51	56	59	62	63	65	66	68	69	71
0.88	50	55	58	60	62	64	65	66	68	70
0.87	49	53	57	59	61	62	63	65	67	68
0.86	48	52	55	58	59	61	62	64	66	67
0.85	46	51	54	56	58	60	61	62	64	66
0.84	45	49	53	55	57	58	60	61	63	65
0.83	44	48	51	54	56	57	58	60	62	64
0.82	43	47	50	53	54	56	57	59	61	62
0.81	41	46	49	51	53	55	56	58	59	61
0.8	40	44	48	50	52	54	55	56	58	60
0.79	39	43	46	49	51	52	54	55	57	59
0.78	38	42	45	48	50	51	52	54	56	58
0.77	36	41	44	46	48	50	51	53	55	57
0.76	35	39	43	45	47	49	50	52	54	56
0.75	33	38	42	44	46	48	49	51	53	54
REJECT	32	37	40	43	45	47	48	49	52	53
	30	36	39	42	44	45	47	48	50	52
	28	34	38	41	43	44	46	47	49	51
	27	33	37	39	42	43	45	46	48	50
	35	32	36	38	40	42	43	45	47	49

A.2 Acceptance of Work

A.2.1 Actions and Acceptance Based on Pay Factors

1 Sublot with pay factors less than 0.90 may be incorporated into the project provided the average pay factor for the completed lot does not fall below 90% (Table A-2).

2 When the pay factor for a sublot falls under 0.75, the sublot shall be removed and replaced (Table A-2).

3 If the average pay factor of all completed lots falls below 0.90, terminate production. Production may resume after the Contractor takes effective and acceptable actions to improve the quality of the production (Table A-2)

4 Rejected material is removed from the work.

5 When approved, it is permissible to voluntarily remove non specification material and replace it with new material to avoid or minimize a pay factor of less than 1.00. New material will be sampled, tested, and evaluated according to this Subsection.

6 Any quantity of material may be rejected based on visual inspection or test results. Do not incorporate rejected material in the work. The results of tests run on rejected material will be excluded from the lot.

7

Table A-2: Actions and Acceptance of Work based on PF

Average all Completed Lots Pay Factor	Single Lot pay factor	Action
>= 0.90	>= 0.75	Incorporate in the project
>= 0.90	< 0.75	Remove all rejected material from the work
< 0.90	N/A	Terminate production

A.3 Dispute Resolution Process

The following shaded subparagraphs 15.4.10 shall not be used until a written notification from Ashghal is issued

1 Lot Dispute Resolution Criteria. The Acceptance results for a lot may be eligible for Dispute Resolution if the Pay Factor (PF) determined according to Procedure outlined in Section A.1, for a lot, based on the V_a, Pb, VMA or density based on the QC results is larger than the corresponding PF based on the Acceptance results. Only independent random QC test results from the corresponding sublots in the lot under Dispute Resolution will be used by the Engineer when processing the Dispute Resolution request. The QC sampling and testing used for the Dispute Resolution request must be conducted in the same manner as the acceptance testing.

2 The PF for the lot will be recomputed based on the combined acceptance and Dispute Resolution sample test results unless there is clear indication that the original acceptance samples results include errors.

3 Samples used for Dispute Resolution.

(a) Mix samples, large enough acceptance samples from each sublot shall be taken that a second set of tests may be conducted on that sublot.

(b) In-place density, the Engineer shall first review the lot test results for data entry and mathematical errors. If there are errors, the lot pay factor for in-place density will be recalculated.

(c) If it is determined that the test discrepancy has not been resolved, then Dispute Resolution coring will completed within 5-days of the receipt of the request for Dispute Resolution. The G_{mm} from the original QA test results shall be used to calculate the new in-place density values. If V_a , P_b or VMA are in Dispute Resolution for the same lot, the average of the new G_{mm} and original acceptance values shall be used to only to calculate the new Dispute Resolution in-place Density values.

4 Dispute Resolution Schedule. The contractor shall submit in writing to the Engineer a request for Dispute Resolution within 2 working days of the receipt of the Acceptance PF results. The request shall include the PF (contractor's QC results) Resolution sample test results.

5 The Engineer shall complete all Dispute Resolution testing within 7 working days upon receiving the Dispute Resolution Samples.

Appendix B

The following Sections B.1 through B.3 inclusive shall not be used until a written notification from Ashghal is issued

B.1 Pavement Smoothness with pay factor

B.1.1 Definitions

International Roughness Index (IRI). Smoothness is defined as the composite International Roughness Index (IRI) per 0.10 km segments. The segment IRI value is used to determine pavement smoothness pay adjustments. The IRI (quarter-car simulation) shall be calculated according to ASTM E 1926 Standard Practice for Computing International Roughness Index of Roads from Longitudinal Profile Measurements.

Areas of Localized Roughness (ALR) are defined as areas greater than the limiting criteria for a continuous IRI calculation with a 7.62 m interval, as calculated by ProVal (Profile Viewing and Analysis) software.

B.1.2 Inertial Profiler (IP)

1 Provide a certified, calibrated and documented IP meeting the requirements of ASTM 950, Class 1.

2 Provide an IP capable of producing a profilogram and exporting raw profile data in an unfiltered electronic Engineering Research Division (ERD) or PPV file format. Produce ERD/PPV filenames in the YYMMDDT-N-D-L-W-S. ERD standardized format in accordance with Table B-1:

Table B-1: Electronic ERD or PPV File Standardized Naming Convention

Abbreviation	*Definition*
YY	Two-digit year
MM	Month (include leading zeros)
DD	Day (include leading zeros)
T	Route type
N	Route Number
D	Primary Direction (EB, WB, NB, SB)
L	Lane number (1 for driving lane, increasing by 1for each lane to left)
W	Wheel Path (L, R or B, indicating left, right or both
S	Beginning station of measurement

B.1.3 Testing

1 Perform daily calibration verification of the profiler using test methods according to the manufacturer's recommendations. If work is being done by a consultant on behalf of engineer, notify the engineer prior to performing the calibration verification. If the engineer requests, arrange to have the engineer observe the calibration verification and operation. Maintain records of the calibration verification activities, and provide the records to the engineer upon request.)

2 Measure the final mainline pavement for IRI in areas with a posted speed vehicle speed of 60 km/hr or greater.

3 Operate profilers within the manufacturer's recommended speed tolerances. Perform all profile runs in the direction of travel. Measure the longitudinal profile of each wheel track of each lane. The wheel tracks are 1.83 m apart and centered in the travelled way of the lane.

4 Measure the profiles of each standard or partial segment. Define primary segments starting at a project terminus and running contiguously along the mainline to the other project terminus. Field-locate the beginning and ending points for each profile run.

5 Define segments one wheel path wide and distinguished by length as follows:

(a) Standard segments are 100 m long.
(b) Partial segments are less than 100 m long.

6 Treat partial segments as independent segments.

7 Use ProVal "Ride Quality Analysis" with 250 mm filter to calculate IRI for each wheel path in each lane.

8 Use ProVal "Smoothness Assurance" analysis to identify ALR. Calculate IRI with continuous short interval of 7.62 m with the 250 mm filter.

9 ***If implemented based on an official notification from ASHGHAL, the*** Pay Adjustments for Smoothness and Localized Roughness shall be as outlined in Section B.2.

B.2 Pay Adjustments for Smoothness

1 Multi-lift Pavements - The pay adjustment factor for each 0.1km segment will be determined from Table B-2. Smoothness will be paid for separate from the mixture and placement payment.

2 Single lift (overlay projects) – The pay adjustment factor for each 0.1km segment will be determined using the equations from Table B-3.

3 The pay is adjusted for partial segments based on their length.

4 Use a 3.0 m metal straight edge to measure areas excluded from IRI measurements. Measure at right angles and parallel to the centerline. Defective areas are surface deviations in excess of 6 mm in 3.0 meter between any two contacts of the straightedge with the surface.

5 Defective area correction. Correct defective areas from points 1 to 4 above. Obtain approval for the proposed method of correction. If no corrections are allowed, no adjustment will be made to the pay adjustment factors.

6 Re-measure corrected areas according to the specified type of pavement smoothness/roughness. The smoothness/roughness value obtained will replace the original.

Table B-2: Pavement Roughness – multiple lift projects

IRI (m/km)	*Pay Adjustment Factor (PAF) (QAR per 0.1 km per lane)*
Less than 0.5	*1000*
0.5 to < 0.6	*6,000-(10,000 x IRI)*
0.60 to < 0.90	*0.00*
0.90 to < 1.2	*3,800-(4,000 x IRI)*
Greater than 1.2	*Corrective Action (1)*
(1)Pay adjustment factor when corrections are not allowed equals 50% of bid price	

Table B-3: Pavement Roughness – single lift overlays

IRI (m/km)	*Pay Adjustment Factor (PAF) (QAR per 0.1 km per lane)*
Less than 0.75	*1000*
0.75 to < 0.85	*6,000-(10,000 x IRI)*
0.85 to < 1.3	*0.00*
1.3 to < 1.5	*3,800-(4,000 x IRI)*
Greater than 1.5	*Corrective Action (1)*
(1) Pay adjustment factor when corrections are not allowed equals 50% of bid price.	

B.2 Pay Adjustments for Localized Roughness

1 Apply localized roughness requirements to all pavements; except localized roughness requirements will not be applied to pavements within 7.5 m of the following surfaces if they are not constructed under this contract: bridges, bridge approaches, or railroad crossings. The department may direct the contractor to make corrections to the pavement within the 7.5 m exclusionary zones and will compensate the contractor for the extra work.

2 The engineer will review each individual wheel track for areas of localized roughness. The engineer will assess areas of localized roughness that exceed an IRI of 1.97 m/km and do one of the following for each location:

(a) Direct the contractor to correct the area to minimize the effect on the ride.
(b) Leave the area of localized roughness in place with no pay reduction.
(c) Assess a pay reduction as follows for each location in each wheel path as per Table B-4

Table B-4: ALR Deductions and Corrective Action

7.62 m Continuous IRI, m/km	Corrective Action or Deduction, per linear 0.30 m
< 1.97	Acceptable
1.97 to < 2.76	Corrective action or QAR50 as directed by the engineer
2.76 to < 3.94	Corrective action or QAR125 as directed by the engineer
> 3.94	Corrective action or QAR250 as directed by the engineer

3 Re-profile corrected areas to verify that the IRI is less than 2.2 m/km after correction. Submit a revised ProVAL smoothness assurance report for the corrected areas to validate the results.

4 Areas excluded from smoothness and ALR evaluation:

- Turn lanes, crossovers.
- 3.05 m on either side of obstructions in lane that obstruction is located.
- Intersections where mainline profiles are merged or blended into the cross stress profile – beginning and end exclusion 30.5 m from the intersection radius.
- Side streets, side connections.
- Paved shoulders.