# 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. These same procedures should be used on non-QMA projects when appropriate. 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
Supplemental Specification 01014 Hot Mix Asphalt (Gyratory Mix Design for Local Systems)
AASHTO R 9-90 Acceptance Sampling Plans for Highway Construction
IM 204 Inspection of Construction Project Sampling & Testing Purpose
IM 208 Materials Laboratory Qualification Program
IM 216 Guidelines for Verifying Certified Testing Results
IM 301 Aggregate Sampling Methods & Determination of Minimum Size of Samples for Sieve Analysis
IM 302 Sieve Analysis of Aggregates
IM 320 Method of Sampling Compacted Pavement Mixtures
IM 321 Method of Test for Compacted Density of Hot Mix Asphalt (HMA)(Displacement)
IM 322 Method of 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 Gyratory Compactor (SGC)
IM 336 Methods of Reducing Aggregate Field Samples to Test Samples
IM 337 Method to Determine Thickness of Completed Courses of Base, Subbase & Asphalt Concrete
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 Preparation of Hot Mix Asphalt (HMA) Mix Sample for Test Specimens
IM 510 Method of Design of Hot Mix Asphalt Mixes
IM 514 Correlation of Field Density for Hot Mix Asphalt (HMA) Paving

## PROCEDURE

### 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 three sub-categories, Certified Plant Inspection (CPI) and QMA, CPI and non-QMA, and projects where both CPI and QMA are not specified. 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 samples selected by the engineer at random and designated as “production samples” 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. The engineer must approve changes in the acceptance sampling/testing frequencies.

All acceptance testing done by the Contractor 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.

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

## 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.

## 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 325, 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 from the roadway, behind the paver, and prior to compaction.

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.

## 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.

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). 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.

## CORRELATION

Correlation is defined as the ability of two labs to achieve similar (statistically equivalent) test values on split samples. To achieve or reestablish correlation, a minimum of two consecutive test results must meet correlation tolerances. The correlation limits of test results are shown under IM 208, Appendix C or IM 216.

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

- The difference between test results on each of two consecutive split samples exceeds the correlation tolerance.
- The difference between test results on any two of three consecutive split samples exceeds the correlation tolerance.
- The test results in a series of split samples (minimum of 3 samples, normally no more than 5) are not variable and random (results are consistently higher or results are consistently lower) and the difference between each split test result is greater than half of the correlation tolerance.
- If greater than 50% of the seven roadway cores for a lot do not correlate, the entire lot will be considered out of correlation.

When correlation is not achieved or maintained, the District Materials Engineer may apply the following actions to resolve split test result differences.

- Retest the same sample
- Both labs will test back-up samples
- The District Materials Engineer will review the sampling and testing procedures of both labs
- The District Materials Engineer will immediately test all samples sent in by the Contractor without allowing cool down and reheating (hot-to-hot testing).
- 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 3rd 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.

During the period of production when correlation 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 correlation was lost. Similarly, when correlation is regained, the use of the Contractor's test results for acceptance is retroactive to the time when correlation was regained.

- If correlation 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 correlation 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.
- If correlation cannot be achieved for roadway density cores, the Engineer's test result will be used in place of 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. On non-QMA designed mixtures, the investigation should include the testing of back-up samples obtained during the production of the lot.

**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.

> **NOTE:** Under no circumstances can changes in the target gradation be set outside of the control points.

Test results are to be recorded in the computer programs provided by the Iowa DOT. A copy of the completed Daily ACC Plant Report (Form #800241) summarizing all test results including the field density QI shall be faxed to the District Materials 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 upon project completion.

**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. The Contractor may change the target binder content to maintain the required mixture characteristics, provided the appropriate documentation and reporting is performed. All changes in proportions must be reported on the Daily ACC 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 ± 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 <u>all</u> 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 | | | ■ | | | ■ | | | ■ | | | ■ | | | ■ | | | ■ |

<u>Field Problem Table</u>

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 <u>all</u> 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 | | | | | | | | | | | | | ■ | | | | |