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## CONTROL OF HOT MIX ASPHALT MIXTURES

### SCOPE

This IM describes the Quality Control/Quality Assurance (QC/QA) procedures for monitoring and controlling plant-produced Hot Mix Asphalt (HMA) on Quality Management of Asphalt (QMA) projects. Because the plant-produced mixtures may not develop test characteristics that meet design criteria, each mixture shall be evaluated during plant production. The evaluation procedures outlined herein are to be carefully followed so that all mix characteristics will conform to the appropriate requirements.

### REFERENCE DOCUMENTS

- Standard Specification 2303 Hot Mix Asphalt
- AASHTO R 9-90 Acceptance Sampling Plans for Highway Construction
- IM 204 Inspection of Construction Project Sampling & Testing
- IM 208 Materials Laboratory Qualification Program
- IM 216 Guidelines for Validating Test Results
- IM 301 Aggregate Sampling & Minimum Size of Samples for Sieve Analysis
- IM 302 Sieve Analysis of Aggregates
- IM 320 Method of Sampling Compacted Asphalt Mixtures
- IM 321 Method of Test for Compacted Density of Hot Mix Asphalt (HMA)(Displacement)
- IM 322 Sampling Uncompacted Hot Mix Asphalt
- IM 323 Method of Sampling Asphaltic Materials
- IM 325 Compacting Asphalt Concrete by the Marshall Method
- IM 325G Method of Test for Determining the Density of Hot Mix Asphalt (HMA) Using the Superpave Gyrotory Compactor (SGC)
- IM 336 Reducing Aggregate Field Samples to Test Samples
- IM 337 Method to Determine Thickness of Completed Courses of Base, Subbase & Hot Mix Asphalt
- IM 338 Method of Test to Determine Asphalt Binder Content & Gradation of Hot Mix Asphalt (HMA) by the Ignition Method
- IM 350 Method of Test for Determining the Maximum Specific Gravity of Hot Mix Asphalt (HMA) Mixtures
- IM 357 Hot Mix Asphalt (HMA) Mix Sample for Test Specimens
- IM 510 Method of Design of Hot Mix Asphalt Mixes

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## **RESPONSIBILITIES**

Appendix A contains an outline of the responsibilities required for all parties.

The Table of Responsibility, in Appendix A, is broken up into two main categories, Quality Action and Type of Project. The Type of Project is further broken down into two sub-categories, Certified Plant Inspection (CPI) and QMA, and projects with small quantities. The Quality Action is subdivided into the types of work needing to be performed. These areas are General, Asphalt Binder, Aggregate, Loose Hot Mix, Compacted Hot Mix and Revisions. The table is organized in a way to represent how the work would progress during a Hot Mix Asphalt paving operation.

Each Quality Action identifies the group responsible for ensuring the desired action is performed. The groups are the Contractor (CONTR), Resident Construction Office/Project Engineer (RCE), District Materials Office (DME), and the Central Materials Office (CTRL).

In addition, there are certain levels of certification required to perform specific activities. Depending on the Quality Action, an individual might be required to be a HMA Sampler, Level I HMA, Level II HMA, Level I AGG, or a Level II AGG Certified Technician.

## **SAMPLING & TESTING**

Samples of the combined aggregate, asphalt binder, and plant-produced mixture are obtained in accordance with IM 204 and analyzed as soon as the operations of the plant stabilize.

Only the information obtained from random samples as directed and witnessed by the Engineer and validated by comparison to one or more of the paired samples tested by the Contracting Authority will be used for specification compliance and included in the moving averages. Additional samples of aggregate and loose hot mix asphalt may be taken to provide better quality control. The results of testing done on additional samples will be for informational purposes only. Any proposed changes in the quality control and verification sampling/testing frequencies require the approval of the District Materials Engineer.

All testing done by the Contractor that is used as part of the acceptance decision shall be performed in qualified labs by certified technicians. On all QMA projects, the Level I HMA-Certified Technician is responsible for making sure that all samples are obtained according to the applicable IMs. Samples of loose HMA and asphalt binder must be taken by someone with a minimum of a HMA Sampler Certification.

Samples taken for acceptance purposes shall be retained until the lot has been accepted.

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## **A. ASPHALT BINDER**

The procedure used in the sampling of asphalt binder is found in IM 323. AASHTO procedures are used in the testing of asphalt binder. The frequencies for taking asphalt binder samples are found in IM 204.

## **B. AGGREGATE**

The procedure used in the sampling of aggregate is found in IM 301. The procedures used in the testing of aggregate are found in IM 336 and IM 302. The frequencies for taking aggregate samples are found in IM 204.

When results from one or more sieves of the specified gradation sample are outside the allowable gradation tolerances, the Engineer may direct and witness one additional aggregate sample or process one loose mix sample to include in the gradation acceptance decision.

## **C. LOOSE HOT MIX**

The procedure used in the sampling of loose hot mix asphalt is found in IM 322. The procedures used in the testing of loose hot mix asphalt are found in IM 357, IM 350 IM 325G, and IM 338. The frequencies for taking loose hot mix asphalt samples are found in IM 204.

The first production sample each day shall be obtained within the first 500 tons (500 Mg) of mix produced. Subsequent daily samples will be obtained from the remaining daily production by dividing the anticipated production beyond the first 500 tons (500 Mg) into three sublots and randomly selecting a sampling point within each sub lot. When less than 2000 tons (2000 Mg) of mix is anticipated to be produced in a day, samples shall be obtained at a minimum rate of one per 750 tons (750 Mg), after the first 500 tons (500 Mg) is sampled. In both cases, samples shall not be taken within the first 100 tons (100 Mg) of production. The specific ton or truckload to begin sampling shall be determined by the Engineer using a random number system. The production samples shall be obtained as directed and witnessed by the Engineer.

The laboratory density,  $G_{mb}$ , of each production sample will be determined by averaging the densities of the compacted specimens. Two Gyratory specimens are compacted to the specified number of gyrations. The number of gyrations or blows is specified in the project documents.

Laboratory voids,  $P_a$ , for each production sample will be determined from the results of laboratory density and the corresponding individual Rice,  $G_{mm}$ , results. The moving average of lab voids will be determined by averaging the last four individual lab void values. A separate moving average will be established for each Job Mix Formula (JMF).

The calibration of the Rice pycnometer shall be checked at the beginning of a project and anytime that a correlation problem occurs.

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#### **D. COMPACTED HOT MIX**

The procedure used in the sampling of compacted hot mix asphalt is found in IM 320. The procedures used in the testing of compacted hot mix asphalt are found in IM 321 and IM 337. The frequencies for taking compacted hot mix asphalt samples are found in IM 204.

The Engineer will provide inspection staff to direct and witness the sampling and perform density measurement during time agreed between the Engineer and the Contractor. The Engineer should make every effort to meet the Contractor's schedule. Results must be determined and reported within the period of time specified in this IM.

The Engineer will transport the cores in accordance with IM 320, or secure the cores for transport by the contractor. The Engineer and Contractor will determine that cores are not damaged. The Engineer will decide if a core is damaged prior to testing.

Field density will be based on the average of the seven density cores taken for each lot. The Quality Index (QI) for density will be determined using the field density compared to the average lab density obtained from samples, which correspond to the pavement from which the cores were taken. Field voids will be determined using the field density and the average of the Rice test results of production samples.

The Quality Index is a statistical measure of the difference between the field density and the minimum required density. The index identifies and compensates for values falling outside the statistical norm (outliers). If the QI results in less than 100% pay, the calculations to identify outliers will be performed. If the calculations identify an outlier at least 1.80 standard deviations from the mean, the outlier will be eliminated and a new QI calculated with the remaining cores. The new QI will be used to determine payment unless it results in a greater penalty. The Quality Index is based on AASHTO R 9-90. The equations used in the determination of the Quality Index are located in the Specifications. Examples on how to calculate the QI as well as outliers are located in IM 501.

#### **VALIDATION**

Validation is defined as the ability of two labs to achieve similar (statistically equivalent) test values on split or paired samples (split for aggregate samples and paired for HMA samples).

When any of the following events occur, validation has not been achieved or maintained.

- The difference between test results on each of two consecutive split/paired samples exceeds the IM 216 tolerance.
- The difference between test results on any two of three consecutive split/paired samples exceeds the IM 216 tolerance.
- The test results in a series of split/paired samples (minimum of 3 samples, normally no more than 5) are not variable and random (results are consistently higher or results are

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consistently lower) and the difference between each split/paired test result is greater than half of the IM 216 tolerance.

Consecutive samples may be either validation samples tested sequentially with another lab or mix specific samples when other mixes are being tested for validation between the two labs. It may be necessary to examine validation of test results on consecutive samples **of the same mix** if more than one mix is being tested between the two labs. Validation problems sometimes only occur during testing of specific mix samples.

To achieve or reestablish validation, a minimum of two consecutive test results must meet IM 216 tolerances, or when previous split/paired sample results were not variable and random, be within half of the IM 216 tolerances.

### **DISPUTE RESOLUTION**

When validation is not achieved or maintained, the District Materials Engineer may apply the following actions as appropriate to resolve split/paired test result differences.

- Retest the same sample
- The District labs will test additional verification samples.
- The District Materials Engineer will review the sampling and testing procedures of both labs
- The District Materials Engineer will immediately test samples sent in by the Contractor without allowing cool down and reheating (hot-to-hot testing).
- Both labs will test samples using comparable reheat periods.
- The District Materials Engineer will establish a correction factor based on the reheat evaluation outlined in Appendix B.
- Both labs will test a sample that was taken and split by the Engineer.
- Both labs and a third laboratory designated by the Contracting Authority will test a sample split three ways. The 3<sup>rd</sup> lab for state projects will normally be the Central Materials Lab.
- The District Materials Engineer will establish a correction factor for the Contractor's gyratory compactor based on the procedure described in Appendix C. The correction factor for  $G_{mb}$  should not exceed 0.030.

Resolution decisions by the Iowa DOT Central Materials Laboratory will be final. During the period of production when validation cannot be achieved, the Engineer's test results will be used for acceptance of the lot. The use of the Engineer's test values for acceptance will be retroactive to the time when the first sample exceeded the validation tolerance. Similarly, when validation is regained, the use of the Contractor's test results for acceptance is retroactive to the

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first test used to reestablish validation. The retroactive use of test results will not apply to the situation where test results are not variable and random and exceed half the IM 216 tolerance.

- If validation cannot be achieved for aggregate gradation, the Engineer's test results will be used for the entire gradation and applied to any calculations involving the gradation for the entire lot.
- If validation cannot be achieved on loose hot mix tests for  $G_{mm}$  or  $G_{mb}$ , the Engineer's test results will be used for any calculations involving that particular test value for the entire lot.

### **PRODUCTION TOLERANCES**

Production tolerances are listed in the specifications.

Variations between two consecutive test results in  $G_{mb}$  or  $G_{mm}$  of more than 0.030 shall be investigated promptly since these tests reflect significant changes in binder content, aggregate properties and/or gradation. In some cases variations may be attributed to segregation, thoroughness of mixing, sampling procedure, and changes in aggregate production.

### **REPORTING**

For each production sample of loose HMA the Contractor will determine, report, and plot (per QMA specification),  $G_{mb}$ ,  $G_{mm}$  and  $P_a$ . Binder content measurement by an approved method will be determined, reported, and plotted daily. Gradation will be determined, reported and plotted daily. The inter lab correlation reports shall be made available.

Test results are to be recorded and plotted in the computer programs provided by the Iowa DOT. Copies of the completed Daily HMA Plant Report (Form #800241) summarizing all test results including the field density QI shall be provided to the District Materials Engineer and the Engineer within four hours of beginning operations on the next working day. Copies of computer files containing the project information shall be furnished to the Engineer on a CD upon project completion. An additional copy of the files shall be furnished to the DME on a CD.

### **ADJUSTING (TROUBLESHOOTING)**

As stated in Standard Specification 2303, "The Contractor shall be responsible for all aspects of the project, provide Quality Control management and testing, and maintain the quality characteristics specified".

The Contractor is responsible for making changes, as necessary, to achieve target values specified on the JMF. These changes can include adjusting the proportions of aggregate and asphalt binder necessary to meet the JMF. If a change in the target gradation is desired, the Contractor must obtain approval of a new JMF from the District Materials Engineer. Changes in the target gradation cannot be set outside of the control points. The Contractor may change the target binder content to maintain the required mixture characteristics, provided the appropriate

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documentation and reporting is performed. All changes in proportions must be reported on the Daily HMA Plant Report (Form #800241).

The addition of new materials to the JMF may be approved by the District Materials Engineer without laboratory tests if the materials are produced from geologically comparable sources, do not constitute more than 15 percent of the total aggregate, meet quality requirements, and produce mixes that meet design criteria. When aggregates are introduced from sources that are not geologically comparable or otherwise differ significantly, complete laboratory mix design testing and approval is required.

Any time the moving average for laboratory voids falls outside the specification tolerance limit, the Contractor must cease operations. The Contractor assumes the responsibility to cease operations, including not incorporating produced material, which has not been placed. Production shall not be started again until the Contractor notifies the Engineer of the corrective action proposed.

Moving averages and the gyratory compaction slope assist in identifying potential problems before they arise. Watch the trends in the moving averages (approaching a specification limit) and the slope of the compaction curve. The slope of the compaction curve of plant-produced material shall be monitored and variations in excess of  $\pm 0.40$  of the mixture design gyratory compaction curve slope may indicate potential problems with uniformity of the mixture.

## **GUIDANCE TABLES**

The tables below are intended to provide guidance on dealing with the most common problems, which arise during the production of HMA. The first table deals with problems, which can show up in the laboratory setting and the second table deals with problems, which can appear in the field.

The following example explains how to read the tables. Both tables are read downward. The shaded regions are the items to be considered for adjusting purposes.

### **Lab Problem Table**

The first step is to identify which lab problem is occurring. If "Low Voids" is the identified problem, move down the column to the "Step 1 Check". Assuming the first check is to be made on the "Binder Content", move down the column to "Step 2 If". If the Binder Content is high proceed to "Step 3 Verify". Each of the shaded items identified in the "Step 3 Verify" should be looked at before proceeding further. Assuming that the items in "Step 3 Verify" are on target, go to "Step 4 Do". In this case, the action to be taken in "Step 4 Do" is to "Lower Binder" in the mix.

In all cases, the items in the “Step 3 Verify” are assumed to be within the allowable tolerances and won’t fall outside of allowable tolerances if the action in “Step 4 Do” is taken.

LAB PROBLEM		Low Voids			High Voids			Low Film Thickness			High Film Thickness			Low VMA			High VMA		
Step 1-Check	Binder Content																		
	Gradation																		
	Aggr. SG (Gsb)																		
	Aggr. Absorption																		
Step 2-If	Low Binder																		
	High Binder																		
	Low -200																		
	High -200																		
	Off JMF Target																		
Step 3-Verify	Filler Bitumen Ratio																		
	Film Thickness																		
	VMA																		
	Field Compaction																		
	Voids																		
	Individual Aggr. Sources																		
Step 4-Do	Lower Binder																		
	Increase Binder																		
	Lower -200																		
	Increase -200																		
	Adjust Aggr. Proportions																		
	Recompute Volumetrics																		

Field Problem Table

The first step is to identify which field problem is occurring. If “High Field Voids” is the identified problem, move down the column to the “Step 1 Check”. Assuming the first check is to be made on the “Lab Voids”, move down the column to “Step 2 If”. If the Lab Voids are high proceed to “Step 3 Verify”. Each of the shaded items identified in the “Step 3 Verify” should be looked at before proceeding further. Assuming that the items in “Step 3 Verify” are on target, go to “Step 4 Do”. In this case the process of looking at the “Step 3 Verify” would lead to the Lab Problem Table and cause one of the actions for High Lab Voids to be used.

In all cases, the items in the “Step 3 Verify” are assumed to be within allowable tolerances and won’t fall outside of allowable tolerances if the action in “Step 4 Do” is taken.



FIELD PROBLEM		Low Field Voids	High Field Voids	Tender Mix	Low Density Q.I.	Agglomerates	Uncoated Aggr.	Brown Rock	Stripping
Step 1-Check	Stockpiles								
	Aggr. Absorption								
	Binder Content								
	Lab Voids								
	Film Thickness								
	Mixing Time								
	Moisture in Mix								
	Mix Temp at Plant								
	Mat Temp								
	Step 2-If	Low							
High									
Yes									
Step 3-Verify	Filler/Bitumen Ratio								
	Film Thickness								
	Voids								
	Field Compaction								
	Aggr. Breakdown								
	Individual Aggr. Sources								
	Moisture								
	Amount of Clay Binder								
	Go To Lab Problem Table								
Step 4-Do	Increase Binder								
	Lower Temp								
	Increase Temp								
	Cover Loads								
	Increase Aggr. Dryer Time								
	Screen								
	Adjust Aggr. Proportions								
	Increase Wet Mixing Time								