HMA PRODUCTION MANUAL

February 2008

Michigan Department of Transportation

CONSTRUCTION AND TECHNOLOGY DIVISION

FOREWORD

This manual is the combination of three separate Hot Mix Asphalt (HMA) manuals used in the design, production, testing of HMA for MDOT projects and a lab and technician qualification program. This manual consists of the following sections:

Section 1: Procedures Manual for HMA Mix Design Processing

This section provides the mix design guidelines for Marshall and Superpave Hot Mix Asphalt mixtures for use on MDOT projects. Included are examples of calculations, documentation requirements, and contact information for MDOT and private testing laboratories.

Section 2: Certification of Hot Mix Asphalt Plants

This section provides the requirements for certifying Hot Mix Asphalt Plants. The certification procedures are administered by the Lansing Construction & Technology Support Area, with direct support from the Region Traveling Mix Inspector. The requirements of these procedures do not replace or supersede MDOT specifications or other legal requirements referenced in this section.

Section 3: HMA QC/QA Procedures Manual of Field Testing

The checklists in this section are intended to provide a quick reference guide for the performance of Hot Mix Asphalt sampling and testing required by the MDOT Hot Mix Asphalt Quality Control/Quality Assurance Program. These checklists do not replace or supersede the referenced MDOT, AASHTO or ASTM test methods or quality assurance procedures. The user should insert the referenced test methods in this manual where indicated.

All requirements contained in this manual for Certification of Hot Mix Asphalt Plants and all MDOT quality assurance procedures will be reviewed and revised annually. Revisions will be distributed through the MDOT Publications Office. These sections are formatted to allow revised pages to be easily substituted. It may be necessary to retain superseded pages for reference on projects which have been advertised prior to the date revisions are implemented.

The values stated in either inch-pound units (English) or SI units (metric) are to be regarded as the standard; within the text and tables, metric units are shown in parentheses. The values stated in each system may not be exactly equivalent; therefore each system must be used independently of the other. Combining values from the two systems may result in nonconformance with the specification.

Section 4: HMA Lab and Technician Qualification Program

This section provides the criteria used to establish and maintain qualification status for laboratories and technicians engaged in sampling and testing Hot Mix Asphalt.

MDOT Mission Statement:

Providing the highest quality integrated transportation services for economic benefit and improved quality of life.

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HOT MIX ASPHALT (HMA) MIX DESIGN LABORATORY QUALIFICATIONS

To be qualified to submit HMA mix designs for projects with the Michigan Department of Transportation (MDOT) oversight, the laboratory must supply documentation for meeting the following criteria:

1. The HMA Mix Designer preparing the HMA mix design must have successfully completed the MDOT Superpave Mix Design Certification Course.

2. Current AASHTO Materials Reference Laboratory (AMRL) inspection. Documentation includes:

    a. Complete copy of the AMRL Laboratory inspection report.

    b. Responses to any deficiencies from the participating laboratory.

AASHTO Materials Reference Laboratory (AMRL) Laboratory Inspection

The following test procedures are required:

ASTM D2726/T166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
ASTM D2041/T209	Maximum Specific Gravity of Bituminous Paving Mixtures
ASTM D1559/T245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D3203/T269	Percent Air Voids in Compacted Dense & Open Bituminous Paving Mixtures
AASHTO T312	Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the SHRP Gyratory Compactor

A copy of the AMRL inspection report and any responses to deficiencies are to be sent to:

Michigan Department of Transportation
Construction & Technology Support Area
Bituminous Mix Design Unit
P.O. Box 30050
Lansing, Michigan 48909

3. Participation in the AMRL Proficiency Sample Program (PSP). The results from the AMRL lab must be forwarded by the HMA mix design laboratory, to C&T HMA Unit in Lansing. The following sample participation is required for all HMA mix design methods.

   a. Hot Mix Asphalt Design (Hveem/Marshall)

   b. Hot Mix Asphalt Gyratory

   c. Coarse Aggregate

   d. Fine Aggregate

4. Contact information for Personnel responsible for signing mix designs from the laboratory on file with the department.

Laboratories applying for initial (probationary) qualification to submit HMA mix designs for department projects will submit a packet containing the above information to the following address:

Michigan Department of Transportation
Construction & Technology Support Area
C/O Bituminous Mixtures and Materials Engineer
8885 Ricks Road
P.O. Box 30049
Lansing, MI 48909

Upon satisfying the requirements for qualifying to submit HMA mix designs for department projects, the design laboratory will receive written notification of their MDOT lab number and may commence submitting designs. The period for review and issuance of the approval to submit is three weeks.

MARSHALL MIXTURE DESIGNS

1. Mix Design General Guidelines

For all projects, the Contractor will supply the Michigan Department of Transportation (MDOT) with a SUBMITTED MIX DESIGN (SMD). The SMD must be prepared by a private testing laboratory, either Contractor or Consultant. SMD's must be prepared in accordance with MTM 322-01, Michigan Test Method for Bituminous Marshall Mix Design Procedure.

- When a Contractor uses a consulting laboratory to supply a mix design, the Contractor must authorize in writing that the consultant acts as the Contractor's agent on mix design issues for the project.

- MDOT will only accept one passing design per course, per project. The maximum number of designs per course, per project, that any one Contractor or Consultant laboratory may submit is two.

Submittal of a submitted mix design shall be made to:

MDOT
Construction and Technology Laboratory
Bituminous Mix Design Unit
8885 Ricks Road
P.O. Box 30049
Lansing, Michigan 48909

Acceptance for evaluation requires a person from the Bituminous Mix Design Unit to review the paperwork and submitted material. Upon acceptance, MDOT will have five workdays to evaluate the submitted mix design. SMD's received after 11.45 a.m. will start the five workday clock on the next scheduled workday.

Note: Work days are Monday through Friday excluding state holidays.

The Project Engineer may require a new mix design from the Contractor on materials at any time it is determined necessary.

2. Paper Review Acceptance Criteria

The Bituminous Mix Design Unit's evaluation of a paper review design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the Mix Design data with MDOT's Bituminous Mix Design Computer Program.

Tolerance Limits for MDOT Paper Review:

Marshall

a. All data must meet specification.

b. Volume of compacted specimens: 515 $cm^3 \pm 8 cm^3$.

c. Spread between three Marshall Gmb’s at a given asphalt content within: 0.013.

d. Spread between Gse’s on a 4-point design within: 0.012.

e. The flow value consistently increases with increasing asphalt content.

f. The percent of air voids steadily decreases with increasing asphalt content.

g. The VMA generally decreases to a minimum value, then increases with increasing asphalt content.

3. Submitted Mix Design

The Bituminous Mix Design Unit's evaluation of the submitted mix design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the submitted mix design data with MDOT's Bituminous Mix Design Computer Program.

At the department’s discretion, any or all of the following testing may be performed.

Test the following physical properties of the recovered aggregate for compliance to specification:

- Aggregate Wear Index (AWI) - for top course material only
- Angularity Index (AI)
- Soft Stone
- Percent Crush
- Current Los Angeles Abrasion Number

Prepare Marshall specimens per ASTM 6926 for testing stability and flow (ASTM 6927), and bulk specific gravity (ASTM 2726).

Prepare specimens for maximum theoretical specific gravity (ASTM 2041).

Perform a sieve analysis (ASTM C136) and asphalt content on mixture submitted and compare results to the mix design and evaluation on:

- Aggregate gradation
- Percent crush
- Percent of recovered asphalt cement

4. **Materials Required**:

   a. 1 - 5000 gram samples of mixture @ optimum asphalt content.

      Note: At least one full test point (0.5 % asphalt) above or below optimum asphalt content is required. Identify on Form 1813 the asphalt content of submitted mix.

   b. Individual Aggregate Wear Index (AWI) samples for each aggregate requiring an AWI value.

      Note: This should be submitted even if a nomograph exists for that aggregate.

5. **Documentation Required:**

   Form 1820 - Contractor Bituminous Mix Design Communication.

   Form 1923 - Sample Identification. **Note**: must be included in each sample package.

   Form 1813 - Submitted Mix Design Summary Sheet.

   Form 1822 - Marshall Mix Design Work Sheet.

   Form 1806 - Theoretical Maximum Specific Gravity.

   Form 1849 - Bituminous Mix Design Checklist.

   Form 1859 - Coarse Aggregate Gravity.

   Form 1860 - Fine Aggregate Gravity.

   Form 1879 - RAP Stockpile Summary Data Sheet. **Note:** only if RAP is included in the mixture.

   Combined gradation plotted on a 0.45 Power Gradation chart.

   Mix Design Regression Analysis.

   Temperature - Viscosity Graph/Table showing mixing and compaction temperatures.

   Note: Current MDOT forms are required on the mix design submittal. If you make a computer copy, it must match the MDOT form exactly. If these forms are not used, the mix design verification process will be stopped until the correct forms are submitted.

6. **Tolerance Limits* for MDOT Verification of Submitted Mix Designs**

   Bulk specific gravity of mixture ± 0.026.

   Theoretical maximum specific gravity ± 0.019.

   Air voids ± 1.00.

   Asphalt content ± 0.3%.

% crush must meet specification for project.

Verification tolerance for crush particle content ± 15%.

Angularity index must meet specification for project.

Stability must meet specification for project.

Flow must meet specification for project.

Aggregate gradation must meet design master gradation specification.

Sieve 1 inch (25.0 mm) thru 3/8 inch (9.50 mm) ± 3.0%.

Sieve No. 4 (4.75 mm) thru No. 50 (0.30 mm) ± 2.0%.

Sieve No. 100 (0.15 mm) thru No. 200 (0.075 mm) ± 1.0%.

Fine aggregate bulk-SSD-apparent specific gravity ± 0.028.

Coarse aggregate bulk-SSD-apparent specific gravity ± 0.028.

Final aggregate blend bulk - SSD - apparent specific gravity ± 0.028.

*SMD's that meet all tolerance limits will be reported out as passing.

7. Submitted Mix Design Time Period (Five Work Days)

MDOT will have five (5) workdays in which to review the submitted mix design.

The five (5) workday time period begins when the mix design submittal forms and materials are deemed to be complete and correct by the Bituminous Mix Design Unit.

The mix design may be refused, or the review and the five (5) workday time period stopped, for the following situations (but not limited to):

a. Evaluation of mix design results indicates a failing design.

b. Incorrect or insufficient material is submitted.

c. Aggregate(s) do not meet physical requirements specified for the project.

d. The Contractor-requested combined gradation does not meet Master Gradation Range in the applicable Standard Specifications or Special Provision.

e. No project office notification.

f. Incomplete documentation.

g. Lacks a current Los Angeles Abrasion Number.

h. Contractor suspends interest in submitted material.

Restart of the five (5) workday clock will commence upon the timely response by the Contractor in efforts to resolve any discrepancies in the submittal.

The Contractor, Traveling Mix Inspector, and/or the Project Engineer will be notified of situations that require cancellation of a Bituminous Mix Design submittal for reasons such as those listed above.

8. Re-submittals

If your mix design fails and you wish to resubmit, the maximum number of mix designs per course, per project, that any one Contractor or Consultant laboratory may submit is two. Follow the requirements below:

MARSHALL MIX DESIGN

Fails on	**Submit**
Gmb	1 - 5000 gram mixture samples Complete paperwork
Gmm	1 - 5000 gram mixture samples Complete paperwork
Air Voids	1 - 5000 gram mixture samples Complete paperwork
Asphalt Content, Gradation, Crush	1 - 5000 gram mixture samples Complete paperwork
Angularity Index	Redesign Complete paperwork
Stability & Flow	Redesign Complete paperwork
AWI	Redesign Complete paperwork

Note: On failing mix designs, MDOT will notify the Contractor or Consultant which test(s) failed. MDOT will not state failed test results.

SUPERPAVE MIXTURE DESIGN

1. Superpave Mix Design General Guidelines

For all projects containing the Special Provision for Superpave Bituminous Mixtures, the Contractor will supply the Superpave Mix Design to the Michigan Department of Transportation. The Superpave Mix Design must be prepared by a private testing laboratory, either the Contractor or consultant. Superpave Mix Designs must be prepared in accordance with the SUPERPAVE MIX DESIGN MANUAL (SP-2)*.

If a Contractor uses a consulting laboratory to supply a mix design, the Contractor must authorize in writing that the consultant acts as the Contractor's agent on mix design issues for the project. MDOT will only accept one passing design per course, per project. The maximum number of designs per course, per project, that any one Contractor or Consultant laboratory may submit is two.

Submittal of a Superpave Mix Design shall be made to:

MDOT
Construction and Technology Laboratory
Bituminous Mix Design Unit
8885 Ricks Road
P.O. Box 30049
Lansing, Michigan 48909

Acceptance for evaluation requires a person from the Bituminous Mix Design Unit to review the paperwork and the submitted material. Upon acceptance, MDOT will have 10 workdays to evaluate the Superpave Mix Design. Superpave Mix Designs received after 11:45 a.m. will start the 10-day work clock on the next scheduled workday.

Note: Work days are Monday through Friday excluding state holidays.

The Project Engineer may require a new mix design to be submitted by the Contractor at any time it is determined necessary.

*****Superpave Mix Design, Superpave Series No. 2 (SP-2). Asphalt Institute, Research Park Drive, P.O. Box 14052, Lexington, Kentucky 40512-4052.

** Forms link with MDOT website: http://mdotwas1.mdot.state.mi.us/public/webforms/index.cfm

SUPERPAVE COMPARISON LEVEL DESIGN SUBMITTAL

1. Paper Review Acceptance Criteria

The Bituminous Mix Design Unit's evaluation of a paper review design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the Mix Design data with MDOT's Bituminous Mix Design Computer Program.

Tolerance Limits for MDOT Paper Review:

Superpave

a. All data must meet specification.

b. Height of a compacted gyratory specimen: 115 mm ± 3 mm.

c. Spread between two gyratory Gmb's at a given asphalt content within: 0.012.

d. Spread between Gse's on a 4-point design within: 0.012.

e. The percent of air voids steadily decreases with increasing asphalt content.

f. The VMA plotted values generally decrease to a minimum value then increase with increasing asphalt content.

2. Superpave Mix Design

The Bituminous Mix Design Unit's evaluation of the Superpave Mix Design will be done as follows:

- Review the submitted documentation and materials for compliance with project specifications.

- Evaluate the design by entering and running the Superpave Mix Design data with MDOT's Bituminous Mix Design Computer Program.

At the department's discretion, any or all of the following testing may be performed.

Test the following physical properties of the aggregate for compliance to specification:

- Aggregate Wear Index (AWI) - for top course material only.
- Angularity Index (NAA Method A).
- Flat and elongated particles.
- Percent crush (1/2 sides).
- Current Los Angeles Abrasion number.
- Fine Aggregate Bulk - SSD - apparent specific gravities and % absorption.
- Coarse Aggregate Bulk - SSD - apparent specific gravities and % absorption.

- Sand equivalent of fine aggregate (ASTM D 2419).
- % Soft Particles.

Prepare gyratory specimens per Superpave Mix Design Manual (SP-2) for bulk specific gravity (ASTM 2726).

Prepare specimens for maximum theoretical specific gravity (ASTM 2041).

Perform a gradation and asphalt analysis on mixture submitted and compare results to the Superpave Mix Design and evaluation on:

- Aggregate gradation.
- Percent crush.
- Percent of recovered asphalt cement.

3. Tensile Strength Ratio (TSR)

On Superpave Mix Designs, the Contractor or consultant will perform the TSR testing for the design. The Contractor or Consultant certifies that the TSR meets specification. If the design requires an anti-strip agent to be added, the type and percent added will be stated on the mix design submittal. All test results will be submitted to MDOT with the design submittal.

During production, a mixture sample may be taken by MDOT. This sample will be submitted and tested at the Bituminous Mix Design Laboratory in Lansing, Michigan.

If the MDOT TSR testing meets project specifications, a report of test is sent to the project office showing the results. If the MDOT test results fail to meet specification, the following applies:

a. The Project Engineer will be notified and a sufficient amount of anti-strip agent will be added to the mixture.

b. The next mix design submitted by the Contractor/Consultant will require the submission of TSR samples for verification/acceptance testing. Subsequent mix design submitted will not be reported out until verification/acceptance of the TSR testing is complete.

4. Materials Required:

Note: All mixture samples are submitted at optimum asphalt content.

3- *gram samples of mixture.
(Gyratory Compaction)
Note: At least one full test point (0.5% asphalt) above or below optimum asphalt content is required.

2 - 1500 gram samples of mixture.
(Virgin Mix Design Only) (Extraction – Use current approved method for determining asphalt content).

* The weight of the mix to compact to 115 mm height.

2 - 1900 gram samples of mixture.
(Rap Mix Design Only) (Extraction – Use current approved method for determining asphalt content).

1 - 190 gram blended aggregate sample for angularity index.
(N.A.A. Method A) (Washed & Dried).

Individual aggregate wear index (AWI) samples for each aggregate, which requires an AWI value. An AWI sample of Reclaimed Asphalt Pavement is not necessary if the designer elects to use an AWI value of 240. If an AWI value greater than 240 is desired for the Reclaimed Asphalt Pavement, then a sample is required.

Note: Individual AWI samples must be submitted even if a nomograph exists for that aggregate or if previously submitted on another design.

1 - 2000 gram sample of blended aggregate, retained No. 4 (4.75 mm) sieve.
(Washed & Dried) (Coarse Aggregate Specific Gravity).

1 - 1400 gram sample of blended aggregate, passing No. 8 (2.36 mm) sieve.
(Washed & Dried) (Fine Aggregate Specific Gravity).

1 - 2000 gram sample of aggregate retained No. 8 (2.36 mm) sieve.
(Washed & Dried) (Aggregate Specific Gravity).
Note: only if 25% or greater is retained on the No. 8 (2.36 mm) sieve.

1 - 1400 gram sample of blended aggregate, passing No. 4 (4.75 mm) sieve.
(Not washed) (Sand Equivalent Test).

5. Documentation Required:

Form 1855 - Superpave Bituminous Mix Design Communication

Form 1923 - Sample Identification **Note:** Must be included in each sample package.

Form 1858 - Superpave Mix Design Summary Sheet

Form 1806 - Theoretical Maximum Specific Gravity Worksheet

Form 1851 - Gyratory Compacted Bulk Specific Gravity Worksheet

Form 1859 - Coarse Aggregate Gravity

Form 1860 - Fine Aggregate Gravity

Form 1862 - Superpave Mix Design Checklist

Form 1879 - RAP Stockpile Summary Data Sheet

Combined gradation plotted on a 0.45 Power Gradation chart.

Mix Design Regression Analysis.

Summary Height Data @ N_{ini}, N_{des}, and $N_{max.}$ For each, replicate at all asphalt contents.

Form 1937 - TSR Worksheet including Graphs from Testing

Temperature - Viscosity Graph/Table showing mixing and compaction temperatures

Note: Current MDOT forms are required on the mix design submittal. If you make a computer copy, it must match the MDOT form exactly. If these forms are not used, the mix design verification process will be stopped until the correct forms are submitted.

6. Tolerance Limits for MDOT Verification of Superpave Mix Designs:

Compacted bulk specific gravity of mixture ± 0.020.

Theoretical maximum specific gravity ± 0.013.

Air voids ± 1.00.

Asphalt content ± 0.3%.

% crush must meet specification for project.

Verification tolerance for crush particle content ± 15%.

Angularity index must meet specification for project.

Aggregate gradation must meet design master gradation specification.

Sieve 1 inch (25.0 mm) through 3/8 inch (9.50 mm) ± 3.0%.

Sieve No. 4 (4.75 mm) through No. 50 (300 μm) ± 2.0%.

Sieve No. 100 (150 μm) through No. 200 (75 μm) ± 1.0%.

The tensile strength ratio must meet a minimum 80%.

Sand equivalent test results must meet specification.

MDOT gyratory test results must meet all project specifications.

Tolerance on the combined bulk specific gravity ± 0.028.

7. Superpave Mix Design Time Period (Ten Work Days)

MDOT will have 10 workdays to review the Superpave Mix Design.

The 10 workday time period begins when the Superpave Mix Design submittal forms and materials are deemed to be complete and correct by the Bituminous Mix Design Unit.

The Superpave Mix Design may be refused, or the review and the 10 workday time period stopped, for the following situations (but not limited to):

a. Evaluation of Superpave Mix Design results indicates a failing design.

b. Incorrect or insufficient material is submitted.

c. Incomplete documentation.

d. Aggregate(s) do not meet physical requirements specified for the project.

e. The Contractor requested combined gradation does not meet Table 10 Aggregate Gradation Requirements of the Special Provision for Superpave Bituminous Mixtures.

f. No project office notification.

g. Non-current Los Angeles Abrasion Number.

h. Contractor suspends interest in submitted material.

Re-start of the 10 workday clock will commence upon the timely response by the Contractor in efforts to resolve any discrepancies in the submittal.

The Contractor/Consultant, Traveling Mix Inspector, and/or the Project Engineer will be notified of situations requiring cancellation of a Superpave Mix Design submittal for reasons such as those listed above.

1. Re-submittals

If your mix design fails and you wish to resubmit, the maximum number of mix designs per course, per project, that any one Contractor or Consultant laboratory may submit is two (2). Follow the requirements below:

SUPERPAVE MIX DESIGN

Fails on	**Submit**
Gmb	3- * gram sample of mixture Complete paperwork
Gmm	3- * gram sample of mixture Complete paperwork

Air Voids	3- * gram samples of mixture Complete paperwork
Asphalt Content, Gradation, Crush	3- * gram samples of mixture Complete paperwork
Angularity Index	Redesign Complete paperwork
AWI	Redesign Complete paperwork
Fine, No. 8 (2.36 mm), Coarse aggregate bulk specific gravities	Resubmit bulk aggregate samples Complete paperwork

***** The weight of the mix to compact to 115 mm height.

Note: On failing mix designs, MDOT will notify the Contractor or Consultant which tests(s) failed. MDOT will not state the failed test results.

SUPERPAVE EXPRESS MIX DESIGN SUBMITTAL PROCEDURE

1. Program Management – Superpave Express Designs

A) Qualifications for Superpave Mix Design Express Status

In order to qualify for Superpave Express Mix Design Status, the following requirements must be met:

1) The Mix Design Laboratory must meet all requirements specified in section 1, Hot Mix Asphalt (HMA) Mix Design Laboratory Qualifications.

2) Mix Design Submittal Requirements for Superpave Express Status Qualification

   a) HMA mixture submittals are 100% complete. (Any design with non-conforming samples or sample submittals, will constitute a submittal failure for Superpave Express Mix Design status.)
   b) All required paperwork and forms are submitted and 100% complete. (Any correspondence initiated by MDOT requiring additional information, due to non-compliant and/or incorrect data, will constitute a submittal failure for Superpave Express Mix Design status.)
   c) Mix designs are verified by MDOT within the stated tolerance limits. The tolerances may be found within the HMA Production Manual, Superpave Comparison Level Design Submittal, Section 6.

3) The last five (5) consecutive Superpave mix design submittals must be in compliance with the criteria stated in items A.1 and A.2.

4) The Mix Designer must request Superpave Express Mix Design status in writing through certified mail with return receipt. MDOT will review each request for compliance to the above criteria. Acceptance into Express Status will be based on previous mix design submittal performance and will be judged at MDOT's discretion.

B) Maintaining Superpave Mix Design Express Status

To maintain Superpave Express Status, seven (7) out of the past ten (10) Superpave mix design submittals must be in compliance with items A.1 and A.2 listed above.

If a design fails under the Superpave Express Status, the designer may resubmit according to HMA Production Manual, Superpave Comparison Level Design Submittal, section 8 (Re-submittals). If the re-submittal fails, only one failure will be acknowledged for that mix design. The mix design number assigned to the original mix design must be referenced when resubmitting.

C) Removal from Superpave Express Status

If criteria in Section B are not met, the designer will be removed from Express Submittal Status. The Mix Designer will be notified by both e-mail and certified mail with return receipt. The date of removal from the Superpave Express Submittal Status will be the date at which the e-mail failure notification was sent.

D) **Reinstatement of Superpave Express Status**

In order to be reinstated into Superpave Mix Design Express Submittal Status, the Mix Designer must meet the requirements stated in **Qualifications for Superpave Mix Design Express Status** listed above.

2. **Superpave Express Mix Design Submittal Paperwork**

Paperwork Required on Express Superpave Mix Design Submittals is the same as that for the comparison level Superpave Mix Design Submittal package. Located on Form 1862, Superpave Mix Design Checklist, is a box labeled, "Approved for Express Mix Design Submittal". This box will be used to differentiate between the two mix design submittal packages.

3. **Materials Required for Express Superpave Mix Design Submittals**

A) 3- * gram sample of mixture @ opt. A.C.[1]

B) AWI samples per Procedures Manual/BOH-IM 2003-01.

4. **Submittal Time Frame**

A) Design will be reviewed and verified within 5 working days after the date of sample login. Therefore, the 5 workday period will start the day after sample receipt.

B) The 5 workday time period may be stopped for any reason, but not limited to, the items listed in item 7, page 13.

NOTE: *Comparison level design submittal will still be allowed for labs that are removed from Superpave Express Submittal Status.*

[1] * = Grams of mixture to achieve 115mm ± 3mm height @ N_{max}

CALCULATIONS

1. Marshall Volumes

The MS-2 Manual* recommends that the correct size of a compacted 4 inch Marshall is 63.5 mm ± 1.27 mm. This is equivalent to a volume of 515 ± 8. If the Marshall height or volume falls outside the limits, the amount of mixture used for the specimen may be adjusted using:

$$\text{Adjusted weight of mix} = \frac{515 * \text{weight of mix used}}{\text{Volume measured}}$$

*Mix Design Methods for Asphalt Concrete (MS-2), Asphalt Institute, Research Park Drive, P.O. Box 14052 Lexington, KY 40512-4052.

2. Gyratory Sample Heights

The correct height of a compacted gyratory sample is 115 mm ± 3 mm. If the gyratory sample height falls outside the limits, the amount of mixture used for the sample may be adjusted, using:

$$\text{Adjusted weight of mix} = \frac{115 * \text{weight of mix used}}{\text{Height measured}}$$

For the mixture samples submitted at optimum asphalt content for gyratory compaction, adjust the submittal weight so MDOT compacts to a 115 mm height.

3. Mix Designs with Reclaimed Asphalt Pavement (RAP)

The Contractor may substitute Reclaimed Asphalt Pavement (RAP) for a portion of the new materials required to produce bituminous mixture for a project. The mixture shall be produced in accordance with Section 501 of the applicable Standard Specifications, or as modified herein.

Documented evidence of testing and accumulated tonnage in the stockpile (tonnage may be estimated) must be provided to the MDOT Construction and Technology Laboratory before a mix design will be processed. Use MDOT form, see appendix.

When RAP is used in a mix design, in which the Angularity Index (NAA Method A) and VMA are calculated from the aggregate bulk specific gravity, the following procedure applies. The RAP Gse is converted to a bulk aggregate specific gravity Gsb using the following formula:

RAP Gsb = (1.097 * RAP Gse) - 0.32

This Gsb represents both the fine and coarse aggregate bulk specific gravities for the RAP, from which the combine bulk aggregate gravity for the blend is calculated.

Example: The average Gse on a RAP stockpile is 2.695. The RAP Gsb is:

RAP Gsb = (1.097 * 2.695) - 0.32
RAP Gsb = 2.956 - 0.32
RAP Gsb = 2.636

CALCULATION OF THE VIRGIN AGGREGATE COMBINED GRADATION

FOR MIX DESIGNS WITH RAP

Combined Gradation with RAP

PIT NUMBER TYPE OF AGGREGATE	RAP	95-5 3/8 CLEAR	41-117 3/8 - 4	41-117 No.4- 0	95-5 DOLOMITE SAND	COMBINED GRADATIO N
PERCENT OF	20.0	20.0	18.0	25.0	17.0	
¾ in. (19.0 mm)	100.0	100.0	100.0	100.0	100.0	100.0
½ in. (12.5 mm)	99.0	98.8	100.0	100.0	100.0	99.6
3/8 in. (9.5 mm)	75.0	62.3	99.8	100.0	100.0	87.4
No. 4 (4.75 mm)	56.0	7.1	11.9	89.5	93.4	53.0
No. 8 (2.36 mm)	32.0	4.3	3.0	56.8	37.1	28.3
No. 16 (1.18 mm)	21.0	3.5	2.1	34.9	22.5	17.8
No. 30 (600 μm)	17.0	2.8	1.7	22.6	16.7	12.8
No. 50 (300 μm)	14.0	2.3	1.5	13.3	13.0	9.1
No. 100 (150 μm)	11.0	2.0	1.3	6.3	8.7	5.9
No. 200 (75 μm)	7.6	1.5	1.1	4.0	5.0	3.9
Crush, Ret. No. 4	100.0	100.0	86.4	84.3	100.0	95

To obtain a combined gradation without the RAP, use the following formula to calculate each of the virgin aggregate adjusted percentages.

$$\text{Virgin aggregate adjusted percentage} = \frac{\text{(mix design virgin aggregate percentage from mix design)}}{\text{((100-RAP percentage) / 100))}}$$

Example for 3/8 - 4 aggregate from Pit 41-117:

(18) / ((100-20) / 100)) = 18 / .80

= 22.5%

Using the individual virgin aggregate adjusted percentages, and the respective aggregate stockpile gradations, compute the blended combined gradation of the belt sample.

Combined Gradation of the Belt Sample

PIT NUMBER TYPE OF AGGREGATE	RAP	95-5 3/8 CLEAR	41-117 3/8 - 4	41-117 No.4- 0	95-5 DOLOMITE SAND	COMBINED GRADATION
PERCENT OF		25.0	22.5	31.25	21.25	
¾ in. (19.0 mm)	100.0	100.0	100.0	100.0	100.0	100.0
½ in. (12.5 mm)	99.0	98.8	100.0	100.0	100.0	99.7
3/8 in. (9.5 mm)	75.0	62.3	99.8	100.0	100.0	90.5
No. 4 (4.75 mm)	56.0	7.1	11.9	89.5	93.4	52.3
No. 8 (2.36 mm)	32.0	4.3	3.0	56.8	37.1	27.4
No. 16 (1.18 mm)	21.0	3.5	2.1	34.9	22.5	17.0
No. 30 (600 μm)	17.0	2.8	1.7	22.6	16.7	11.7
No. 50 (300 μm)	14.0	2.3	1.5	13.3	13.0	7.8
No. 100 (150 μm)	11.0	2.0	1.3	6.3	8.7	4.6
No. 200 (75 μm)	7.6	1.5	1.1	4.0	5.0	2.9
Crush, Ret. No. 4	100.0	100.0	86.4	84.3	100.0	93

4. Bulk Aggregate Specific Gravities

The formula for combining the coarse, No. 8 (2.36 mm) and fine bulk specific gravities is as follows:

$$\text{Combined } Gsb = \frac{P_1 + P_2 + \ldots + P_n}{\frac{P_1}{G_1} + \frac{P_2}{G_2} + \ldots + \frac{P_n}{G_n}}$$

where:

Gsb	=	bulk specific gravity
P_1, P_2, P_n	=	individual percentages by mass of aggregate
G_1, G_2, G_n	=	individual bulk specific gravities of aggregate

Example #1 Virgin Mix

Combined Coarse Gsb = 2.670
Combined No. 8 (2.36 mm) Gsb = 2.688
Combined Fine Gsb = 2.620

Combined Gradation: <u>% Passing</u>

No. 4 (4.75 mm) sieve 71%
No. 8 (2.36 mm) sieve 40 %

$$\text{Combined } Gsb = \frac{29 + 31 + 40}{\frac{29}{2.670} + \frac{31}{2.688} + \ldots + \frac{40}{2.620}} = 2.655$$

If less than 25% retained on the No. 8 (2.36 mm) Sieve. Show Calculation for combining fine & coarse.

Example #2 RAP Mix

Virgin Fine Combined Gsb = 2.676
Virgin Coarse Combined Gsb = 2.702
RAP Gsb = 2.715

Combined Gradation of Mix:	% Passing
No. 4 (4.75 mm) sieve	37%
No. 8 (2.36 mm) sieve	23%

Gradation of RAP	% Passing	Percent of Mix
No. 8 (2.36 mm) sieve	56.6%	15%

<u>Combined Virgin Fine & RAP Gsb:</u>

56.6 * .15 = 8.5%

23-8.5 = 14.5%

8.5/.23 = 37%

14.5/.23 = 63.0%

$$\frac{37+63}{\frac{37}{2.715}+\frac{63}{2.676}} = 2.690$$

<u>Combined Virgin Coarse & RAP Gsb:</u>

43.4 * .15 = 6.5%

77-6.5 = 70.5%

6.5/.77 = 8.4%

70.5/.77 = 91.6%

$$\frac{8.4+91.6}{\frac{8.4}{2.715}+\frac{91.6}{2.702}} = 2.703$$

Combined Gsb = $$\frac{23+77}{\frac{23}{2.690}+\frac{77}{2.703}} = 2.700$$

5. Tensile Strength Ratio (TSR) Samples

When submitting TSR data, you need to submit a worksheet showing compacted bulk specific gravity calculations, TMD at Opt. A.C., percent air voids, height of the TSR sample, and completed work sheet.

Example:

Sample #	Wt in Air	SSD Wt.	Wt. in Water	Volume of Sample	Specific Gravity	TMD	Air Voids	Height of Sample

How to calculate the right sample size to achieve 95 mm height at 7 percent air voids:

- A good starting point is about 3800 to 3900 grams of mix and compact it to 95 mm height.
- Bulk sample out and calculate air voids.
- Make adjustments from first sample.

Example:

Sample #	Wt in Air	SSD Wt.	Wt. in Water	Volume of Sample	Specific Gravity	TMD	Air Voids	Height of Sample
1	3863	3883	2256.5	1626.5	2.375	2.516	5.6	95

At what height did you achieve 7 percent air voids? A quick check is to take this formula and keep trying different heights.

$\frac{X}{Y}$ * Original G_{mb} $\frac{95.0}{96.4}$ * 2.375 = 2.340

X = height at last gyration
Y = height at any gyration Air voids = 7.0%

Once you have found the height at which you achieved 7 percent air voids you can substitute the mass of the sample in for the G_{mb}.

$\frac{X}{Y}$ * Mass of Original Sample $\frac{95.0}{96.4}$ * 3863.0 = 3806.7

A 3807 gram sample should give you a 95 mm TSR sample at 7 percent air voids ± 1 percent.

Highlights of the TSR test. (AASHTO DESIGNATION T 283)

- Preparation of the samples
  - Mix mixture and cool at room temperature for two hours ± 0.5 hours.
  - Place mixture in oven at 140°F (60°C) for 16 hours of curing.
  - After curing, place mixture in oven at 275°F (135°C) for two hours prior to compaction.
  - Compact mixture to 95 mm height.

- Conditioning of specimens
  - Three specimens will be stored at room temperature until testing.
  - At testing time, they will be placed in a leak proof plastic bag and placed in a 77°F (25°C) water bath for minimum of two hours.
  - The other three specimens will be vacuum saturated so that 55% to 80% of original air voids are filled with water.
  - If samples are less than 55% saturated, put back under vacuum until at least 55% is obtained.
  - If specimens are greater than 80% saturated, must discard specimens and compact new ones.
  - Once 55% to 80% is reached, wrap in plastic film, place in plastic bag with 10 mL water and place in freezer at 0 ± 5°F (-18 ± 3°C) for a minimum of 16 hours.
  - After removal from freezer, place specimens in water bath at 140 ± 1.8°F (60 ± 1°C) for 24 ± 1 hours. As soon as possible, remove plastic bag and film.
  - After 140°F (60°C) water bath, transfer specimens to a 77 ± 1°F (25 ± 0.5°C) water bath for 2 ± 1 hours.

- Testing of specimens
  - Remove from 77°F (25°C) water bath and place between to bearing plates.
  - Apply load to specimens by means of constant rate movement, 2 inches (50 mm) per minute.
  - Record maximum compressive strength.

- Calculations
  - If steel loading strips are used, calculate the tensile strength as follows:

$$S_t = \frac{2P}{\Pi t D}$$

Where:

S_t = tensile strength, psi (Pa),
P = maximum load, pounds (Newton),
t = specimen thickness, inches (mm),
D = specimen diameter, inches (mm)

  - Take the average tensile strength of the three conditioned specimens and divide by the average of the three unconditioned specimens. The ratio has to be a minimum of 80%.

AGGREGATE REQUIREMENTS

1. **New Aggregate Source**
   If the aggregate source is new, the Contractor must submit to the Region Materials Unit a legal description for the new source and directions for driving to the location so a pit number may be assigned.

2. **Los Angeles (L.A.) Abrasion Number**
   Los Angeles Abrasion values are required on all new and existing aggregate sources. A Los Angeles Abrasion test is required if the percent retained on the No. 4 (4.75 mm) sieve is greater than 10 percent, or the percent retained on the No. 8 (2.36 mm) sieve is greater than 35 percent. An aggregate source with an L.A. Abrasion value lower than 35 is valid for 5 years, provided there are 3 L.A.s at 35 or under on record. If an aggregate source has an L.A. Abrasion value over 35, a minimum of one per year is required. If an L.A. Abrasion is required, contact your Region Materials Unit to obtain the sample for submission to the Lab.

   The Los Angeles Abrasion Number can be found on Construction and Technology's public website. The link is as follows: http://www.michigan.gov/mdot/0,1607,7-151-9623_26663_27303---,00.html.

3. **AWI Samples - BOH-IM 2003-01 and BOH-IM 2003-09**
   The following procedure applies for each aggregate component in a blended HMA Top or Leveling Course mixture with an Aggregate Wear Index (AWI) requirement that retains more than five percent by weight on the No. 4 (4.75 mm) sieve. Start with a 2500 gram sample of each aggregate component and separate the retained No. 4 (4.75 mm), 3/8 inch (9.50 mm), and ½ inch (12.5 mm) aggregate by sieving. Wash each sieve size and dry. For each sieve size count out 300 particles and place in a small bag.

   Note: Depending upon the gradation of the aggregate, a 300 particle count may not be possible.

   In both cases, count the particles and place in a small bag and write the count and sieve size on the outside of the bag. For each aggregate put all the individual sieve size bags into a larger bag and include Form 1923 and Form 1820 completely filled out.

   The AWI Number can be found on Construction and Technology's public website. The link is as follows: http://www.michigan.gov/mdot/0,1607,7-151-9623_26663_27303---,00.html.

4. **10% Minimum Aggregate Requirement**
   No less than 10 percent of any single aggregate is allowed in the mix design, excluding mineral filler or baghouse fines. With written permission from the Project Engineer or the traveling mix inspector, less that 10 percent of single aggregate may be allowed. The written permission must be included with the mix design submittal.

5. **Superpave Fine Aggregate Angularity**
   Fine aggregate angularity will be tested per Test Method for Uncompacted Void Content of fine Aggregate, ASTM C 1252, Method A. All aggregates including RAP which have material retained on the No. 16 (1.18 mm), No. 30 (600 μm), No. 50 (300 μm) and No. 100 (150 μm) are to be used in the blend.

Note: The RAP sample can be the result of either an extraction or asphalt ignition oven. For calculations, the GSE of the RAP is to be used. For virgin aggregates, the bulk aggregate gravity will be used.

6. **Aggregate Bulk Specific Gravities**
   Verification testing will be preformed on the combined blend. If the aggregate gradation meets the conditions stated below, the Contractor/Consultant is required to record the test values for MDOT verification. Gsb for each aggregate should be performed if that aggregate meets the conditions stated below:

   a. Coarse bulk gravity on each individual aggregate that retains ≥25% on the No. 4 (4.75 mm) sieve.

   b. No. 8 bulk gravity on each individual aggregate that retains ≥25% on the No. 8 (2.36 mm) sieve.

   c. Fine bulk gravity on each individual aggregate that has ≥25 passing the No. 8 (2.36 mm) sieve.

      You will have a ± 0.028 tolerance on the combined bulk specific gravity.

7. **Soft Particle Content**
   The Contractor/Consultant will conduct the testing to insure that the soft particle content of the blended aggregate meets minimum specifications. MDOT will conduct a soft particle content on one of the submitted samples for verification to specification.

   A sample may be taken (requested by the mix design unit) by MDOT during the project plant production of the mixture. The soft particle content will then be tested. If the soft particle content fails to meet the specification criteria, the Project Engineer will be contacted.

8. **Sand Equivalent**
   The Contractor/consultant will conduct the testing to insure that the Sand Equivalent content of the blended aggregate meets minimum specifications.

   MDOT may test the blended aggregate at their discretion for verification to specification.

9. **Nomograph**
   If a nomograph exists for an aggregate which requires an AWI value, the AWI number from the nomograph will be used for the mix design. An aggregate sample should still be submitted so the nomographs may be updated on a yearly basis.

CONTACT INFORMATION

1. **Contacts** - See Website for current list of contacts.

Grant Carr Mixture Testing	517-322-5691
Eric Oudsema Aggregate Bulk Gravity - TSR’s Submission of Marshall and Superpave Mix Designs Sand Equivalent Test	517-322-5692
Victor Prewitt Status of newly submitted Los Angeles Abrasion Test results	517-322-1219
Alan Robords Assigning pit numbers - AWI’s - Nomographs - Existing Los Angeles Abrasion Numbers	517-322-1357
Marc Beyer Region Mix Inspectors (RMI) Plant certification 1911's	517-322-1020

SECTION 2: CERTIFICATION PROCEDURE OF HOT MIX ASPHALT PLANTS

All HMA facilities must be certified prior to furnishing HMA to MDOT. The certification inspection and documentation will be completed by the Region Mix Inspector (RMI) in accordance with the following procedure. Certification will be valid for either the current construction season, for permanent plant locations, or for the duration of a temporary plant location.

A. Notification

1. Permanent plant location - The Contractor shall arrange for a certification inspection with the RMI either prior to the start of each construction season or prior to the start of HMA production at that location.

2. Temporary plant location - The Contractor shall arrange for a certification inspection with the RMI prior to HMA production at that location.

B. Inspection

The RMI will notify the Engineer of the inspection arrangements. Either the Engineer or his/her representative may participate in the inspection. The inspection will encompass all components of the HMA facility. The Contractor shall provide copies of all of the required scale certifications and equipment calibrations. The Contractor shall provide evidence that the plant is in compliance with current Michigan Department of Environmental Quality (MDEQ) requirements.

C. HMA Certification

Inspection Report Form - The RMI will complete and provide copies of the inspection checklist as appropriate. Equipment deficiencies will be noted and must be corrected before a certification will be issued.

D. De-Certification

Any plant equipment malfunction that directly affects mix quality must be repaired in a timely manner. Failure to do so may result in decertification of that plant. The Engineer receiving HMA mixture from the plant at the time of decertification will receive both verbal and written notification.

The Contractor/Owner will receive immediate written notification of decertification action. The RMI will note what the deficiency is when completing the written notification. The RMI will re-certify the plant when the noted deficiencies have been corrected.

HMA FACILITY

A. All Plants

HMA mixtures shall be produced in continuous, batch, drum mixer or other approved specialized plants. HMA plants shall be in good mechanical condition and any defective plant equipment or malfunction that directly affects the mix quality must be repaired in a timely manner. Failure to do so will result in decertification of that plant. The Contractor shall provide adequate and safe stairways for accessibility to plant operations. Adequate safeguards shall be provided to prevent injury to the personnel from plant components. The mixture sampling platform shall be of the proper height(s) for safe access to the mixture in all hauling units and shall have a safe and adequate stairway. Sampling platforms must comply with Part 45 of General Industries Fall Protection Standards and shall comply with MIOSHA regulations at the time of certification. The placement, structure, and adequacy of the sampling platforms shall be approved by the RMI. HMA plants shall meet the requirements specified herein.

1. Aggregate Stockpiles - Aggregate stockpiles shall be constructed and maintained at the plant site. Mix production on any day shall not start until the Contractor has stockpiled, at the plant site, sufficient quantities of all aggregates so as to have uninterrupted production. Aggregate stockpiles should be identified.

2. Asphalt Storage Tanks - Each tank shall identify the grade of binder being stored. Asphalt storage tanks shall be equipped for heating the asphalt binder material at uniform temperatures. There shall be provisions for effective and positive control of the temperature of the asphalt binder within the ranges specified under Table 904-5. Thermometers shall be installed in such locations so as to accurately indicate the temperature of the asphaltic binder material at all times.

3. Aggregate Feed - Power driven belt feeders shall be provided which are capable of supplying an accurately adjustable and continuous flow of each aggregate to the drier. The feeders' rate of flow shall be readily and incrementally adjustable and shall be capable of being secured in any position. The plant shall have a minimum number of cold feed bins to meet mix blend requirements. The plant may not feed two materials from one cold feed bin. There must be a cold feed bin for each material required. The feeders shall be equipped with cut-offs which will automatically stop the operations of the asphalt plant at any time the flow of aggregate is stopped. The aggregate feed system shall be equipped with a mechanical screening device for the removal of oversized material. For HMA base mixtures, the oversize screen shall have a one dimension opening of 1-¾ inches (44 mm). For all other mixes it shall have a one dimension opening ¼ inch (6 mm) larger then the maximum aggregate size in the HMA mixture being produced.

4. Drier - The drier shall be designed so as to continuously heat and dry the aggregates to specification requirements. It shall be equipped with an automatic modulation device to control and maintain the temperature within the specified limits. The drier shall dry the aggregates uniformly. In the event that the drier does not dry the aggregates satisfactorily, the Contractor shall make whatever adjustments may be necessary to give satisfactory results. When excessive moisture is present in the mixture, production shall be discontinued until the necessary corrections are made.

5. Indicating Pyrometer - An indicating pyrometer or other approved thermometric instrument shall be so located as to be in full view of the plant operator and so installed as to indicate the temperature of the material at the discharge end of the drier or mixer. Said instrument shall continuously indicate the temperature of the aggregate at the discharge end of the fine aggregate bin for batch type plants or the mixture temperature at the discharge end of drier drum mixer plants. The sensitivity and efficiency of this instrument shall be such as to record a variation of ± 7°F (4°C) in temperature within one minute. Whenever the thermometric recording instrument does not function properly and does not provide an accurate display of the aggregate temperatures, the Contractor shall provide other satisfactory means for measuring the temperature, except that mixing operations shall be suspended when a properly functioning pyrometer is not provided within 24 hours. Failure to repair is cause for decertification. Recording pyrometer may be used in lieu of the indicating pyrometer.

6. Dust Collectors - Dust collectors shall be provided on all plants. When the plant is equipped to collect baghouse fines in a separate silo, these fines may not be used in subsequent mixtures. Surplus fine aggregate material collected in a silo may not be used in subsequent mixture unless it is a component of an approved mix design.

7. Air Quality Permit - All HMA plants shall be covered by a Michigan Air Pollution control permit. For any portable HMA plant, the Contractor shall obtain a permit-to-install from the Permit Section, Air Quality Division (AQD), of the Michigan Department of Environmental Quality (MDEQ). This permit shall be applied for a minimum of 30 calendar days for plants with an active MDEQ permit (or 60 calendar days for plants not previously permitted in Michigan) prior to the plant being installed. For proposed plant sites in Wayne County, the Contractor shall apply directly to the Wayne County Air Pollution Control Division instead of MDEQ.

8. Mineral Filler Feed (if required by mix design) - Plants furnishing HMA mixture shall be equipped with a mineral filler silo. A method of accurately metering or weighing mineral filler into the mixture shall be provided.

9. Sampling Spigot - The pipeline supplying asphalt binder to the plant shall be equipped with a sampling spigot located in a position between the asphalt binder pump and the point where the asphalt binder enters the mixture. Personnel safety is critical in selecting the position of the sampling spigot.

10. Additive Sampling - A means for sampling any mixture additives will be provided. The sampling point shall be between the source feeder mechanism and the point at which the additive enters the mixture.

11. Interlock System for Aggregate, Mineral Filler, or Asphalt Binder - An interlocking system shall be provided to halt production of HMA mixtures if any one of the feed system's aggregate, mineral filler or asphalt binder malfunctions.

12. Scales - Scales for weighing HMA mixtures must meet requirements of Section 109.01G of the current Standard Specifications for Construction.

13. Hot Mix Surge Bins - Surge bins may be used to facilitate an uninterrupted supply of HMA mixture under the following conditions:

a. The HMA mixture shall be maintained at a level above the cone, which will ensure that the surge bin will not be emptied during operating periods, except at the end of the day's operations. The bin shall be equipped with a bin level indicator and a horn or buzzer to alert the operator, or an interlock mechanism to prevent the discharge of the mix when the level of the material in the bin has reached a point where insufficient material is in the bin to complete a full load without emptying the bin.

b. Surge bins shall be equipped with a gob hopper at the inlet of the bin. If it is determined that the use of a hot mix surge bin causes segregation, or adversely affects the quality of the mixture, its use shall be discontinued until corrective action has been taken.

c. Surge bins shall have a minimum capacity of at least 100 tons (70 metric tons) or be twice the capacity of the maximum hauling unit.

B. Batch Plants

Batch plants shall accurately proportion aggregate, mineral filler, and asphalt binder by weight.

1. Hot Aggregate Bins - The plant shall have hot aggregate bins of a total capacity of not less than 10 times the weight of the batch being mixed. Each hot aggregate bin shall be equipped with a bin-level indicator which shall indicate when the bin compartment is filled to approximately one-half the bin capacity.

2. Batch Scales - The scales in batch plans shall meet the requirements specified herein:

a. The scales shall come to rest after the weighing of each ingredient to facilitate the monitoring of the proportioning operations. The scales shall comply with the requirements of the National Bureau of Standards Handbook 44, with the following exceptions and additions:

i) The value of the minimum graduated interval for scales, which have a nominal capacity of less than 5000 pounds (2300 kg), shall not be greater than 5 pounds (2.3 kg), except that the minimum graduated interval for the scale, which weighs the asphalt binder, shall not be greater than 2 pounds (0.746 kg).

ii) The value of the minimum graduated interval for scales which have a nominal capacity of 4000 pounds (1866.2 kg) or more shall not be greater than 0. 1 percent of the nominal capacity of the scale.

b. Accuracy - The tolerance value for all plant scales shall be 2 pounds (0.746 kg) per 825 pounds (373.2 kg) of load or the value of one minimum graduated interval, whichever is greater. At such times as the Engineer may direct, the Contractor shall suspend operations and shall provide such devices and assistance as are required to enable the Engineer to check the accuracy of the scales.

c. Location - All scales shall be located so they will be in plain view of the operator at all times.

3. Batch Mixer -The plant shall be equipped with a batch mixer of the twin pugmill type. It shall be heat-jacked and equipped with a sufficient number of paddles or blades set in run-around order to produce properly mixed batches of any material required under these specifications. When the clearance between the tip of the paddle blades and mixer liner exceeds one inch, either the blades or liner, or both, shall be replaced to reduce the clearance. Paddle blades reduced by wear in excess of 25 percent in face area from their new condition shall be replaced. The mixer shall be enclosed except for openings necessary to admit materials. It shall be capable of holding and properly mixing at least a 1650 pound (746.48 kg) batch of paving mixture. The mixer paddle shafts shall operate at a speed sufficient to produce satisfactory mixing of the aggregates and the asphalt binder in the specified wet mixing time.

4. Timing Device - The plant shall be equipped with an approved accurate time-lock system to control mixing operations. This system shall lock 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 asphalt bucket throughout the dry mix period, and the mixer gate throughout the dry and wet mix periods. The dry mix period is defined as the interval of time between the closing of the weigh box gate and the start of the discharge of the asphalt bucket. The wet mix period is defined as the interval of time from the start of the discharge of the asphalt bucket to the discharge of the pugmill. The timing device shall be enclosed in a suitable case that can be locked.

5. Automatic Proportioning and Cycling Controls - When producing HMA mixtures, batch plants will be required to have systems for automatic batching or proportioning of the various components of the HMA mixtures meeting the following requirements. The automatic proportioning controls shall include equipment for accurately proportioning batches of the various components of the mixture by weight or volume in the specified sequence and for controlling the mixing operations. Adjustable timing devices and other time delay circuits to space the individual component batching and mixing operations will be required, together with the a interlock cut-off circuits necessary to interrupt and stop the automatic cycling of the batching operations whenever and error in weighing occurs or there is a malfunctioning of any other portion of the control system.

   The automatic control for each batching scale system shall be equipped with a device for stopping the automatic cycle in the underweight check position and in the overweight check position for each material so that the tolerance setting may be checked.

   Each dial scale system shall be equipped with a removable dial puller which can be attached to the dial lever system so that the dial can be moved smoothly and slowly through its range to check the settings of the automatic control system. Digital display systems shall be capable of being cycled through a simulated batching operation to check the settings of the automatic control system.

   Operation of the asphalt plant will not be permitted when the automatic proportioning and cycling controls are not operating properly or are not in proper adjustment. Manual operations will only be permitted when a breakdown or malfunction occurs after production has started. Manual operation due to a breakdown or malfunction will be permitted for the remainder of the workday in which the breakdown or malfunction occurs plus one additional workday, provided this method of operation will produce results meeting the specification requirements. If the Contractor has not corrected the malfunction in the allotted time, production of mixture for the project will be stopped until all corrections have been made and the Engineer is assured that the automatic proportioning and cycling controls operate properly.

6. Weight Batch Proportioning - The accuracy required for the equipment weighing the batch components, based on a percentage of the total batch weight, will be to within ± 0.1 percent for the asphalt binder and ± 0.5 percent for each of the other components (aggregate and mineral filler). The weighing system shall be equipped with an interlock to cut off the cycling and weighing operations at any time any individual component weight or the total batch weight exceeds the tolerances specified.

C. Drum Mixer Plants

Drum mixer plants shall be capable of simultaneously heating and mixing the aggregates with a controlled amount of asphalt binder and mineral filler in a rotating cylindrical dryer drum and discharging the mixture into a hot mix surge bin. The plant console shall have displays for both the rate of feed and accumulated weights or amounts of the aggregate, mineral filler, and asphalt binder by weight or volume.

1. Aggregate Feed - The aggregate shall be supplied to the dryer/mixer drum at a continuous, uniform controlled feed rate. The aggregate feed rate shall be measured by an approved electronic weighing device. The weighing device shall also be used to control the rate of flow of asphalt binder and mineral filler (if needed) to the drum mixer. Aggregate feeders shall be used to meet the established job-mix formula. The plant shall have a minimum of number of cold feed bins to meet the mix design blend.

2. Aggregate Moisture Tests - The Contractor shall be responsible for monitoring the moisture content of the raw aggregate.

3. Asphalt Binder Metering - The asphalt binder shall be continuously delivered to the dryer/mixer drum. The rate of feed of the asphalt binder shall be displayed on a totalizer located in the control room. The plant console shall contain provisions for setting the specific gravity and also monitoring temperature of the asphalt binder.

4. Drier/Mixer Drum - The slope of the drum, the flight configuration, and the rate of rotation of the drum shall be maintained and operated in accordance with the manufacturer's recommendations or as approved at time of certification.

5. Calibration - Provisions shall be made for diversion and calibration of the aggregate, mineral filler, asphalt binder, and other additives. The plant shall be calibrated by the Contractor prior to the start of the initial production of HMA mixture for the project and at other intervals as directed by the Engineer in accordance with the manufacturer's recommendations. The plant shall be equipped with the following calibration facilities so that the electronic plant controls can be checked and controlled to assure proper proportions.

    a. Aggregate -The Contractor shall provide means for diverting and weighing the aggregate for a time period not to exceed five (5) minutes. The Contractor has the option of running the aggregate into the surge bin during the plant calibration and weighing with a suspended weigh hopper or into a truck and weighing on approved platform scales.

    b. Mineral Filler - When mineral filler is used, the plant shall be equipped with a system to divert the mineral filler into an approved container. The container shall be of a sufficient capacity to hold a calculated weight or volume equal to 4% of the rated capacity of the plant during the calibration test. The Contractor shall have an approved platform scale or suspended weigh hopper for the weighing of the mineral filler. The calibration will consist of diverting the filler for a period of time not to exceed 5 minutes. The calibration may be done simultaneously with the aggregate and asphalt binder, or separately. If done separately, the aggregate feed control portion of the console will be set at the anticipated production rate during the calibration period.

c. Asphalt Binder - The plant shall be equipped with a tank for the calibration of the asphalt binder feed system. The calibration will consist of diverting the asphalt binder for a time period not to exceed five (5) minutes. The calibration of the asphalt binder may be done simultaneously with the aggregate or may be done separately. If done separately, the aggregate feed control portion of the console will be set at the anticipated production rate during the calibration period.

d. Additive - When additives are used, the plant shall be equipped with a means of accurately calibrating the additive feed system.

D. Combination/Specialized Plants

Will be inspected and certified on an individual basis based on modification or changes. This will be done with RMI's and Bituminous Field Office staff.

QUALITY CONTROL PLAN

The Contractor shall provide a Quality Control Plan (QCP), which might include the following information:

A. Project

1. Company name, plant location, plant (MDOT) number, plant phone and fax numbers, lab phone and fax numbers, office phone and fax numbers:
2. Sampling plan, aggregate, binder, mixture, etc., will include location, method, frequencies:
3. How the random number will be selected:
4. When and how daily belt samples will be taken:
5. Quality control of aggregate stockpiles including RAP stockpiles:
6. How daily moisture sampling will be done:
7. Signatures and date, Contractor and MDOT:

B. Personnel

1. Name(s), title(s) and telephone number(s) of person(s) responsible for the QCP:
2. Name(s), title(s), telephone number(s), qualification and certification number(s) of qualified employee(s) performing sampling, testing and inspection:
3. Name(s), title(s), and telephone number(s) of employee(s) work under the supervision of the qualified employee(s):
4. List the duties, responsibility, accountability, and authority of the above employee(s):

C. Documentation

1. Contractor may use MDOT forms:
2. When not using MDOT forms, Contractor must use forms approved by the Project Engineer:
3. Quality control charts must be approved by the Project Engineer:
4. Contractor will include examples of all non-MDOT forms and control charts to be used:

D. Quality Control

1. How you plan to control the quality of the mixtures being produced:
2. If out of tolerance how this will be corrected:

BITUMINOUS PRE-PRODUCTION MEETING ATTENDANCE

CONTROL SECTION	JOB NUMBER	PROJECT LOCATION	PROJECT ENGINEER	DATE

NAME / TITLE	COMPANY	CELL PHONE	OFFICE PHONE	FAX	E-MAIL ADDRESS

PROJECT HMA MIXTURE INFORMATION

CONTROL SECTION	JOB NUMBER	PROJECT LOCATION	PROJECT ENGINEER	DATE

MARSHALL MIX. S.P. # & DATE	MARSHALL QC/QA S.P. # & DATE	SUPERPAVE MIX. S.P. # & DATE	PWL / SUPERPAVE S.P. # & DATE

MDOT LAB TECH. CONTACT	COMPANY	CELL PHONE	OFFICE PHONE	FAX	E-MAIL ADDRESS

CONTRACTOR LAB TECH. CONTACT	COMPANY	CELL PHONE	OFFICE PHONE	FAX	E-MAIL ADDRESS

MIX TYPE	MIX DESIGN NUMBER	BINDER GRADE	PLAN QUANTITY	SUBLOT SIZE	REMARKS

HMA PRE-PRODUCTION MEETING TOPICS

1) HMA addendums or changes

2) Random number sheets signed by MDOT and Contractor

3) Signed certification statement submitted by Contractor

4) Plant location(s) and certification status

5) Project HMA Mixtures

6) Contractor Quality Control (QC)
   - A) Contractor QC Plan submitted
     - i) QC Plan Administrator contact info
     - ii) Foreman contact info
   - B) Random sampling method
   - C) Mixture sampling and testing frequencies
   - D) Core sampling and testing frequencies
   - E) Tolerances
     - i) Action and Suspension limits (PWL)
     - ii) Single Test and Running avg. of 5 (Marshall)
   - F) Documentation (1903C, Core Density, PWL Spreadsheet, Control Charts)
   - G) Distribution of test results
   - H) Timeframes
   - I) Binder samples

7) MDOT Quality Assurance (QA)
   - A) MDOT QA Plan submitted
     - i) QA Plan Administrator contact info
     - ii) MDOT Lead inspector contact info
   - B) Documentation (1903B, 1907, PWL Spreadsheet)
   - C) Distribution of test results
   - D) Timeframes
   - E) Four cores per sublot (marked after final rolling)
   - F) Core location based on longitudinal and transverse measurements
   - G) MDOT must witness coring and take immediate possession of cores
   - H) Damaged cores
   - I) Core thickness
   - J) No cores in driveways, hand patching or sampling area's
   - K) If center of core is less than 5" from pavement edge, use next transverse random #
   - L) Free standing water to be removed from core holes
   - M) As cores are taken, holes filled in with HMA and compacted by the Contractor
   - N) Core outliers

8) Binder Content Procedure
   - A) Calculated from Gmm
   - B) Vacuum Extraction
     - i) Document number of washes

9) Initial Production Lot
   - A) Mixture sampling (QA splits, Dispute Resolution, QC)

B) Cores (QC, QA)
C) Testing timeframes and tolerances
D) Requirements for moving into full production

10) Alternate Acceptance Methods
  A) Mixtures with small tonnages
  B) Hand Patching material
  C) Sublot sizes
  D) Density
  E) VI limits

11) Mixture Sampling
  A) Qualified samplers (MDOT & Contractor)
  B) Mixture sampling methods
    i) Plates and shovel
    ii) Shovel only
    iii) Mini-stockpile
  C) Sample area documentation
    i) 10' max sample area (per sample)
    ii) No cores within 5' before through 5' after sample areas
  D) Sample Identification
    i) QA / D.R. (dispute resolution)
    ii) IPL's
    iii) Full production

12) Suspension of Production
  A) Sublot RQL or Suspension limits are exceeded
  B) Lot PWL below 50% (QC, QA)
  C) Visible pavement distress
  D) QC plan not followed

13) JMF Changes

14) Dispute Resolution
  A) Timeframes
  B) Requests submitted in writing
  C) Signed certification that test results are true and accurate
  D) Independent Random QC samples (IPL's / mixture / cores)
  E) QC conducted in the same manner as QA
  F) QC pay factor higher than QA pay factor
  G) Dispute Resolution test results replace the original QA test results
  H) Testing Costs

15) Construction Items
  A) Traffic Control
  B) Flagging
  C) Milling
  D) Bond Coat
  E) Paving
  F) Rolling
  G) Start date for production

LAB CORRELATION PROCEDURE

The following procedure shall be used to evaluate the HMA results during the Initial Production Lots

(IPL) to determine if the split sample test results correlate.

The Lab Correlation Procedure shall consist of both the paired-t test and the mean difference tolerance. The Quality Assurance and Quality Control Test data for the split samples shall be input and compared. If either the paired-t test or the mean difference tolerance indicate that the lab results do not correlate, then an investigation into the reasons for non-correlation is required. The results of the investigation shall be documented.

Paired-t Test

The t-test for paired measurements, or paired-t test, uses the difference between each pair of tests of split samples and determines whether the difference is much different from zero (0). The t-test for paired measurements calculates a “paired-t value” (t_{pair}) from the difference in the split sample test results. The t_{pair} value is calculated using the following formula:

$$t_{pair} = \frac{\left|\overline{X}_d\right|}{\left(\frac{S_d}{\sqrt{n}}\right)}$$

Where: X_d = Individual difference between split sample test results

n = Number of split samples

$\overline{X}_d$ = Mean of the differences between the split sample test results, calculated as follows:

$$\overline{X}_d = \frac{(x_{d1} + x_{d2} + \ldots x_n)}{n}$$

S_d = Standard Deviation of the differences between the split sample test results, calculated as follows:

$$S_d = \sqrt{\frac{\sum (x_d - \overline{x}_d)^2}{n - 1}}$$

The calculated t_{pair} value is then compared to a "critical t value" (t_{crit}) obtained from the table below, with n-1 degrees of freedom, where n = the number of split samples, and the Level of Significance, alpha (α), of 0.01 (Probability = 1%) is used.

t-test Critical Values for Various Levels of Significance	
Degrees of freedom	**α = 0.01**
1	63.657
2	9.925
3	5.841
4	4.604
5	4.032
6	3.707
7	3.499
8	3.355
9	3.250
10	3.169
11	3.106
12	3.055
13	3.012
14	2.977
15	2.947
16	2.921
17	2.898
18	2.878
19	2.861
20	2.845
21	2.831
22	2.819
23	2.807
24	2.797
25	2.787
26	2.779
27	2.771
28	2.763
29	2.756
30	2.750
40	2.704
60	2.660
120	2.617
∞	2.576

Based on the comparison of the calculated t_{pair} value for the split sample test results to the appropriate t_{crit} value from the above table, one of two decisions will be made:

- **When $t_{pair} \geq t_{crit}$** – The difference between the paired test results of the split samples is greater than is likely to occur from chance, and therefore the Contractor's & Agency's test result do not correlate.

- **When $t_{pair} < t_{crit}$** – There is no reason to believe that the paired test results are different and therefore they may be assumed to have come from the same Population and correlate.

Mean Difference Tolerance

Binder Content	± 0.40
G_{mb}	± 0.020
G_{mm}	± 0.019
Air Voids	± 1.00%
VMA	± 1.20%

For convenience, the following worksheet shall be used to complete the Lab Correlation Evaluation. This worksheet can also be found as a separate tab on the PWL worksheet.

IPL Split Sample Testing Comparison

%AC - P_b

Split Sample Number	Contractor	Agency	Difference (Xd)
1	5.51	5.01	0.50
2	5.52	5.02	0.50
3	5.53	5.03	0.50
4	5.05	5.04	0.01

$X_{d\ Mean}$	0.38	Degree of Freedom	3
S_d	0.25	Prob. α	1%
t_{pair}	3.07	$t_{critical}$	5.84
Split Sample Results:		**Correlates**	

G_{mm}

Split Sample Number	Contractor	Agency	Difference (Xd)
1	2.546	2.600	0.054
2	2.456	2.500	0.044
3	2.400	2.400	0.000
4	2.300	2.300	0.000

$X_{d\ Mean}$	0.025	Degree of Freedom	3
S_d	0.029	Prob. α	1%
t_{pair}	1.71	$t_{critical}$	5.841
Split Sample Results:		**Do not Correlate**	

G_{mb}

Split Sample Number	Contractor	Agency	Difference (Xd)
1	2.399	2.407	0.008
2	2.398	2.404	0.006
3	2.414	2.424	0.010
4	2.402	2.416	0.014

$X_{d\ Mean}$	0.009	Degree of Freedom	3
S_d	0.003	Prob. α	1%
t_{pair}	5.56	$t_{critical}$	5.841
Split Sample Results:		**Correlates**	

V_a

Split Sample Number	Contractor	Agency	Difference (Xd)
1	4.37	4.14	0.230
2	4.49	4.18	0.310
3	3.96	3.58	0.380
4	4.26	3.82	0.440

$X_{d\ Mean}$	0.34	Degree of Freedom	3
S_d	0.09	Prob. α	1%
t_{pair}	7.51	$t_{critical}$	5.84
Split Sample Results:		**Do not Correlate**	

VMA

Split Sample Number	Contractor	Agency	Difference (Xd)
1	15.94	15.56	0.380
2	15.78	15.60	0.180
3	15.19	14.77	0.420
4	15.82	15.39	0.430

$X_{d\ Mean}$	0.35	Degree of Freedom	3
S_d	0.12	Prob. α	1%
t_{pair}	6.03	$t_{critical}$	5.84
Split Sample Results:		**Do not Correlate**	

PROCEDURES FOR JOB MIX FORMULA ADJUSTMENTS

The Hot Mix Asphalt (HMA) Technical Subcommittee developed this document to promote statewide standardization of Job Mix Formula (JMF) adjustments during HMA production. In order to target the current JMF a Contractor can make changes to the process controls of the HMA plant without requesting an adjustment.

Use the following procedure when a contractor requests a change to the original JMF HMA Field Communication (Form 1911) established during the MDOT mix design verification process.

The process for changing Form 1911 can be initiated more than once during production. However, you cannot submit a subsequent Form 1911 change until the affects on production of the initial change are established.

The contractor must request changes to Form 1911 in writing. The written request can be e-mailed, faxed, mailed, or hand delivered to the project engineer, with a copy to the region mix inspector (RMI). Should the project engineer approve the requested change to Form 1911, the contractor's letter of request must be signed by the project engineer and filed with the project records.

Whenever a JMF adjustment is approved, a new Form 1911 will be created by the RMI. The mix design number on the new Form 1911 will have the original mix design number, followed by the letters "mod" and a number indicating how many modifications have been made to this mix design designation (i.e., 04MD-111mod2). The remarks section must contain a description of the changes since the previously established JMF for that mix.

Any proposed changes to the existing JMF must adhere to the following procedures:

1. The contractor may propose a change to the existing JMF based on quality control and/or quality assurance test results.

2. MDOT must verify that any JMF adjustment meets all requirements in the Special Provision for Superpave or Marshall Hot Mix and the contract requirements, such as aggregate wear index. Mixture production must stop if consensus properties do not meet specification.

3. An approved JMF adjustment may be applied retroactively only to the current lot and only for parameters with target values.

4. When the aggregate blend proportions are changed by 10 percent or less from the blend percentages listed on the original mix design, the Bulk Specific Gravity of Aggregate (Gsb) from the mix design will continue to be used for calculating mixture properties.

5. For changes greater than 10 percent, production must stop and the contractor must re-determine the Gsb for the mixture and submit it to the RMI. MDOT region materials personnel will take a sample from the aggregate belt and perform verification testing on the Gsb. If the MDOT sample result verifies the contractor's Gsb within + or – 0.028, the contractor's Gsb will be accepted for the new Form 1911 and production will resume. If the MDOT sample result does not verify the contractor's Gsb, a new mix design will be required for the mixture. The Gsb verification will be completed by MDOT within five business days (includes Saturday).

Changes to the aggregate blend proportions are limited to 20 percent total change from the blend percentages listed on the original mix design. For example, remove 10 percent of aggregate #1 + add 10 percent of aggregate #2 = 20 percent total.

6. Approved Gsb changes will require recalculation of all volumetric properties.

7. Establish the Specific Gravity of Asphalt (Gb) for the asphalt binder grades before the start of production. Unless a change in asphalt binder suppliers occurs, the Gb established on the initial Form 1911 will not change during the course of production. If a Gb change is necessary due to an asphalt binder supplier change, then a change to the existing JMF is required.

8. Adjustments to the effective specific gravity of aggregate (Gse) will require a new mix design. However, if 6 above applies, a new Gse is calculated without requiring a new mix design.

HMA SAMPLE REDUCTION PROCEDURE

PROCEDURE REFERENCE DOCUMENT
ASTM C 702

1. Place the heated sample on a clean, smooth, non-porous surface.

2. Thoroughly blend the entire sample until the material is uniformly mixed.

3. Flatten the sample to a uniform thickness by pressing the material straight down, so that the resulting pile contains the material originally in it.

4. Divide the flattened pile into 4 equal quarters.

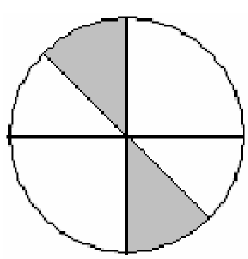
5. Scrape any fines clinging to the tools and equally distribute them back into the 4 quarters.

6. Reduce the size of the sample by removing opposite eights or quarters (including fines) and repeating steps 2 through 6 until the required sample size can be obtained from opposite diagonals.

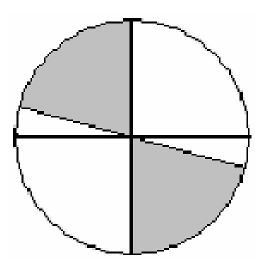
7. Test samples must be obtained from two opposite diagonals (including fines). Each opposite diagonal must be a minimum of one eighth up to a maximum of one quarter of the flattened pile.

2. Retain excess material until testing is complete.

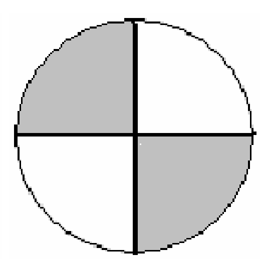
Examples of proper test sample selections



Opposite Eighth's



Opposite Eighth's +



Opposite Quarters

CHECKLIST FOR CALIBRATION OF PYCNOMETER

PROCEDURE REFERENCE DOCUMENT

MTM 314 (Theoretical Maximum Specific Gravity of HMA Paving Mixtures)

NOTE:

a) All pycnometer weights required for this procedure ***do not*** include a pycnometer lid.
b) The pycnometer calibration should be verified a minimum of once per week.
c) The dry weight of the pycnometer must be verified daily. If the pycnometer dry weight varies by more than 0.1 gram from the previous calibration, repeat the entire calibration process.

1. Weigh the dry, empty pycnometer, to the nearest 0.1 gram and record the weight on a calibration worksheet.

2. Immerse the empty pycnometer in 77 ± 1.8° F (25 ± 1° C) water bath. Verify that the water bath overflow outlet is functioning.

3. Allow the pycnometer to reach water bath temperature for 3 to 5 minutes.

4. Weigh the pycnometer in water, on the suspended weighing apparatus under the scale, to the nearest 0.1 gram and record the weight on a calibration worksheet.

5. Record the pycnometer identification number and date of calibration on the calibration worksheet for future reference.

PYCNOMETER CALIBRATION DOCUMENTATION

Date							
Pycnometer ID Number							
Pycnometer Dry Weight							
Pycnometer Weight in Water							

CHECKLIST FOR
THEORETICAL MAXIMUM DENSITY (TMD)

PROCEDURE REFERENCE DOCUMENT
MTM 314 (Theoretical Maximum Specific Gravity of HMA Paving Mixtures)

NOTE 1 - All pycnometer weights required for this procedure ***do not*** include a pycnometer lid.
NOTE 2 - The size of the sample for this procedure must conform to the following requirements;

Nominal Maximum Aggregate Size	Minimum Sample Size, grams
¾" (*19 mm*) or smaller	2000
1" (*25 mm*) or larger	* 2500

* If the sample size exceeds two-thirds the volume of the pycnometer, it must be tested in portions with none of the portions tested being less than 1250 grams.

1. Place a quartered sample on a large, clean tray and spread out as thin as possible.

2. Separate the mixture particles by hand as the sample is cooling. (*A fan may be used to speed cooling*.) Coarse aggregate particles should be no larger than single stone size, and the fine aggregate portion should be no larger than 1/4 inch.

3. Verify that the dry weight of the pycnometer is within 0.1 gram of the calibrated dry weight.

4. After the sample has cooled to room temperature, carefully transfer the separated mixture particles into a calibrated pycnometer. ** See Note 2 above.*

5. Weigh the pycnometer and sample to the nearest 0.1 gram. Record this weight on the worksheet.

6. Verify that the water bath temperature is 77 ±1.8 °F (25 ±1 °C). Add water from the water bath to the pycnometer and sample. The final water level must be a minimum of 1 inch above the mixture sample and 1-1/2 inches below the top of the pycnometer.

7. Place the pycnometer on the vibrating table. Place the clear lid on the pycnometer.

8. Turn on the vacuum pump and the vibrating table. Allow the vacuum pump and vibrating table to run for 15 ±2 minutes with the manometer stabilized at 25 ±2 mm of Hg.

9. At the end of the vacuum period, turn off the vibrating table and gradually release the vacuum pressure using the bleeder valve.

10. Carefully immerse the pycnometer and sample in the 77 ±1.8 °F (25 ±1 °C) water bath and suspend on the weighing apparatus under the scale. Verify that the water bath overflow outlet is functioning.

11. After an immersion period of 10 ±1 minutes, record the weight of the pycnometer and sample on the worksheet.

12. Complete the necessary calculations.

BULK DENSITY PROCEDURE

CHECKLIST FOR
MARSHALL DENSITY AND PERCENT AIR VOIDS PROCEDURE

The desired volume of the Marshall specimen is 515 cc ± 8 cc. This is approximately 2½ inches (63.5 mm) in height of compacted specimen or approximately 1200-1250 gms of loose mixture.

Refer to Michigan Test Method 315 and procedures. **Newest MTM should be used**.

1. Place the three quartered samples in 32 ounce (946 mL) ointment cans and cover.

2. Place containers, with sample, in oven. Oven temperature may not exceed upper limit of mixing temperature range.

3. Allow samples to heat to the compaction temperature identified on the JMF, Form 1911.

4. Place three Marshall molds, hand tools, and equipment in oven to allow them to reach compaction temperature.

5. Place Marshall hammer assembly on an electric hot plate (in close proximity to the Marshall pedestal) and allow to heat up to compaction temperature (280°F ± 5°F {138°C ± -15°C}).

   Note: Steps 6 – 14 should be completed as quickly as possible to reduce the potential for temperature loss before compaction is completed.

6. Verify the samples and the molds have reached compaction temperature.

7. Remove a mold from the oven and place a paper disk on base plate of mold. Set the mold and collar sections on top of the base plate over the paper.

8. Remove a sample from the oven and carefully transfer it to the mold using a 4 inch Marshall funnel. With a spatula, rod the mixture in the mold (15 times around the perimeter and 10 times through the interior portion), and then taper the top perimeter portion of the specimen.

9. Transfer mold and sample to Marshall pedestal and put hold down device in place. Place a paper on top of sample.

10. Place Marshall hammer assembly in place. Using the handle-holding device, secure the hammer assembly in the vertical position as close as possible to being perpendicular to the base.

11. Lift the moveable weight portion of the hammer assembly to the top and release it (this is considered one blow of the hammer). Repeat this procedure to complete a fifty (50) blow cycle. The blows should be cycled at approximately one per second.

12. Remove the hammer assembly from the mold and place it back on the hot plate.

13. Remove top portion of Marshall mold assembly. Turn partially compacted Marshall specimen (lower portion of assembly) over and re-position on base (it may be necessary to replace papers). Replace top portion of Marshall mold. Specimen shall be uniformly seated on the base plate.

14. Repeat steps 10 through 13.

15. Remove entire mold assembly with sample from pedestal and transfer to work counter.

16. Separate top collar and base from assembly. Remove papers, label specimen and place mold and specimen on edge and allow to air cool to ambient temperature. A fan may be used to speed cooling.

17. Repeat steps 7 through 16 for the remaining two samples.

18. Clean the equipment that has been used (hammer assembly, mold parts, etc.).

19. When the Marshall specimens have reached ambient temperature, remove them from the molds using the Marshall specimen extruder.

20. Carefully scrape the top and bottom edges of the specimens and examine (to assure there are no loose particles of mix clinging to them).

    Note: All weights shall be recorded to the nearest 0.1 gm.

21. Place the first Marshall specimen on top of the scale. Read and record the dry weight of the specimen on a Marshall density worksheet.

22. Repeat step 21 for the remaining two Marshall specimens.

23. Submerge the three Marshall specimens in the water bath under the scale for a 3 to 5 minute soaking period. Make sure to remove all air bubbles from outside of specimens. (Water bath should be maintained at 77°F ± 1.8°F (25°C ±1°C). If the temperature of the specimen differs from the temperature of the water bath by more than 2°C, the specimen shall be immersed in the water bath for 10 to 15 minutes instead of 3 to 5 minutes.

24. Tare the scale and place the first Marshall in the suspended weighing basket under this scale. Allow the scale to settle. Read and record the weight of the specimen in water.

25. Remove the specimen from the bath and place on a damp towel and quickly blot all surfaces to obtain a saturated surface dry condition.

26. Place the specimen on the scale, read and record the weight of the saturated surface dried specimen.

27. Repeat steps 24 through 26 for the remaining two specimens.

28. Complete the required calculations for each of the specimens.

29. Average the three Marshall densities.

30. Complete the calculation.

Note: Instead of a hand-operated hammer, a mechanically operated hammer may be used provided it has been calibrated to give results comparable with the hand-operated hammer. The hand-operated hammer will be the standard hammer. Calibration shall be accomplished by increasing/decreasing the number of blows. (Weight of the hammer shall be maintained within 10 ± 0.02 pounds with a freefall of 18 ± 0.06 inches).

CHECKLIST FOR
GYRATORY COMPACTOR

Referenced Document AASHTO T312-03, Section 7.

The desired height of the gyratory specimen is 115mm ± 3mm. Approximately 4900 ± grams.

1. Place gyratory molds in oven set at compaction temperature identified on the JMF, Form 1911.

2. Place the two quartered samples into separate mold loading devices* and place into oven to bring samples to compaction temperature as stated on JMF. Oven temperature may not exceed upper limit of mixing temperature range.

3. As soon as mold and sample have reached compaction temperature, remove mold from oven. Make sure bottom plate is properly seated in the bottom of mold and place paper disc in bottom of mold.

4. Transfer the material directly from the separate mold loading device* to the mold and in one continuous motion to maintain a homogeneous mass.

5. Level off sample, place paper disc on top and place the top plate over the paper disc making sure the beveled side of plate is up.

6. Place mold with sample into the gyratory compactor as per the manufacturer's requirements. Verify the machine settings are correct for mold size, angle, pressure, and number of gyrations.

7. Start the gyratory compactor.

8. When the gyratory compactor stops, extrude sample or remove mold, as applicable. The specimen can be extruded from the mold immediately after compaction for most HMA. However, a cooling period of 5 - 10 minutes in front of a fan may be necessary before extruding some specimens to ensure the specimens are not damaged. Remove paper disc from sample after a short period of time using care to avoid damage to specimen.

9. Allow samples to reach ambient temperature. Then carefully clean top and bottom of all loose particles and label samples.

10. Refer to Michigan Test Method 315 (Bulk Specific Gravity and Density of Compacted HMA Mixtures Using Saturated Surface-Dry Specimens. **Newest version should be used**.

***It is recommended to use this device or equivalent. The purpose of the device is to allow the mold to be filled in one continuous motion to maintain a homogeneous mass.**

EXTRACTION PROCEDURES

CHECKLIST FOR
HMA MIXTURE ANALYSIS CENTRIFUGE EXTRACTION

CARE-ACCURACY-PRECISION

1. Obtain a representative sample of HMA mixture (1200-1600 grams).

   a. Sample size may be adjusted depending on capacity of extractor to be used.

   b. If splitting the sample to run two (2) extractions, combine the weights from both extractions before calculating percentages.

2. Sample is dried to a constant weight. The sample is allowed to cool, then carefully weighed to closest 0.1 gram and weight recorded on worksheet.

3. Extractor bowl is set on stable base, e.g. ac sample can.

4. Sample is transferred to extractor bowl (care must be taken to ensure no part of the sample is lost during the transfer.) Extractor bowl is then placed in extractor.

5. Solvent is poured over sample until it is covered (note volume of solvent required).

6. Sample is prodded and stirred with spatula for a minimum of 10 minutes.

7. Spatula blade is cleaned with solvent into bowl.

8. Filter is put in place.

9. Bowl cover is placed in position and secured with lock nut (finger tight).

10. Extractor is started and pencil lead stream of effluent (solvent and asphalt) established.

11. When effluent flow slows to a dripping rate, the extractor is shut down and bowl rotation stopped. Care must be taken to ensure that all the effluent has been extracted before recharging.

12. Extractor bowl is recharged with solvent (same amount of solvent as used in step no. 5).

13. Agitate extractor bowl for a minimum of 2 minutes.

14. Extractor is started and a pencil lead stream established.

15. Solvent wash cycles (steps 11 thru 13) should be repeated until effluent is relatively free of asphalt (slightly straw colored).

16. Clear water (volume equivalent to that of the solvent) is then added to sample.

17. Agitate extractor bowl for a minimum of 2 minutes.

18. Extractor is started and a pencil lead stream established.

19. Clear water wash cycles (steps 16 thru 18) are repeated until effluent is relatively clear (initial washes will have a milky appearance).

20. Sample may be given high rpm spin cycle at conclusion of final water wash cycle.

21. Extractor bowl, with sample, is removed from the extractor and placed on a stable base; e.g., ac sample can.

22. Remove lock nut and cover from bowl. Examine cover for residual dust. If dust is present, brush it back into sample.

23. Carefully remove filter, fold, and transfer to sample pan.

24. Aggregate is carefully transferred to sample pan (narrow bladed spatula may be used to scrape aggregate loose from extractor bowl).

25. Remaining aggregate is flushed from bowl with clear water, or air dried and then brushed into sample pan.

26. Folded filter is placed on sample of extracted aggregate in the sample pan.

27. Sample is placed on burner to dry.

28. When aggregate and filter are dried to a constant weight, ignite filter and burn completely to an ash.

29. Sample is removed from hot plate and allowed to cool.

30. Sample is weighed to closest 0.1 gram and weight recorded on worksheet.

31. Sample carefully returned to sample pan.

32. Liquid detergent and water added to sample.

33. Sample is washed repeatedly, with each wash being decanted over No. 200 (75 µm) sieve. A No. 16 (1.18 mm) protection sieve should be over the wash sieve until water appears clear.

34. Material retained on No. 200 (75 µm) sieve is flushed with a small amount of clear water back into sample pan.

35. Sample is placed on burner to dry to a constant weight.

36. Sample is then removed from heat and allowed to cool.

37. Sample is weighed to closest 0.1 gram.

38. Weight is recorded on worksheet.

39. Sample is placed in a set of sieves and shaken for 10 minutes.

40. Material retained in each sieve is weighed. Weight is recorded on worksheet.

41. Aggregate retained on and above the No. 4 (4.75 mm) sieve is kept separate to use for crush content.

42. Material retained on and above No. 4 (4.75 mm) - material is weighed and weight recorded on worksheet and is picked for crushed particles.

43. Crushed particles are weighed and weight recorded.

44. All calculations completed (see notes at conclusion of checklist).

45. Save sample until test results are compared to mix specifications and JMF.

46. Equipment is cleaned and put back in organized manner.

<<<< NOTES >>>>

a. Weights retained, when totaled, should be equal to the weight of dry extracted aggregate.

b. Fraction retained should total 100 %.

c. Cumulative fraction passing No. 200 (75 μm) should be the same as P. 200 (75μm) in the fraction retained column and also in the P. 200 (75 μm) in agg. of HMA column.

d. Percent of crushed particles should be noted on work sheet.

e. Dispose asphalt/solvent mixture and water/solvent mixture as directed by the Traveling Mix Inspector (RMI) or by the Contractor.

CHECKLIST FOR
HMA MIXTURE ANALYSIS VACUUM EXTRACTION

CARE-ACCURACY-PRECISION

1. Dry 200 ± 5 grams of Diatomaceous Earth (DE).

2. Place the DE on two tared low ash filters. Record the weight on the worksheet.

3. Tighten the wing nuts on the funnel ring so as to prevent leakage under the ring and retain an air gap under the filter support.

4. Pour approximately 1000 mL of the solvent into the funnel ring. Stir the combined solvent and DE, until the DE is completely in suspension.

5. Once in suspension, immediately start the vacuum pump. Allow the DE to settle into a uniform layer on top of the filter and vacuum off the clean solvent

6. Place the 12 inch (304.8 mm) diameter No. 200 (75 μm) sieve on top of the funnel ring.

7. Obtain a representative sample of the asphalt mixture to be tested. (Minimum size of sample to be used as shown in Table 1 of AASHTO T164-01). The sample is to be heated and dried to a constant weight (note b). For your convenience, this table is as follows:

Table 1 – Size of Sample

NominalMaximum Aggregate Size		Minimum Mass of Sample, kg
(mm)	(in.)	
4.75	(No. 4)	0.5
9.5	3/8	1
12.5	½	1.5
19.0	¾	2
25.0	1	3
37.5	1 ½	4

*If splitting the sample to run two (2) extractions, combine the weights from both extractions before calculating percentages.

8. Place the sample in a tared pan. Weigh the sample to the nearest 0.1 gram. Record the weight on the worksheet.

9. Pour enough solvent over the sample to completely cover. Stir the sample and solvent to dissolve the asphalt. Allow sample to soak for a minimum of five minutes, stirring occasionally.

10. Start the vacuum pump. Slowly decant the effluent over the surface of the 12 inch (304.8 mm) No. 200 (75 μm) sieve sitting on top of the funnel ring.

11. With the vacuum pump running, repeat steps 9 and 10 until the asphalt cement is completely dissolved, the effluent is a light straw color or close to the original solvent color, and the aggregate is visually clean.

12. Once the effluent is a light straw color or close to the original solvent color, and the aggregate is visually clean, cover the sample with solvent. Allow to stand a minimum of 15 minutes, stirring occasionally. Slowly decant the effluent over the surface of the 12 inch (304.8 mm) No. 200 (75 μm) sieve sitting on top of the funnel ring.

13. If the effluent has darkened, repeat step 12 until the effluent is a light straw color or close to the original solvent color. This will complete the solvent washes.

14. Pour enough water (hot water works best) over the solvent washed sample to completely cover it. A drop of liquid detergent will be added to aid in releasing the dust. Stir the sample to emulsify the residual solvent (the water should turn a milky color).

15. Using the same procedure as the solvent, decant the water over the No. 200 (75 μm) sieve.

16. Repeat steps 14 and 15 until the wash water is free of dust and/or emulsified solvent (water should be nearly clear).

17. Allow the vacuum to pull all the water from the filter surface. Wash the P 200 (75 μm) material from the P 200 (75 μm) screen into the extracted aggregate. Aggregate is now ready to dry.

18. Place the extracted aggregate in a pan and place on a hot plate or burner to dry to a constant weight (see note b). The temperature of the extracted aggregate shall not exceed 400 °F.

19. Scrape the DE dust from the edge of the extractor toward the center breaking all the DE dust free from the paper filter. Remove the funnel ring from the extractor and carefully transfer all residual DE dust remaining on the funnel ring into a pan. Place the filter paper and DE dust in the pan, separate from the aggregate. Dry the DE dust using a hot plate or burner until the filter paper is dry enough to ignite. Once the filter paper has completely turned to ash, dry the DE dust to a constant weight (note b). The 400 °F maximum aggregate temperature does not apply when drying the DE dust.

20. When the extracted aggregate is dry and cool, weigh and record the weight on the worksheet. Complete the sieve analysis as per centrifuge extraction procedures.

21. Complete all computations on worksheet.

<<<< NOTES >>>>

a. It may be necessary to scrape the dust laden top layer of DE toward the center to allow the water to pass more freely.

b. Constant weight is defined as follows:

The sample shall be dried until further drying does not alter the mass more than 0.3 grams in a 15 minute time frame.

Helpful Hint: The completeness of drying when using a stove with an open flame or hot plate may be indicated by placing a slip of paper on the sample. Curling of the paper indicates the presence of moisture. Drying is to be continued until the paper placed on the sample remains flat and the constant weight has been achieved (note b).

CHECKLIST FOR
IGNITION FURNACE

Reference and applicable documents **<u>Newest MTM should be used</u>.**

MTM 319 - Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method.

1. Sample size shall be equal to calibration size ± 10 grams if calibration method I is used. Sample size shall be 100 ±10 grams greater than the calibration sample if calibration method ii is used. Samples shall not exceed 2000 grams. If larger size samples are needed, the test sample may be divided into suitable increments, tested, and the results appropriately combined for calculation of asphalt content.

2. Preheat the ignition furnace to 900°F ±9°F (482°C ± 5°C), or to approved test temperature. If method ii was used for calibration, use temp. 104°F (40°C) less than that used for calibration.

3. Input the correction factor for the specific mix to be tested into the ignition furnace controller, and record on worksheet.

4. Weigh and record the weight of the sample baskets and catch pan (with guards in place).

5. Distribute approximately equal portions of the sample among the baskets, starting with the bottom basket in the catch pan. Use a spatula or trowel to level the sample, taking care to keep material away from the edges of the basket. Re-nest baskets in the catch pan as the sample is being distributed. Replace cover and guard on basket assembly.

6. Weigh and record the sample, baskets, catch pan and basket guards. Calculate and record the initial weight of the sample (total weight of the sample basket assembly).

7. Input the initial weight of the sample in whole grams into ignition furnace controller. Verify that correct weight has been entered.

8. Open the chamber door. Using the sample transfer device, place the baskets with the sample into the furnace. Close the chamber door and verify that the sample weight (including the baskets) displayed on the furnace's scale equals the total weight recorded within ± 5 grams. Differences greater than 5 grams or failure of the furnace balance to stabilize may indicate that the sample baskets are contacting the furnace wall and will invalidate the test. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

9. Allow the test to continue until the stable light and audible stable indicator signify that the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

10. Open the chamber door. Using the sample transfer device, remove the baskets with the sample. Place hot sample and basket assembly on a heat proof surface and place the protective cage over it. Allow to cool to room temperature.

11. Empty the contents of the baskets into a pan or bowl. Use a small wire sieve brush to ensure that all fines are removed from the baskets.

12. Perform the sieve analysis.

13. Attach a copy of original printed out test results to worksheet.

CHECKLIST FOR
SIEVE ANALYSIS

Refer to these test methods and procedures. **Newest MTM should be used**.

MTM 108	MTM 109	MTM 110
MTM 117	MTM 118	MTM 311

1. Sample is placed on burner to dry.
2. Sample is removed from hot plate and allowed to cool.
3. Sample is weighed to closest 0.1 gram and weight recorded on worksheet.
4. Sample carefully returned to sample pan.
5. Liquid detergent and water are added to sample. (Detergent not required for ignition sample).
6. Sample is washed repeatedly, with each wash being decanted over No. 200 (75 μm) sieve (a No. 16 (1.18 mm) protection sieve should be over the wash sieve) until water appears clear.
7. Material retained on No. 200 (75 μm) sieve is flushed with a small amount of clear water back into sample pan.
8. Sample is placed on burner to dry to a constant weight.
9. Sample is then removed from heat and allowed to cool.
10. Sample is weighed to closest 0. 1 gram.
11. Weight is recorded on worksheet.
12. Sample is placed in a set of sieves and shaken for 10 minutes.
13. Material retained in each sieve is weighed. Weight is recorded on worksheet.
14. Aggregate retained on and above the No. 4 (4.75 mm) sieve is kept separate to use for crush content.
15. Material retained on and above No. 4 (4.75 mm), materials is weighed and weight recorded on worksheet and is picked for crushed particles.
16. Crushed particles are weighed and weight recorded.
17. All calculations are completed. (See notes at conclusion of checklist).
18. Save sample until test results are compared to mix specifications and JMF.
19. Equipment is cleaned and put back in organized manner.

FORMULAS FOR CALCULATING ASPHALT AND VMA

1. Calculating Asphalt Content

$$Pb = \frac{100 \text{ x } Gb \text{ x } (Gse - Gmm)}{Gmm \text{ x } (Gse - Gb)}$$

Where:

Pb - Asphalt Content (%)

Gb - Specific Gravity of Asphalt Cement

Gse - Effective Specific Gravity of Aggregate (From Mix Design)

Gmm - Maximum Theoretical Specific Gravity of Mixture

2. Calculating Voids in the Mineral Aggregate (GSE)

$$VMA = 100 - \left(\frac{Gmb \text{ x } (100 - Pb)}{Gse} \right)$$

Where:

VMA - Voids in the Mineral Aggregate (%)

Gmb - Bulk Specific Gravity of Compacted Marshall Specimen

Pb - Asphalt Content (%) Calculated FROM FORMULA, NOT EXTRACTED VALUE

Gse - Effective Specific Gravity of Aggregate (from 1911)

3. Calculating Voids in the Mineral Aggregate (GSB)

$$VMA = 100 - \left(\frac{Gmb \text{ x } (100 - Pb)}{Gsb} \right)$$

Where:

VMA - Voids in the Mineral Aggregate (%)

Gmb - Bulk Specific Gravity of Compacted Mixture

Pb - Asphalt Content (%) Calculated FROM FORMULA, NOT EXTRACTED VALUE

Gsb - Bulk Specific Gravity of Total Aggregate (From 1911)

PROCEDURE FOR DETERMINING PAVEMENT DENSITY
CHECKLIST FOR DETERMINING PAVEMENT DENSITY (CORES)

1. Check for proper preparation of cores for testing.

   A. Identification
      - Mixture type i.e. wearing, base, etc.
      - Lot No., Sublot No.
      - Core No.

   B. Condition
      - Bottom surface must be sawed.
      - Proper handling and storage of core samples is critical for accurate density results. This is a Contractor responsibility.
      - Any loose material should be removed from core samples before weighing.

2. Check the temperature of the water in the water bath under the scale. It should be controlled at 77 °F ± 1.8 °F (25 °C ± 1 °C).

3. Place core in bath for a three to five minutes time period. Make sure to remove all air bubbles from outside of specimens. If the temperature of the cores differs from the water temperature by more than 2 °F (1 °C) the cores shall be immersed for 10 to 15 minutes.

4. Zero the scale and place a core in the suspended basket in the water bath.

5. Allow the scale to settle and read and record the weight of the core (in water) on line E of the worksheet.

6. Remove the core from the bath and using a damp cloth, with a blotting motion, surface dry the specimen.

7. Zero the scale. Place the surface dried core on the scale pan. Read and record the weight of the specimen in air.

8. Place the core in a tared pan (pie plate) in oven. Thoroughly dry the specimens to constant mass at 230 °F ± 9 °F (110 °C ± 5 °C.) Note: a 15 to 24 hour time period is usually adequate.

9. Remove the core from the oven and allow to cool to room temperature.

10. Place the core and pan on the scale and weigh and record the total weight.

11. Subtract the pan weight from the total weight to determine the oven dry weight of the core.

12. Determine the volume of the core specimen.

13. Determine the specific gravity of the core specimen, G_{mb}.

14. Using the verified maximum theoretical specific gravity, G_{mm} of the mixture (check for correct sublot), determine the percent compaction of the mixture.

15. Repeat steps 1 thru 14 as necessary to determine the percent compaction of each of the cores.

ROUNDING OFF METHOD

1. Rounding of test data and test results used for the acceptance and payment of HMA mixtures.

2. Rounding procedure of ASTM E29-93a sections 4.3, 6.4 and 6.5 shall apply. This procedure is restated here.

3. When the figure next beyond the last place to be retained is less than 5, retain unchanged the figure in the last place retained.

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.2344 =	93.2	93.23	93.234

4. When the figure next beyond the last place to be retained is greater than 5, increase by one the figure in the last place retained.

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.2678 =	93.3	93.27	93.268

5. When the figure next beyond the last place to be retained is 5, increase by one the figure in the last place retained if it is odd; leave the figure unchanged if it is even.

EXAMPLES:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.3365 =	93.3	93.34	93.336
	93.3375 =	93.3	93.34	93.338

6. The rounding off value should be obtained in one step by direct rounding off of the most precise value available and not in two or more steps of successive roundings.

7. Most Precise Value Available:

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	2.9466	2.9	2.95	2.947

Note: 2.946 rounded to the nearest 0.1 is 2.9; do NOT round first to 2.95 and then to 3.0.

EXAMPLE:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	3.5549	3.6	3.55	3.555

Note: 3.5549 rounded to the nearest 0.01 is 3.55; do NOT round first to 3.555 and then to 3.56.

8. At any time a test method or procedure requires test data or test results to be recorded it must be rounded to the significant place required, ***before being carried forward into further calculations or being compared to specification limits***. Rounded numbers shall be used for any future calculations. Rounding shall be done as above procedure. Figures may be checked for accuracy at any time.

PROCEDURE FOR ACCEPTANCE SAMPLE REHEATING

The entire sample shall be allowed to cool down to or warm up to ambient temperature before quartering. Reheating shall take place immediately prior to performing the tests, including quartering. Oven temperature may not exceed upper limit of mixing temperature range. Samples shall not be reheated overnight or for extended periods (maximum of 3 hours). The sample to be used for determining Theoretical Maximum Density shall be processed immediately and not returned to the oven.

Note: Lids must be left on samples in buckets during reheating.

CORE HANDLING AND TRANSPORTING PROCEDURE

1. Cores being removed from pavement must be witnessed by owner/agency.

2. Evaluate core for any damage upon removal from pavement.

3. Cores shall be handled carefully as to keep the core in a good condition.

4. Core must be identified and labeled when removed from pavement as follows:

   - Mixture Type, i.e. wearing, base, etc.
   - Sublot No.
   - Core No.

5. Identify the portion of the core to be tested, (top, center, bottom).

6. Core thickness of the mixture material to be tested (appropriate lift) must be measured at the time of removal.

7. Cores shall be placed in a transport container.

8. Cores shall be handled in a safe manner as not to damage cores while transporting from coring site to testing site. The process during transport is to use a standard cooler, and place individual cores vertically (surface side down) in plastic concrete cylinder molds cut to fit the size of the cooler. The temperature inside the cooler containing cores shall not exceed 77 ºF. If ambient temperature is greater than 77 ºF, the cooler shall be cooled with ice. When cores are received at the testing site, they shall be checked for identification, proper paperwork and that they are not damaged.

SECTION 4: HMA LAB AND TECHNICIAN QUALIFICATION PROGRAM

HMA QUALITY ASSURANCE LABORATORY

QA Laboratory Qualification Process –Title 23, of the Code of Federal Regulations, Part 637, states that all states develop a procedure for qualifying all testing personnel and laboratories used in acceptance decisions for federal aid on projects on the National Highway System.

MDOT's Central Lab shall be AASHTO accredited in applicable Hot Mix Asphalt test procedures. A qualified lab must meet the following requirements to work on any MDOT project:

- QA Labs will be assessed by AMRL, the AMRL assessments will follow the AMRL regional cycle (currently every 18 months).
  - The AMRL assessment is not for accreditation but for process and equipment reviews – See **MINIMUM TEST METHODS REQUIRED FOR QC/QA LABORATORY REVIEWS** for specific requirements.
- QA Labs must participate in the annual AMRL Proficiency Testing Program to include, at a minimum, the AASTHO or ASTM tests listed in **MINIMUM TEST METHODS REQUIRED FOR QC/QA LABORATORY REVIEWS**.
- QA Labs must meet the minimum requirements of AASHTO R-18 with regard to the Quality Manual (QM).
  - AASHTO R-18 requires that labs must have a Quality Manual (QM) that includes specific information - See **QUALITY MANUAL REQUIREMENTS** for specifics.
- QA Labs must be evaluated by C&T staff annually to ensure compliance with the QM. The Internal Review/IAT column within **MINIMUM TEST METHODS REQUIRED FOR QC/QA LABORATORY REVIEWS** will be completed when auditing a lab. A copy of the evaluation will be included in the QA Labs QM.
- The Lansing C&T lab must conduct a yearly round robin for all QA & QC testing labs.
  - The results of the round robin will be compared to specific tolerance requirements. If test tolerances are not met, the testing processes and equipment will be reviewed and discussed. If a determination explaining the differences cannot be found, a second round robin sample will be run at any lab that did not verify.
  - If the results of the second round robin do not result in verification within the required tolerances, C&T staff will review testing procedures, equipment, and processes to determine the cause of failure to verify.
  - The lab must meet the round robin specific tolerance requirements in order to be considered a qualified lab.
- At the discretion of the Region and in conjunction with Lansing C&T Lab, additional round robins can be administered.
  - The C&T round robin must be completed prior to the region round robin.
  - QA labs will be identified on the Round Robin Report.
  - The results of the round robin will be compared to the test tolerance requirements. If test tolerances are not met, the testing processes and equipment will be reviewed and discussed. If a determination explaining the differences cannot be found, a second round robin sample will be run at any lab that did not verify. The Lansing C&T Lab will participate in the second round robin.
- QA Labs must employ qualified technicians.

HMA QUALITY CONTROL LABORATORIES

QC laboratories must meet the following minimum criteria in order to perform testing on any MDOT project:

- QC Labs must meet the minimum requirements of AASHTO R-18.
    - AASHTO R-18 requires that labs must have a Quality Manual (QM) that includes specific information (See **QUALITY MANUAL REQUIREMENTS**).
- QC Labs must be evaluated by an internal/external source annually to ensure compliance with the QM. The Internal Review/IAT column within **MINIMUM TEST METHODS REQUIRED FOR QC/QA LABORATORY REVIEWS** will be completed when auditing a lab. A copy of the evaluation will be included in the QC Labs QM.
- QC Labs must employ qualified technicians
- QC labs must participate in the C&T Round Robin for all labs that provide QC and/or local acceptance. The results of the round robin will be compared to the test tolerance requirements located in the acceptance specification. If test tolerances are not met, the testing processes and equipment will be reviewed and discussed. If a determination explaining the differences cannot be found, a second round robin sample will be run at the lab that did not verify. The Lansing C&T Lab will participate in the second round robin. The QC lab must meet the round robin specific tolerance requirements in order to be considered a qualified lab.
- QC labs are encouraged to participate in region round robin testing.

HMA QUALIFIED TECHNICIANS

HMA Qualified Technicians must obtain and maintain the following:

HMA QA Technicians:

- Technicians performing QA must become certified and maintain their certification through a program approved by MDOT (the training committee currently approved the technician certification program housed at Ferris State University – QC/QA Technician Certification Program).
- Technicians must be evaluated on a yearly basis using an internal and/or external source.
  - The IAT process located in the MDOT Quality Assurance Manual will be used for this evaluation.

HMA QC Technicians:

- Technicians performing QC on HMA must become certified and maintain their certification through a program approved by MDOT (the training committee currently approved the technician certification program housed at Ferris – QC/QA Technician Certification Program).
- HMA QC Technicians must be evaluated on a yearly basis using an internal and/or external source.
  - The checklist in the **QUALIFIED HOT MIX TESTING** will be completed when evaluating a technician. A copy of the technician evaluation will be included in the QC Labs QM. It is the responsibility of the technician to have a copy of this evaluation at any QC lab in which he/she is working.

  OR

  - The IAT process located in the MDOT Quality Assurance Manual can be used for this evaluation.

MAINTAINING RECORDS

- Lansing C&T HMA Unit shall maintain a data base to include the following information for QA/QC HMA testing facilities:
  - Lab Name
  - Last AMRL Review Date (Required for QA Labs only)
  - Previous AMRL Review Date (Required for QA Labs only)
  - AMRL Proficiency Date (Required for QA Labs only)
  - Internal/External Evaluation Date
  - Round Robin Date
  - Notification of Deficiency/Corrective Action Date
- Lansing C&T HMA Unit shall maintain a data base to include the following information for QA/QC HMA testers:
  - HMA Certification Number
  - Expiration Date
  - QA IAT Date
  - QC Technician Evaluation
  - Notification of Deficiency/Corrective Action Date

It is the responsibility of the laboratory supervisor or the individual QA or QC technician to supply Lansing C&T HMA Unit with the necessary information to keep the databases updated.

The Lansing C&T HMA Unit will biannually review databases and inform the MDOT Statewide Quality System Manager (QSM), laboratory supervisor, or individual QA or QC technician, of any deficiencies or required corrective actions. The previously mentioned notification will be documented in the applicable databases.

DISQUALIFICATION OF LABORATORIES & TECHNICIANS

- QA/QC Laboratories
  - It will be the Lansing C&T HMA Unit's responsibility to biannually ensure databases are up to date. Therefore, ensuring requirements of this document have been adequately met.
    - Deficiencies will be reported to the MDOT Statewide QSM, lab supervisor, or applicable technician.
    - Deficiencies and date of notification will be documented in the applicable databases.
  - Failure to correct a deficiency within a 20 working day period will result in notification of the facility deficiency to the Engineer of Construction and Technology. The notification will include a recommendation, up to disqualification, from testing on MDOT projects.
  - Upon correcting all deficiencies, a lab can be reinstated by the Engineer of Construction and Technology to resume testing on MDOT projects.
- QA/QC Technicians
  - Falsifying Data – Permanent removal for testing on MDOT projects. Reinstatement cannot be considered.
  - Failure to meet the requirements of MDOT's IAT program or a contractor's internal/external review.
  - Failure to obtain recertification through a program approved by MDOT (the Training Committee currently approved the technician certification program housed at Ferris – QC/QA Technician Certification Program).
  - Upon correcting all deficiencies, a technician can be reinstated by the Engineer of Construction and Technology to resume testing on MDOT projects.

MINIMUM TEST METHODS REQUIRED FOR QC/QA LABORATORY REVIEWS

Test Method	AASHTO, ASTM, MTM	AMRL Laboratory Assessment	AMRL Proficiency Testing	Internal Review / IAT **
Reducing Samples of Hot Mix	T328			√
Quantitative Extraction of Bitumen from Bituminous Paving Mixtures (Method E)	T164, D2172, MTM 325	√	√	√
Bulk Specific Gravity of Compacted Bituminous Mixtures using Saturated Surface-Dry Specimens	T166, D2726, MTM 315	√	√	√
Sieve Analysis of Fine and Coarse Aggregate *	T27, C136, MTM 109	√	√	√
Mechanical Analysis of Extracted Aggregate *	T30, D5444, MTM 311	√	√	√
Maximum Specific Gravity of Bituminous Paving Mixtures	T209, D2041, MTM 314	√	√	√
Preparation of Bituminous Specimens using Marshall Apparatus	T245, D6926, MTM 309	√	√	√
Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures	T-269, D3203	√	√	√
Preparing and Determining the Density of HMA Specimens by Means of the SHRP Gyratory Compactor	T-312, D6925, MTM 315	√	√	√

The current MTM test method shall be used during Internal Reviews. If an MTM is not available, use the appropriate AASHTO or ASTM as indicated in the applicable Special Provision.

For AMRL laboratory assessment and proficiency testing, the test method will be determined by the Lansing C&T HMA Unit.-

* Either Method can be reviewed to satisfy the requirements for Sieve Analysis.

** Current Michigan MTM/IAT Checklists shall be used for documentation of the review.

QUALITY MANUAL REQUIREMENTS

Have there been any changes made or updates required in the following sections of the quality manual?

Describe any actions taken below and update manual accordingly. R-18 will be followed to determine calibration and equipment check frequency.

	Changes Made?	Manual Updated?
a) Legal name and address		
b) Organizational charts		
c) Staff position descriptions		
d) Staff biographical sketches		
e) Staff training methods		
f) Staff evaluation methods		
g) Staff training/evaluation forms		
h) Equipment inventory list		
i) Equipment calibration/check list		
j) Procedure describing in-house calibrations/checks		
k) In-house equipment calibration/check procedures		
l) Equipment calibration/check certificates		
m) Procedures followed to produce test records		
n) Procedures followed to prepare, check, and amend test reports		
o) Test report forms		
p) Procedures for sample identification, storage, retention, and disposal		
q) Policies relative to on-site inspections and corrective action		
r) Policies relative to proficiency sample testing and corrective action		
s) Policies relative to handling external technical complaints		
t) Policies relative to internal quality system reviews		
u) Policies relative to subcontracting		

Actions taken:

____
____
____
____
____
____

Reviewed by: ______________________________ Date: ______________________

Next Review Date: ____________________

QUALIFIED HOT MIX ASPHALT TESTING

Date:_______
Lab No./Lab Name: _________________________
Company Name: _________________________
Lab Location: _________________________

LABORATORY

[ ]* Transportation of Mixture to Lab
[ ] List of Equipment Calibrated or Verified
[ ] Test Methods and Frequency of Calibration/Verification

MATERIALS TESTING – QC/QA HMA

[ ] Sample
[ ] Sample Reduction Procedure
[ ] Maximum Theoretical Specific Gravity (Gmm)
[ ] Test Performed in accordance with current MTM. Use the current checklist to verify procedure.
[ ] Compaction of Gyratory Specimen
[ ] Test performed in accordance with current MTM. Use the current checklist to verify procedure.
[ ] Compaction of Marshall Specimen
[ ] Test performed in accordance with current MTM. Use the current checklist to verify procedure.
[ ] Bulk Specific Gravity of Bituminous Mixture (Gmb)
[ ] Test performed in accordance with current MTM. Use the current checklist to verify procedure.
[ ] Volumetric Properties
[ ] AC Content, Air Voids and VMA calculated correctly.
[ ] Sieve Analysis
[ ] Test performed in accordance with current MTM. Use the current checklist to verify procedure.

DOCUMENTATION

[ ]* Control Charts
[ ] Test Data
[ ]* Diary
[ ] List of Documents on File at Plant or Lab

* Only if Applicable

APPENDIX A - MDOT FORMS

TO BE PLACED IN THIS SECTION BY TESTER

1829	Testing of HMA Mixtures (Calculation Worksheet)
1839	Testing of HMA Mixtures (Vacuum Worksheet)
1878	Testing of HMA Mixtures (TMD and Marshall)
1903	Daily Report of HMA Plant Inspection
1903b	Report of Acceptance Testing
1903c	Daily Report of Contractor's Quality Control Tests
1905	Testing of HMA Mixtures (Centrifuge Worksheet)
1907	MDOT Report of Compacted HMA Mixture Core Density & Percent Compaction
1912	Testing of HMA Mixtures (Ignition Furnace Worksheet)
1923b	Sample Identification (HMA Materials from Project)

APPENDIX B - MICHIGAN TEST METHODS (MTM)

TO BE PLACED IN THIS SECTION BY TESTER

MTM 107	Sampling Aggregates
MTM 108	Materials Finer than No. 75 μM (No. 200) Sieve in Mineral Aggregates by Washing
MTM 109	Sieve Analysis of Fine, Dense Graded, Open Graded and Coarse Aggregates in the Field
MTM 110	Determining Deleterious and Objectionable Particles in Aggregates
MTM 117	Determining Percentage of Crushed Particles in Aggregates
MTM 118	Measuring Fine Aggregate Angularity
MTM 309	HMA Marshall Mix Design Procedure
MTM 311	Determining Aggregate Gradation for HMA Mixture
MTM 313	Sampling HMA Paving Mixtures
MTM 314	Theoretical Maximum Specific Gravity and Density of HMA Paving Mixtures
MTM 315	Bulk Specific Gravity and Density of Compacted HMA Mixtures Using Saturated Surface-Dry Specimens
MTM 319	Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method
MTM 324	Sampling HMA Paving Mixtures Behind the Paver
MTM 325	Quantitative Extraction of Bitumen from HMA Paving Mixtures

APPENDIX C - PROJECT SPECIFICATIONS

TO BE PLACED IN THIS SECTION BY TESTER