ASHGHAL
Interim Advice Note No. 100

Amendments to Section 6 Parts 4, 5, 6 & 8 of QCS 2014

ADVICE

This Interim Advice Note (IAN) provides information and guidance on amendments and additions to Qatar Construction Specifications (QCS) 2014, Section 6 Parts 4, 5, 6 & 8, namely:

- Section 6 - Roadworks, Part 4 Unbound Pavement Materials
- Section 6 - Roadworks, Part 5 Asphalt Works
- Section 6 - Roadworks, Part 6 Concrete Road Pavements
- Section 6 - Roadworks, Part 8 Recycled and Stabilised Road Materials

This Interim Advice Note shall take precedence over these Sections and Parts of QCS 2014.

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Qatar Deserves The Best

Circulation:	**Ashghal Departments, Contractors, Supervision Consultants, Design Consultants, PMCs.**
Application:	This Interim Advice Note (IAN) applies with immediate effect from the date of approval.

Rev	Date	Reason for Issue	Author	Checked	Approved
0	01.06.2015	For Implementation	**Dr. Walaa Eldin Ibrahim** QA/QC Expert	**Theocharis Tzavelas** Senior QA/QC Specialist	**Abdulla Ahin A A Mohd** Manager of Roads Design Department

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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 Roads Design Department, Infrastructure Affairs.

Signed on behalf of the Ashghal – Infrastructure Affairs - Roads 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:

Abdulla Ahin AA Mohd

Abdulla Ahin A A Mohd
Manager of Road Design Dept
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We cannot acknowledge every response, but we thank you for your 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 2014 - Qatar Construction Specifications 2014**
- **Qatar Highway Design Manual - QHDM**
- **IAN 011 - Cycleway Design Guidelines**
- **IAN 021 - Cycleways and Footways Pavement Design Guidelines**
- **IAN 016 - Pavement Design Guidelines**
- **IAN 101 – Amendments to QHDM**
- **MS-2 - Latest revision**

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 100 shall take precedence with respect to Ashghal projects.

4 Withdrawn / Amended Standard

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

- PWA Guides
  - Guide for Marshall mix design and quality control of asphalt mixtures
  - Guide for Superpave mix design and quality control of asphalt mixtures
  - Guide for performance testing of flexible pavement layers
  - Specifications and quality control of unbound materials
  - Guide for measuring smoothness of roads pavements
  - Guide for construction of thin asphalt concrete layers
- IAN 019 - Amendments to Sections 5 and 6 of QCS 2010 (only parts relevant to Section 6: Road works)

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
- Relevant Ashghal Design & Build projects

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.

7 Amendments to Section 6 Parts 4, 5, 6 & 8 of QCS 2014

7.1 Amendments to Section 6 - Part 4

THE FOLLOWING CHANGES ARE MADE TO QCS 2014, SECTION 6 (ROAD WORKS), PART 4 (UNBOUND PAVEMENT MATERIALS):

PART 4 UNBOUND PAVEMENT MATERIALS

4.2 MATERIALS

4.2.4 Fine Aggregate

Replace Table 4.1 and substitute with the following:

Table 4.1
Specifications of fine aggregates for Road Base and Subbase layers

Parameter	Standard	Specification Limits		Minimum Frequency
		Road Base	Subbase	
Liquid Limit	ASTM D4318	25%max.	25% max.	- Each source - Visible change in material - 1 test every 1000m^3
Plasticity Index	ASTM D4318	6 % max.	6 % max.	
Sand equivalent[a]	ASTM D2419	35 min.	25 min.	
Organic content	BS 1377 Part 3	0.5% max.	0.5% max.	

If the Sand Equivalent does not meet the required criteria then the result of this test shall be examined in conjunction with other properties (i.e. Atterberg limits) as directed by the Engineer. [a]

Add paragraph 3:

The wet method for the preparation of the Liquid Limit and Plasticity Index samples shall always be used [b].

[a, b]:Technical reasoning

[a]: Review of the International literature could not confirm relationship between Sand Equivalent and modulus (or any other performance related properties) of Road Base and Subbase Layers. Sand Equivalent is meant to provide an indication of the amount of total fines present in the material without discrimination of how much of that is clay. Since the real concern is plasticity and organic content, which are to weaken the unbound layers, the limit on the Sand Equivalent can therefore be relaxed when other properties (PI & OM) are within acceptable limits as indicated in Table 4.1.

[b]: Since most materials in Qatar include particles retained on 0.425mm sieve, the dry method is not allowed by the standard.

7.2 Amendments to Section 6 - Part 5

THE FOLLOWING CHANGES ARE MADE TO QCS 2014, SECTION 6 (ROADWORKS), PART 5 (ASPHALT WORKS):

PART 5 ASPHALT WORKS

5.2.2 Fine Aggregate

Replace Table 5.1 and substitute with the following:

Table 5.1
Fine Aggregate Specifications for Marshall Mixes

Parameter	Standard	Specification Limits	Minimum
Plasticity index	ASTM D 4318	4% max. (stockpile) Non Plastic (hot bins)	- Each source - Visible change in material - 1 test every $2000m^3$
Sand equivalent value	ASTM D2419	45% min.	
Soundness by magnesium sulphate	ASTM C88	18% max.	
Acid soluble chloride content	BS 1377 Part 3	0.1% max.	
Acid soluble sulphate content	BS 1377 Part 3	0.5% max.	
Clay lumps and friable particles	ASTM C142	None	
Organic Impurities	ASTM C40	No Impurities	
Un-Compacted Voids[c]	AASHTO T304	45% min	
Water Absorption[d]	ASTM C128	Wearing Course: 1.5% max Base Course: 2.0% max	

[c, d]**: Technical reasoning**

[c]*: It is well known that angularity of fine aggregates has significant impact on asphalt mix resistance to permanent deformation. Angularity improves shear resistance and indirectly limits the amount of natural sand that can be used in a mix. Natural Sands are known to be rounded in shape and lacks the interlocking provided by crushed angular sand.*

[d]*: Durability of asphalt mixes are highly related to the bitumen film thickness provided by the total bitumen content in the mix. High absorptive aggregate can reduce the film thickness by absorbing the bitumen and thus reducing the effective bitumen available for coating of aggregates. In addition, reduced bitumen film thickness, and/or lower effective bitumen content could result in brittle behavior due to high effective filler to bitumen ratio, which accelerates fatigue damage.*

5.2.3 Coarse Aggregate

Replace Table 5.2 and substitute with the following:

Table 5.2
Coarse and Combined Aggregate Specifications for Marshall Mixes

Parameter	Standard	Specification Limits			Minimum Frequency
		Base Course (Class A)	Base Course (Class B)	Wearing Course	
One or more Fractured Faces	ASTM D5821	100% min.			- Each source - Visible change in material - 1 test every 2000m^3
Two or more Fractured Faces[e]	ASTM D5821	≥ 85%, ESAL:≤ 10M ≥ 90%, ESAL:10-30M ≥ 100%, ESAL:≥30M			
Gradation (Combined)	ASTM C136	Table 5.7, Job Mix gradation and Table 5.10 tolerances			
Flat and Elongated Particles (5:1)	ASTM D4791	15 % max.	15% max.	10 % max.	
Soundness (5 cycles by Mg SO_4)	ASTM C88	15 % max.	15% max.	10 % max.	
Los Angeles Abrasion	ASTM C131 ASTM C535	30% max.	30% max.	25% max.	
Water absorption	ASTM C127	2.0% max.	2.0% max.	1.5% max.	

[e]: Technical reasoning

[e]: According to the Superpave mix design procedure Two Fractured Faces ensure higher aggregate angularity which can contribute significantly to mix stability and rutting resistance of asphalt mixes. Since Qatar conditions include warm climate and extremely heavy truck loading, this additional requirement will reduce the risk of premature rutting damage.

5.2.6 Asphalt Binder

Replace paragraph 1 (b) and substitute with the following:

PG 76-10 S, H, V or E: Based on the Engineer approval, the PG76-10 binder can be used in asphalt mixes. PG76-10 S, H, V or E are specified for standard, heavy, very heavy, and extreme heavy loading. These binder types shall be polymer-modified binders (PMBs) meeting AASHTO M332 specifications in addition to the tests criteria as listed in Table 5.5. Sampling shall be in accordance with ASTM D140.

Replace table 5.5 and substitute with the following:

Table 5.5[f]

Specifications for Polymer-Modified Asphalt Binder

Item	Property	Test Method	Criteria			
			PG76S-10	**PG76H-10**	**PG76V-10**	**PG76E-10**
1	20–Year Design ESALs, millions[g]		< 10	10 – 20	20 – 50	≥ 50
2	If Traffic Speed is less than 20km/hr (Standing/Intersections)[g]		Use grade PG76H-10	Use grade PG76V-10	Use grade PG76E-10	Use grade PG76E-10
3	Flash Point, min, °C	ASTM D92	230	230	230	230
4	Viscosity @ 135°C, max, Pa.s	ASTM D4402	3.00	3.00	3.00	3.00
5	Dynamic Shear, G*/sinδ @ 76°C and 10 rad/s, min, kPa	ASTM D7175	1.00	1.00	1.00	1.00
6	Separation Test: Absolute Difference between G* @ 76°C and 10 rad/s of Top and Bottom Specimens, max, %[h]	ASTM D7173 [h]	20	20	20	20
7	Time Stability: Average of G* values measured in Separation test (item 6) divided by the initial G* value measured in (item 5), range[i]		0.8 - 1.2	0.8 - 1.2	0.8 - 1.2	0.8 - 1.2
8	Particulate Retained on Sieve Test, %[j]	PWA 100	0	0	0	0
9	Solubility, min, %	ASTM D5546	99	99	99	99
10	Polymer Content, min, % by mass[k]	Supplier Certificate Required	2.0	2.0	3.0	3.0
	Rolling Thin Film Oven (RTFO) Residue					
11	Mass Change, max, %	ASTM D2872	1.00	1.00	1.00	1.00
12	Dynamic Shear, G*/sinδ, @ 76°C and 10 rad/s, min, kPa	ASTM D7175	2.20	2.20	2.20	2.20
13	MSCR, $J_{nr3.2}$ @ 76°C, max, kPa^{-1}	ASTM D7405	4.50	2.00	1.00	0.50
14	MSCR, Recovery $R_{3.2}$ @ 76°C and 3.2 kPa, %[l]		Report	Report	Report	Report
15	MSCR, J_{nrdiff} @ 76°C, %[m]		Report	Report	Report	Report
	Pressurized Aging Vessel (PAV) Residue					
16	PAV Aging Temp., °C	ASTM D6521	110	110	110	110
17	Dynamic Shear, G*×sinδ @ 37°C and 10 rad/s, max, kPa	ASTM D7175	5000	6000	6000	6000
18	Bending Beam, S @ 0°C and 60s, max, MPa	ASTM D6648	300	300	300	300
19	Bending Beam, m-value @ 0°C and 60s, min	ASTM D6648	0.300	0.300	0.300	0.300

Absolute Difference = Abs {100*[(top-bottom)/top]} [h]
Time Stability = [(top+bottom)*0.50]/ (G* from item 4) [i]
See PWA Test Method 100 [j]

PWA Test Method 100[j]
(After Nevada DOT Test Method: Nev. T730C)

METHOD OF TEST FOR SIEVE TEST OF ASPHALT BINDER

SCOPE
This method is to determine if particulates are present in an asphalt binder sample.

SUMMARY OF TEST METHOD
An asphalt sample is poured over a 2.00 mm sieve and a visual observation is made to determine if any particulates are retained on the sieve.

APPARATUS
1. Sieve, size of 2.00 mm with a 76 mm diameter, made of wire cloth conforming to Specification ASTM E11.
2. Containers, cylindrical seamless metal containers, with an approximate diameter of 76 mm and depth of 50 mm, or similar container.
3. Digital Balance
4. Oven, capable of maintaining temperatures to 163°C.

PROCEDURE
Heat the sample in an oven until it has become sufficiently fluid to pour. Unmodified asphalt binders will be heated in an oven set at 135 ± 5.5°C. Modified asphalt binders will be heated in an oven set at 163 ± 5.5°C. After the sample is fluid, stir to achieve uniformity while taking care to avoid the entrapment of air. Preheat the sieve to the same temperature as the asphalt binder. Set the sieve onto the container and place both on the balance. Pour 100 ± 0.1 g of asphalt binder onto the sieve. Place the container and the sieve back into the appropriate oven for a sufficient amount of time to allow the asphalt to drain through the sieve. Draining time shall not exceed 2 hours. Remove the sieve and container from the oven. Visually inspect the sieve for any particulates retained on the sieve.

REPORT
Report the number of particulates retained on the sieve.

[f, g, h, i, j, k, l, m]**: Technical reasoning**
[f]*: This table includes all the requirements of AASHTO M332 and additional criteria to control the quality of PMB during storage and handling. In addition the requirements for testing of binder after RTFO is expanded to include G*/sinδ, which allows evaluating relative aging as compared to un-aged value. This table eliminates the need to maintain the original criteria of AASHTO M320, which is listed in Table 5.5 in the QCS 2014.* [g]*: These ESAL intervals are used in the QHDM pavement type classification. In order to maintain consistency in design of pavements, these values should be used. In addition, international literature does not provide reasonable justification for the intervals listed in AASHTO M332. In fact there are a few studies criticizing the logarithmic approach used in that standard. The effect of speed at intersections and in heavily trafficked urban areas requires shifting the grades to account for standing or slow moving vehicles as shown in item 2 of the table.* [h]*: The Separation of additives used for modification of bitumen is detrimental to the Quality of modified bitumen. This test is required to ensure that the suspension and/or interaction of additives in bitumen is permanent and will not change during handling and production of asphalt mix.* [i]*: Certain additives can continue to react with the bitumen or are degradable during storage at elevated temperatures. This calculation that includes measurements from items 4 & 5 will provide assurance that the modifier will remain stable in the bitumen at high temperature storage. Extensive studies by NCHRP program have been reported in this regard, which confirm the need to have an indicator of time stability.* [j]*: This test ensures that the polymer particles are fully shear milled and digested during the modification process. No lumps are contained in the asphalt binder.* [k]*: Although there are technologies for bitumen modification that require no additives (oxidation and acid reaction), there are significant concerns of extreme usage of these technologies due to the proven effect of changing the molecular structure of the bitumen. In other words, over utilization of these technologies could result in unbalanced bitumen with poor physical and durability characteristics. To avoid over usage of these technologies, a minimum polymer content is required. The reason for selecting 2% and 3% of polymer content is the fact that a Pen 60/70 can be improved by one grade (i.e. PG64 to PG70) using these percentages. Therefore, to reach a PG76 no supplier will be tempted to over dose using oxidation or acid reaction. There is substantial number of publications in the US and*

Canada regarding the recommendation for moderate use of oxidation and acid modification.
(l, m): The international literature does not provide any evidence that percent recovery and J_{nrdiff} are performance related properties. It appears that they are in AASHTO M332 to ensure the proper use of elastomeric additives only. Since the world of bitumen modification is wider than elastomeric additives, and since stress sensitivity are both important aspects of modification, it is required to report these values so that PWA collect sufficient data, correlates them to performance of pavements, and select proper limits in the future if these properties are proven as such. Although these two parameters are proposed in AASHTO M332, most highway agencies in the United States have been very reluctant to implement the limits proposed as of now. This is due to the fact that this standard is relatively new and there is no sufficient performance data to justify the limits set in the AASHTO M332.

Replace Paragraphs 4 & 5 and substitute with the following:

Binders modified using Crumb Rubber and other binders containing particulate materials shall be produced by blending the modifier/rubber with the binder before introducing to the mix (wet process). These binders when graded according to Table 5.5, shall not include particles with longest dimensions of more than 250µm. In addition, the requirements listed in Table 5.5 for the solubility (item 8) shall be waived. However, the residue from the solubility test shall be examined using ignition oven or furnace to confirm that no mineral/metal particles exist by measuring the residue. The maximum measurable weight of the ignition oven or furnace residue shall not exceed 1% of the original modified binder weight.

5.3 MARSHALL MIX DESIGN

5.3.2 Marshall Mix Design Criteria

Replace paragraph 2 and Table 5.6 and substitute with the following:
The required compacted lift thicknesses shall be between 2.5 and 4.0 times the NMAS (Nominal Maximum Aggregate Size) as shown in table 5.7, for example for Wearing Course with NMAS of 19.0mm, the lift thickness shall be 47.5mm to 76.0mm[n].

(n): Technical reasoning

Thickness outside this range will result in difficulty of achieving uniform In-place density. Variability in density across the depth and/or low density can result in poor performance.

Replace Table 5.7 and substitute with the following:

Table 5.7

Combined Aggregate Gradation for Asphalt Concrete Mixes

ASTM Sieve Size	Percentage Passing (By Weight)		
	Base Course (Class A) Marshall Mix Design[o]	**Base Course (Class B) Marshall Mix Design**	**Wearing Course Marshall Mix Design**
37.5 mm	100	-	-
25.0 mm	80 – 100	100	100
19.0 mm	62 - 92	80 - 100	86-100
12.5 mm	-	63 - 85	69 - 87
9.5 mm	45 - 75	57 - 77	58 - 78
4.75 mm	30 - 55	40 - 60	40 - 60
2.36 mm	20 - 40	25 - 45	25 - 45
0.850 mm	15 - 30	15 - 30	15 - 30
0.425 mm	10 - 22	10 - 22	10 - 22
0.180 mm	6 - 15	6 - 15	6 - 15
0.075 mm	2 - 8	2 - 8	2 - 8

(o): Technical reasoning

Base Course Class A (Marshall Mix Design) – According to ASTM D6926 standard the maximum aggregate size shall be 25.0mm (1.0 inch). In this case the gradation shown in the table should be modified to reflect 100% passing sieve 25.0mm. However, if sizes greater than 25.0mm is desired to be used in the asphalt mixture then ASTM D5581 (or "Superpave" mix design) shall be used and the gradation shown in table 5.5 should be used as is.

Replace Table 5.8 and substitute with the following:

Table 5.8

Design Criteria for Marshall Design Mixes

Parameter	Base Course (Classes A & B)	Wearing Course
Aggregate Properties	Tables 5.1 and 5.2	
Aggregate Grading	Table 5.7	
Number of Compaction blows at each end of specimen (see paragraph 5)	75	75
Binder Content (% of total mix) inclusive of tolerances[(p)]	3.2 – 4.4	3.4 – 4.4
Stability minimum (kN)	9.5 min.	11.5 min.
Flow (mm)	2 to 4	2 to 4
Marshall Quotient (Stability/Flow) (kN/mm)[(q)]	4.75	4.75
Voids in Mix (Air Voids) (%)[(r)]	4.0 to 6.0	5.0 to 7.0
Voids in Mineral Aggregate VMA (%)	Table No.5.9	
Voids Filled with Asphalt VFA (%)[(s)]	55 to 75	55 to 75
Voids in Marshall Specimen at 400 Blows per face at optimum binder content (%)[(t)]	2.5 min.	3.0 min.
Retained Stability (%)	75 min.	75 min.
(Filler/Binder) Ratio	0.8 to 1.5	0.75 to 1.35
Tensile Strength (Wet) at 25°C (AASHTO T283), at the Design Asphalt Binder Content, min, kPa[(u)]	700	700
Tensile Strength Ratio at 25°C (AASHTO T283), at the Design Asphalt Binder Content, min, %[(v)]	70%	70%

[(p, q, r, s, t, u, v)]: Technical reasoning

[(p)]: For mixes with PMB the upper limit could be adjusted based on the engineers' approval, for reasons of workability and/or durability. PMB inherently has higher viscosity which results in resistance to compaction therefore allowing higher binder content will allow achieving required density in the field. In addition, higher binder content will result in thicker bitumen film in mixes which improves durability.

[(q)]: This parameter could be considered as an over specification since it makes the design too restrictive. Mathematically it can be shown that this parameter will result in dry mixes because it requires higher stability and very risky low value of flow. For example for a stability value of 12kN to 14kN, which is typical of Pen 60/70 mixes in Qatar, the allowable flow will be 2.5mm to 2.9mm. Such low flow values will not only encourage dry mixes but could result in less flexible mixes prone to fatigue and/or premature aging. Therefore, a lower value of Marshall Quotient can be accepted as directed by the engineer.

[(r)]: The range of 2.0% voids (target of 3.0 -5.0%) has been used successfully since the Marshall mix design was invented. Allowing a wider range in QCS 2014 (4.5 - 8.0% or 5.0-8.0%) is not justified and could allow more variability in quality.

[(s)]: In very warm climates like Qatar reducing the value to 50% increases the risk of premature oxidation, which could lead to early fatigue damage. In the last 2 years ANAS has consistently recorded acceptable mixes with VFA above 55%, and thus there is no need to take such risk.

[(t)]: Actual field data from LSA (asphalt mixture certified by LSA) and QA/QC project collected by ANAS between 2012 and 2014 indicate that achieving the high limits of voids listed in QCS 2014 are difficult. In addition, there is no record showing that the current 2.5 and 3.0 limits present a risk of rutting damage, thus there is no justification for the more restrictive values.

[(u, v)]: International practice indicates that using the ratio only without considering the actual wet strength value could be misleading since performance is related to the actual strength values more than the ratio. Therefore, there is a need to limit the minimum value of the Wet Tensile Strength. For example a mix with a dry strength of 200 kPa and a wet strength of 160 kPa has a retained ratio of 80%, while a mix with a dry strength of 1000 kPa and a wet strength of 700 kPa has a retained ratio of only 70%. It is clear that the second mix will perform better due to a wet strength of almost 500% higher. In addition, the procedure in AASHTO T283 is more controlled and includes a more effective method of conditioning the wet sample since there are strict requirements on the voids and the saturation. The retained strength as described in the QCS 2014 lack the same controls listed in AASHTO T283.

Replace Paragraph 5 and substitute with the following:

Base Course (Classes A & B) and Wearing Course samples shall be prepared and tested using Marshall Apparatus in accordance with ASTM D6926 and ASTM D6927, respectively.

Replace Paragraph 6 and substitute with the following:

Upon the request of the Engineer, the Tensile Strength Ratio (TSR) in accordance with AASHTO T283 shall be obtained for the mix for quality control purposes.

Replace Table 5.9 and substitute with the following:

Table 5.9
Minimum Percent Voids in Mineral Aggregate (VMA)

Nominal Maximum Particle Size (mm) (w, x)	**Minimum VMA, Percent**		
	Design Air Voids, Percent (y, z)		
	3.0	**4.0**	**5.0**
1.18	21.5	22.5	23.5
2.36	19.0	20.0	21.0
4.75	16.0	17.0	18.0
9.5	14.0	15.0	16.0
12.5	13.0	14.0	15.0
19.0	12.0	13.0	14.0
25.0	11.0	12.0	13.0
37.5	10.0	11.0	12.0
50	9.5	10.5	11.5
63	9.0	10.0	11.0

Standard Specification for Wire Cloth Sieves for Testing Purposes, ASTM E11 (AASHTO M92). (w)
The nominal maximum particle size larger than the first sieve to retain more than 10 percent. (x)
Interpolate minimum voids in the mineral aggregate (VMA) for design air voids values between those listed. (y)
If Design Air voids value is more than 5.0%, use the VMA limits as listed for 5.0 %. (z)

(z): Technical reasoning

Allowing the increase in VMA higher than what is listed for the 5.0% Air Voids will result in risk of increasing bitumen content above what is needed for proper film thickness coating the aggregates. Such increase could result in unstable mixtures and potential rutting. The listed VMAs are sufficient to allow proper bitumen and void content.

Replace Table 5.10 and substitute with the following:

Table 5.10
Job Mix Tolerances for Field Mixtures and Blended Hot Bin Aggregates

Description	Base Course (Classes A & B)	Wearing Course
Extracted Aggregate retained on 4.75 mm sieve or larger	±4%	±4%
Extracted Aggregate passing 4.75 mm sieve and retained on 850 µm sieve	±3%	±3%
Extracted Aggregate passing 850 µm sieve and retained on 75 µm sieve	±2%	±2%
Extracted Aggregate passing 75 µm sieve	±1.0%	±1.0%
Binder Content	±0.2%	±0.2%
Specific Gravity of coarse aggregate retained on 2.36 mm sieve after blending of hot bin aggregate samples (aa)	±0.02	±0.02
Specific Gravity of fine aggregate passing on 2.36 mm sieve after blending of hot bin aggregate samples (ab)	±0.02	±0.02

(aa, ab): Technical reasoning

(aa, ab): Coarse & Fine Aggregate Specific Gravity Limits – These are required to ensure consistency of the aggregate sources. Changes beyond these limits have been related to contractors changing their aggregate sources, which could invalidate the JMF and will require a new mix design.

5.3.3 Quality Control Testing

Replace Paragraph 9 and substitute with the following:

Base Course (Class B) and Wearing Course samples shall be prepared and tested using Marshall Apparatus in accordance with ASTM D6926 and ASTM D6927, respectively.(ac)

(ac): Technical reasoning

Substituting aggregates of 25mm is not acceptable since it will make the mix unrepresentative of what will be constructed.

Replace Paragraph 10 and substitute with the following:

Upon the request of the Engineer, the Tensile Strength Ratio (TSR) in accordance with AASHTO T283 shall be obtained for the mix for quality control purposes.(ad)

(ad): Technical reasoning

Limits have been added to table 5.8 and thus the statement is not needed.

Add Paragraph 18:

The measurement of the maximum theoretical specific gravity of the asphalt mixture (Gmm) shall follow the ASTM D2041: “Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.” The calculation of the maximum specific gravity shall follow the method described in section 10.1.1: Bowls Used under Water Determination.(ae)

(ae): Technical reasoning

For the sake of consistency, all labs should run the test according to section 10.1.1 method.

Add Paragraph 19:

All cores obtained for the measurement of in-place compaction shall be saw-cut at the interface of the asphalt layers and at the interface with the sub-base/base course layer prior to the measurement of the bulk specific gravity.(af)

(af): Technical reasoning

It has been observed that some labs are using chisels to separate layers which cause significant damage to sample. Requiring a saw cut will establish consistency and eliminate risk of core damage.

Add Paragraph 20:

The specific gravity of aggregates used in the calculation of the Voids in Mineral Aggregates (VMA) shall be the bulk specific gravity of the combined gradation (Coarse and fine aggregates).[ag]

[ag]: Technical reasoning

The QCS 2014 requires following the MS-2. Using the bulk specific gravity of the combined gradation is a requirement in the MS-2. Adding this statement will stop the labs from using other types of specific gravity measures.

Add Paragraph 21:

The calculation of the dust proportion shall be based on the effective asphalt binder content taking into consideration the percent of absorbed binder.[ah]

[ah]: Technical reasoning

Using the effective binder content is a more accurate representation of Dust to Binder ratio than the total binder content since the absorbed bitumen should not be considered in calculating the ratio.

Add Paragraph 22:

A new mix design shall be required if any of the following conditions occur:

- The asphalt binder fails the specified Pen Grade or the Performance Grade (PG) and/or a new asphalt binder source is used.
- The daily measured bulk specific gravity of the fine or the coarse aggregate portions of the combined gradation sampled from the hot bins differ from the values used in the approved Mix Design by more than 0.020.[ai]

[ai]: Technical reasoning

Mix design is very sensitive to changing source of binder and sources of aggregates, this statement is needed to ensure that the contractor will request new mix design approval when sources are changed to improve the consistency and quality of the pavement.

5.5 SUPERPAVE MIX DESIGN

Replace Table 5.17 and substitute with the following:

Table 5.17

Sampling and Testing Frequency of Superpave Field Mixtures

Item / Parameter	Standard	Specification	Minimum Frequency
Aggregate Conformance	Sections 5.2.1, 5.2.2, 5.2.3 and Table 6 - Appendix		
Mineral Filler conformance	Section 5.2.5		Every 300t
Prime Coat conformance	Section 5.2.7		
Tack Coat conformance	Section 5.2.8		
Asphalt Binder conformance	Section 5.2.6		
Rate of application for Prime Coat	ASTM D2995	0.45 – 0.75 kg/m^2 at 60 – 85 ^{0}C	- 1 per 250 m^2 - 1 every 75m per lane
Rate of application for Tack Coat	ASTM D2995	0.15 – 0.38 kg/m^2 at 10 – 60 ^{0}C	
Sampling of bituminous mixtures	ASTM D979	-	Test based
Temperature of bituminous mixture	BS EN 12697 Part 13	• ±10 ^{0}C of JMF temperature in truck • Min. JMF compaction temperature +20 ^{0}C at paver • Min. JMF compaction temperature prior rolling (sec. 1.5.4 – Appendix)	Each truck
Binder content (%) (aj)	ASTM D2172 ASTM D6307	JMF value ±0.20	- Each source; - Visible change in material - 1 test per 500t per layer for Base Course - 1 test per 250t per layer for Wearing Course
Gradation of extracted aggregates	ASTM D5444	Table 9 Appendix	
Effective Specific Gravity of Aggregates (G_{se})	ASTM D6857 ASTM D2041	$G_{sb} < G_{se} < G_{sa}$	
Voids in mineral aggregate (VMA)	AASHTO T312 ASTM D6857 or ASTM D2041 (Eq. 2) ASTM D2726	±1.5	
Voids in Mix (V_a) (Min 2 Gyratory specimens at N_{des}) (ak)		±1	
Density (% of G_{mm}) at N_{max} (Min 1 Gyratory specimens at N_{max})		Table 5 Appendix	
Dust to binder ratio ($P_{0.075}$ / P_{be})	ASTM D6857 / ASTM D2041 ASTM D2172 / ASTM D6307 ASTM D5444	Table 5 Appendix	
Dry Tensile Strength at 25°C (al)	AASHTO T283	Report	
Wet Tensile Strength at 25°C (am)	AASHTO T283	Report	
Tensile Strength Ratio at 25°C (an)	AASHTO T283	80% min	
Indirect tensile strength (IDT)	ASTM D6931	IDT of JMF min.	
Moisture Sensitivity (Retained IDT)	ASTM D6931 Sec. 1.5.8 Appendix	Sec. 1.5.8 Appendix	Weekly
Dynamic Modulus at 10 Hz, 45 °C, 0kPa confinement (ao)	AASHTO PP60 AASHTO TP79 Procedures A, B AASHTO PP61	Report	Every 10,000t
Flow Number (F_n) at 54.4 °C, 600kPa deviatory stress, and 0kPa confinement (ap)		Report	

Item / Parameter	Standard	Specification	Minimum Frequency
In-place air voids	ASTM D5361 ASTM D2726	6 – 8%	- 1 test per 200t per layer for Base Course; - 1 test per 100t per layer for Wearing Course
Thickness	ASTM D5361 ASTM D3549	Section 5.11.1	
Field density (nuclear gauge) (%G_{mm})	ASTM D2950	92 – 94%	At 50m intervals in alternate wheel tracks
Evenness of surface	Section 5.11.2 & 5.11.3		

Performance Testing listed in the Table 5.17 can be used by the contractor to request approval for deviation from the PG grade required. [ao, ap]

[aj, ak, al, am, an, ao, ap]: Technical reasoning

[aj]*: Mixture performance is very sensitive to variation in bitumen content. The range of ±0.40 listed in QCS 2014 is too wide and could allow variability in quality. The currently used values of ±0.20 are achievable and thus will provide better control.*

[ak]*: Mixture performance is very sensitive to variation in voids content. The range of ±1.3 listed in QCS 2014 is not needed since literature and practice show that the ±1.0 is achievable and thus will provide better control.*

[al, am, an]*: Tensile Strength Values & Ratio – International practice indicates that using the ratio only without considering the actual wet strength value could be misleading since performance is related to the actual strength value more than the ratio. Therefore, there is a need to limit the minimum value of the Wet Tensile Strength. For example a mix with a dry strength of 200 kPa and a wet strength of 160 kPa has a retained ratio of 80%, while a mix with a dry strength of 1000 kPa and a wet strength of 700 kPa has a retained ratio of only 70%. It is clear that the second mix will perform better due to a wet strength of almost 500% higher. In addition, the procedure in AASHTO T283 is more controlled and effective method of conditioning the wet sample since there are strict requirements on the voids and the saturation. The retained strength as described in the QCS 2014 lack the same controls listed in AASHTO T283.*

[ao, ap]*: Performance Testing – Since performance testing is new in Qatar, enforcing limits on performance properties is premature. Therefore, by requiring reporting only sufficient data could be collected and reasonable limits could be established in the future. In addition, since pavements are built with mixtures rather than binders contractors should be allowed to use equal or better mixture performance results to request using different binder grade. For example mixture with PG76V-10 can substitute mixture with PG76E-10 when performance results of mixtures show that the first mix is equal or better than the second.*

5.11 THICKNESS AND LEVEL

5.11.3 Evenness and Rideability

Replace paragraph 8 and substitute with the following:

The rideability of the driving surface of the completed pavement shall be measured in terms of the International Roughness Index (IRI) which shall be tested with a certified and calibrated Inertial Profiler meeting the requirements of ASTM E950–Class 1 (Longitudinal sampling shall be less than or equal 25mm)[(aq)].

Replace paragraph 15 and substitute with the following:

Three runs of data collection (both wheel tracks in each lane) shall be conducted. The processing of the data for IRI shall be completed using a software provided by the profiler manufacture and shall include calculating the average IRI value of the three runs for the two wheel tracks. The following is a list of the calculations that shall be completed for each section and each run:

1. The processed data shall be reported for every 25m and 400m consecutive subsections calculated using the Moving Average statistical method and applying a 250mm filtering.
2. The overall average IRI for each section (averaging left and right wheel paths) on each run.
3. The coefficient of variation of the overall average IRIs (across test section). This value should be less than or equal to 3% for three runs for the data to be accepted.

The following items shall be part of the collected raw data as listed in test standard:

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

Add paragraph 16:

The IRI of the driving surface shall not exceed the following limits:
New Construction, Reconstruction and Pavement Rehabilitation (*Works include overlay, Mill and Inlay/overlay, or Partial Reconstruction works which include all asphalt layers and part of the aggregate base layer***):**

- Average value over a 400m section ≤ 1.00 m/km.

Directional ramps on bridges or interchanges and tunnels of minimum length of 400m shall be tested, unless otherwise instructed by the Engineer, and shall have an IRI not exceeding the following limits:

- **Flexible Pavement**: Average value over a 400m section ≤ 1.00 m/km
- **Composite and Rigid Pavement**: Average value over a 400m section ≤ 1.20 m/km [(ar)].

No more than two 25m sub-sections within any of the 400m section shall have IRI values greater than 1.5 m/km.
Any section with rideability exceeding the specified criteria shall be corrected or removed and replaced in accordance with the instructions of the Engineer and to his satisfaction at the Contractor's cost.
The minimum length of the rectification work undertaken shall be 100m. All rectified segments shall be re-tested following the completion of rectification work at no additional cost to the client.

[(aq, ar)]**: Technical reasoning**
[(aq)]*: It is very important to emphasis the range of longitudinal profile sampling since it will directly affect the*

final result of IRI. Sampling at larger intervals can result into misleading smoothness indication.
[ar]*: International Standards recommendations (AASHTOWare Pavement ME, ASTM E950 and ASTM E1926)*

APPENDIX

Replace Table 9 and substitute with the following:

Table 9
Superpave Job Mix Formula Tolerances for HMA Plant Mix

Mix Composition Property	Tolerance Limit
Asphalt Binder Content (P_b)[as]	±0.20
Gradation Passing 4.75 mm and Larger Sieves	±5
Gradation Passing 2.36mm to 150µm Sieve	±4
Gradation Passing 75µm Sieve	±1.2
Air Voids (V_a)	±1.3
Voids in Mineral Aggregate (VMA)	±1.5
Field Density	92 to 94 (%G_{mm})

[as]: Technical reasoning

Binder Content Tolerance – Mixture performance is very sensitive to variation in bitumen content. The range of ±0.40 listed in QCS 2014 is too wide and could allow variability in quality. The currently used values of ±0.20 are achievable and thus will provide better control.

Add clause 5.16:

5.16 Construction of Thin Asphalt Concrete Layers Guidelines

A thin asphalt layer is defined as having a thickness less than 45 mm. Asphalt mixtures for thin layers shall be designed with a nominal maximum aggregate size (NMAS) of 9.5 mm or less (see Footnote). It should be noted that the QCS 2014 includes a Superpave mix design for mixtures with NMAS aggregates of 9.5 mm and 4.75 mm. In case a Marshall mix design is planned by the contractor, it is required that the contractor submits a mix design conforming to an internationally recognized procedure. Examples of such procedures is "IS-135: Thin Overlays for Pavement Preservation technical publication, NAPA, USA".
The production of asphalt mixtures and the construction process for a thin asphalt layer shall follow similar techniques to the construction of regular asphalt layers with the following exceptions:

1. *Applied over Asphalt Pavement:*
    a. *Milling machine shall be equipped with fine milling drum having teeth spacing between 5 and 8 mm with ridge to valley depth between 3 and 5 mm to provide an even roughened precisely defined surface texture.*
    b. *The Milling machine shall be equipped with a built-in precise grade control for longitudinal profile and transverse slope to verify against the design level and tolerances.*
    c. *When the thin asphalt concrete layer is applied as a wearing course, it is recommended that a polymer-modified tack coat is used to achieve the maximum bond with the pavement underneath.*
2. *Applied over New Concrete Pavement: the concrete surface shall be broom finish after screeding and before setting with minimum texture depth of 2.0 mm to provide better bond. Tack coat shall be similar to asphalt pavement under item 1.c.*
3. *Applied over Old Concrete Pavement: the concrete surface shall be ground to achieve good texture and all deteriorated joints shall be repaired. Tack coat shall be similar to asphalt pavement under item 1.c.*
4. *The ratio of layer thickness to the NMAS shall be equal or more than 2.5.*

5. *Mixing temperature shall be 15°C higher than the mixing temperature identified during the mix design process.*
6. *Material Transfer Vehicle (MTV) shall be used to reduce segregation and eliminate truck-paver bumping.*
7. *Screed shall be set at high frequency and low amplitude.*
8. *Compaction:*
    a. *The rolling pattern shall be established based on a trial section,*
    b. *In-place air voids shall be consistent with the project specifications,*
    c. *Only static drum and pneumatic tire rollers (PTR) shall be used,*
    d. *Rollers shall closely follow the paver to avoid cooling down of the thin mat,*
    e. *Mix temperature at beginning of compaction shall be higher than 135°C.*

7.3 Amendments to Section 6 - Part 6

THE FOLLOWING CHANGES ARE MADE TO QCS 2014, SECTION 6 (ROADWORKS), PART 6 (CONCRETE ROAD PAVEMENTS):

PART 6 CONCRETE ROAD PAVEMENTS

6.4 REQUIREMENTS FOR CEMENT BOUND MATERIALS

6.4.1 General Requirements for Cement Bound Materials

In case CBM is used for asphalt surfaced roads, Replace paragraph 3 and substitute with the following:

Cement and water shall comply with the requirements of the Section 5 - Part 16. Aggregates shall comply with the requirements of QCS 2014 Section 6 - Part 4(at).

(at):Technical reasoning

The CBM is actually the regular unbound materials mix treated with cement to enhance its properties. Therefore, the aggregates properties shall comply with the unbound materials requirements.

In case CBM is used for asphalt surfaced roads, Replace paragraph 4 and substitute with the following:

Cement for use in all cement bound materials shall be delivered and stored in compliance with the requirements of Section 5 – Part 3 and Section 5 - Part 16. (au)

(au):Technical reasoning

The CBM is actually the regular unbound materials mix treated with cement to enhance its properties. Section 5 - Part 3 and Section 5 - Part 16 include better detailed requirements for the cement handling and storage.

In case CBM is used for asphalt surfaced roads, CBM 5 category shall be used with the following properties/notes:

Category	Mixing Plant	Method of Batching	Moisture Content	Minimum Compaction
CBM 5	Mix in place(NOTE 3) or mix in the plant	volume or mass	NOTE 1	NOTE 2

NOTE 1 To suit the requirements for strength, surface level regularity and finish

NOTE 2 95% of cube wet density during casting (av)

NOTE 3 For mix in place CBM, contractor is required to submit quality control plan to show specific cement dosage and consistency of cement dosage. In addition, aggregate gradation tolerances should include ±5% for aggregate larger than 4.75mm and ±2% for smaller aggregates for the Engineer approval.

(av):Technical reasoning

The degree of compaction is the ratio of field density to the cube density; therefore, the cube wet density shall be used in the calculation for checking if the minimum compaction is achieved.

CBM 5 used for asphalt surfaced roads shall meet the following strength criteria:

Category	Curing	Compressive Strength Testing	Minimum 7 days Cube Strength	
			Average of Five Specimens (MPa)(NOTE 1)	Individual (MPa)(NOTE 2)
CBM 5	BS EN 13286(aw)	BS EN 13286(aw)	1.0 to 2.1(ax)	Max. 2.5

NOTE 1 The average strength of 5 cubes shall not exceed the stated figure
NOTE 2 The strength of any individual cube shall not exceed the stated figure

(aw, ax):Technical reasoning

(aw): The BS 1924 is withdrawn and replaced by BS EN 13286
(ax): International practices show that in order to minimize the potential for reflective cracking, the 7-day compressive strength for the CBM under asphalt concrete layers shall range between 1.0 MPa and 2.1 MPa for the average of 5 specimens, and a maximum of 2.5 MPa for the strength of individual specimen. The Compressive strength measurement shall follow BS EN 13286. CBM with strength higher than the indicated values shall not be allowed.

6.4.6 Curing

In case CBM is used for asphalt surfaced roads, Replace clause 6 and substitute with the following:

Whichever method is used, immediately prior to overlaying with any bituminous layer a cationic bituminous tack coat shall be applied at a rate between 0.35 l/m^2 to 0.55 l/m^2. (ay)

(ay):Technical reasoning

The rate of application shall be reported in terms of Liter per square meter.

6.4.12 Testing of Cement Bound Materials

In case CBM is used for asphalt surfaced roads, Replace paragraph 1 and substitute with the following:

Samples shall be provided in accordance with BS EN 13286 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.

In case CBM is used for asphalt surfaced roads, Replace paragraph 2 and substitute with the following:

One 150 mm cube shall be made from each sample taken in accordance with sub-clause 1 of this clause. The cubes shall be made in accordance with BS EN 13286*(az)* without further mixing of the material and within 2 hours of the addition of the cement. Cubes shall be cured and tested in accordance with Table 6.6.

(az):Technical reasoning

The BS 1924 is withdrawn and replaced by BS EN 13286

7.4 Amendments to Section 6 - Part 8

THE FOLLOWING CHANGES ARE MADE TO QCS 2014, SECTION 6 (ROADWORKS), PART 8 (RECYCLED AND STABILISED ROAD MATERIALS):

PART 8 RECYCLED AND STABILISED ROAD MATERIALS

8.3 MATERIALS

Replace paragraph 4 and substitute with the following:

For BSM and CTB, material passing the 0.425mm sieve shall have a maximum liquid limit of 25% and the plasticity index shall not exceed 6.(aaa)

(aaa):Technical reasoning
The CTB is actually the regular unbound materials mix treated with cement to enhance its properties. Therefore, the aggregates properties shall comply with the unbound materials requirements.

8.4.1 Preparation and Mix Design for Cement Treated Base

Replace paragraph 4 and substitute with the following:

The CTB mix shall have a minimum individual 7 day compressive strength > 1.0 MPa with a maximum average 7 day compressive strength of 2.1 MPa when tested in accordance with ASTM D1633.(aab)

(aab):Technical reasoning
(abx): In order to minimize the potential for reflective cracking, the 7-day compressive strength for the CTB under asphalt concrete layers shall range between 1.0 MPa and 2.1 MPa. The Compressive strength measurement shall follow ASTM D1633. CTB with strength higher than the indicated values shall not be allowed.