HMA PRODUCTION MANUAL

MARCH 2019

CONSTRUCTION FIELD SERVICES DIVISION

Michigan Department of Transportation

(Rev. 2019)

Preamble

This manual provides guidance to administrative, engineering, and technical staff. Engineering practice requires that professionals use a combination of technical skills and judgment in decision making. Engineering judgment is necessary to allow decisions to account for unique site-specific conditions and considerations to provide high quality products, within budget, and to protect the public health, safety, and welfare. This manual provides the general operational guidelines; however, it is understood that adaptation, adjustments, and deviations are sometimes necessary. Innovation is a key foundational element to advance the state of engineering practice and develop more effective and efficient engineering solutions and materials. As such, it is essential that our engineering manuals provide a vehicle to promote, pilot, or implement technologies or practices that provide efficiencies and quality products, while maintaining the safety, health, and welfare of the public. It is expected when making significant or impactful deviations from the technical information from these guidance materials, that reasonable consultations with experts, technical committees, and/or policy setting bodies occur prior to actions within the timeframes allowed. It is also expected that these consultations will eliminate any potential conflicts of interest, perceived or otherwise. MDOT Leadership is committed to a culture of innovation to optimize engineering solutions.

The National Society of Professional Engineers Code of Ethics for Engineering is founded on six fundamental canons. Those canons are provided below.

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform Services only in areas of their competence.
3. Issue public statement only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, reasonably, ethically and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

FOREWORD

This manual is the combination of three separate Hot Mix Asphalt (HMA) manuals used in the design, production, and testing of HMA for the Michigan Department of Transportation (MDOT) projects and a Laboratory 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 HMA 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 Procedures of Hot Mix Asphalt Plants

This section provides the requirements for certifying HMA Plants. The certification procedures are administered by the Lansing Construction Field Services Support Area, with direct support from the Region Traveling Mix Inspector. The requirements of these procedures do not replace or supersede *MDOT Standard Specifications for Construction* or other legal requirements referenced in this section.

Section 3: HMA Quality Control/Quality Assurance (QC/QA) Procedures for Field Testing

The checklists in this section are intended to provide a quick reference guide for the performance of HMA sampling and testing required by the MDOT HMA QC/QA Assurance Program. These checklists do not replace or supersede the referenced MDOT, American Association of State Highway and Transportation Officials (AASHTO) or American Society for Testing and Materials (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 HMA 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 Laboratory 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 HMA.

MDOT Mission Statement

"Providing the Highest Quality Integrated Transportation Services for Economic Benefit and Improved Quality of Life."

For copies of this manual, contact the MDOT Publications Office;

Telephone: (517) 322-1676
E-Mail: MDOT-Publications@michigan.gov

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SECTION 1: PROCEDURES MANUAL FOR HMA MIX DESIGN PROCESSING

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) on-site assessment. Documentation includes:

   - Complete copy of the AMRL inspection report.
   - Responses to any deficiencies from the participating laboratory.

AASHTO MATERIALS REFERENCE LABORATORY (AMRL) LABORATORY INSPECTION

The following test procedures are required:

D2726/T166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
D2041/T209	Maximum Specific Gravity of Bituminous Paving Mixtures
D6926/T245	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
D3203/T269	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
T312	Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the SHRP Gyratory Compactor
C136/T27	Sieve Analysis of Fine and Coarse Aggregate
C128/T84	Fine Aggregate Specific Gravity and Absorption
C127/T85	Coarse Aggregate Specific Gravity and Absorption
C1252/T304	Uncompacted Void Content of Fine Aggregate

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

Michigan Department of Transportation
Construction Field Services
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 laboratory must be forwarded by the HMA mix design laboratory, to Construction Field Services Bituminous Unit in Lansing, Michigan. The following sample participation is required for all HMA mix design methods.

    - HMA Marshall Design
    - HMA Gyratory
    - Coarse Aggregate (including Coarse Aggregate Specific Gravity and Absorption)
    - Fine Aggregate (including Fine Aggregate Specific Gravity and Absorption, Uncompacted Void Content using ASTM C1252 Method A).

4. Contact information for personnel responsible for signing mix designs from the laboratory on file with MDOT.

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

Michigan Department of Transportation
Construction Field Services
C/O Bituminous Mixtures and Materials Engineer
8885 Ricks Road
P.O. Box 30049
Lansing, Michigan 48909

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

GENERAL MIX DESIGNS

General Mix Designs are those not specific to a MDOT or a federal-aided local government project and are allowed to be submitted annually in December-February for Marshall Mixes and Superpave Mixes. The General Mix Design submissions will be limited to a maximum of four individual mixes per HMA plant.

General Mix Designs will be reviewed in the order in which they are received. The General Mix Design will have no time limitations for MDOT to authorize approval, and will be last in priority behind mix designs associated with a specific project. All the Superpave Mix Designs will be evaluated using the most current version of *2012 Standard Specifications for Construction*. All General Superpave Mix Designs are submitted as Non-Express mix designs. All Marshall Mix Designs will be evaluated using the most current version of FUSP 501(F) Marshall Hot Mix Asphalt Mixture. All General Mix Design submissions must comply with the Comparison Level submittal procedures as defined in the HMA Production Manual.

MARSHALL MIXTURE DESIGNS

1. Marshall Mix Design General Guidelines

For all projects, the Contractor/Consultant 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/Consultant. SMD's must be prepared in accordance with the latest version of the Michigan Test Method for Bituminous Marshall Mix Design Procedures (MTM 322).

- 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/Consultant laboratory may submit is two.

Submittal of a submitted mix design shall be made to:

Michigan Department of Transportation
Construction Field Services 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 work days to evaluate the submitted mix design. SMD's received after 11.45 a.m. will start the five work day clock on the next scheduled work day.

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

The Project Engineer may require a new mix design from the Contractor/Consultant 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

- All data must meet specification.
- Volume of compacted specimens: 515 cm^3 ± 8 cm^3.
- Spread between three Marshall Gmb's at a given asphalt content within: 0.013.
- Spread between Gse's on a 4-point design within: 0.012.
- The flow value consistently increases with increasing asphalt content.
- The percent of air voids steadily decreases with increasing asphalt content.
- The Voids in Mineral Aggregate (VMA) generally decreases to a minimum value, then increases with increasing asphalt content.

3. Submitted Mix Design (SMD)

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

- Review the submitted documentation and materials for compliance with project specifications.
- Evaluate the design by entering and running the SMD 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) (MTM 117)
    - Soft Stone
    - Percent Crush
    - Current Los Angeles Abrasion Number
- Prepare Marshall specimens per ASTM D6926; for testing stability and flow (ASTM D6927); and bulk specific gravity (ASTM D2726).
- Prepare specimens for maximum theoretical specific gravity (ASTM D2041).
- 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 sample of mixture at optimum asphalt content.

NOTE: 2C designs require 7000 gram sample of mixture at optimum asphalt content.

b) 1 - 2500 gram representative RAP sample.

c) Individual Aggregate Wear Index (AWI) shall samples shall be provided for each aggregate requiring an AWI value.

NOTE: This should be submitted even if a nomograph exists for that aggregate unless directed otherwise by Aggregate Quality Control.

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.

  NOTE: At least one full test point (0.5 % asphalt) above and below optimum asphalt content is required. Identify on the Submitted Mix Design Summary Sheet (Form 1813) the asphalt content of the submitted mix.
- Form 1822 - Marshall Mix Design Work Sheet.
- Form 1806 - Theoretical Maximum Specific Gravity.
- Form 1849 - Marshall Mix Design Checklist.
- Form 1859 - Coarse Aggregate Gravity.
- Form 1860 - Fine Aggregate Gravity.
- Form 1879 – Recycled Asphalt Pavement (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.
- Copy of the project proposal cover page, schedule of items page showing the required mix and HMA application table.
- Copy of the mixture specification that differs from the standard MDOT mixture specification.

NOTE: Current MDOT forms are required on the mix design submittal. If the Contractor/Consultant duplicates the form, 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% (± 4.0% for 2C Mixes)
- Sieve No. 4 (4.75 mm) thru No. 50 (0.30 mm): ± 2.0% (± 3.0% for 2C Mixes)
- Sieve No. 100 (0.15 mm) thru No. 200 (0.075 mm): ± 1.0%.
- Tolerance on the combined bulk specific gravity ± 0.028.

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

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

MDOT will have five work days in which to review the SMD.

The five work day 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 work day time period stopped, for the following situations (but not limited to):

- Evaluation of mix design results indicates a failing design.
- Incorrect or insufficient material is submitted.
- Aggregate(s) do not meet physical requirements specified for the project.
- The Contractor/Consultant requested combined gradation does not meet Master Gradation Range in the applicable Standard Specifications or Special Provision.
- No project office notification.
- Incomplete documentation.
- Invalid Los Angeles Abrasion Number.

- Contractor/Consultant suspends interest in submitted material.

Restart of the five work day clock will commence upon the timely response by the Contractor/Consultant in efforts to resolve any discrepancies in the submittal.

The Contractor/Consultant, Region 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 the mix design fails and the Contractor/Consultant wish to resubmit, the maximum number of mix designs per course, per project, that any one Contractor/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,	1 - 5000 gram mixture samples
Gradation, Crush	Complete paperwork
Angularity Index	Redesign Complete paperwork
Stability & Flow	Redesign Complete paperwork
AWI	Redesign Complete paperwork

NOTE 1: On failing mix designs, MDOT will notify the Contractor/Consultant which test(s) failed. MDOT will not state failed test results.

NOTE 2: 2C designs require 7000 gram sample of mixture at optimum asphalt content.

SUPERPAVE MIXTURE DESIGN

1. Superpave Mix Design General Guidelines

For all projects containing Superpave Bituminous Mixtures, the Contractor/Consultant will supply the Superpave Mix Design to the Michigan Department of Transportation (MDOT). The Superpave Mix Design must be prepared by a private testing laboratory, either the Contractor/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/Consultant laboratory may submit is two.

Submittal of a Superpave Mix Design shall be made to:

Michigan Department of Transportation
Construction Field Services 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 work days 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 work day.

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/Consultant 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://mdotcf.state.mi.us/public/webforms/

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 Michigan Department of Transportation's (MDOT) Bituminous Mix Design computer program.

Tolerance Limits for MDOT Paper Review:

Superpave

- All data must meet specification.
- Height of a compacted gyratory specimen: 115 mm $\pm$ 3 mm.
- Spread between two gyratory Gmb's at a given asphalt content within: 0.012.
- Spread between Gse's on a 4-point design within: 0.012.
- The percent of air voids steadily decreases with increasing asphalt content.
- The Voids in Mineral Aggregate (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 – Saturated Surface Dry (SSD) - apparent specific gravities and % absorption.

  - Coarse Aggregate Bulk - SSD - apparent specific gravities and % absorption.
  - Sand equivalent of fine aggregate (ASTM D2419).
  - % Soft Particles.
- Prepare gyratory specimens per *Superpave Mix Design Manual (SP-2)* for bulk specific gravity (ASTM D2726).
- Prepare specimens for maximum theoretical specific gravity (ASTM D2041).
- 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/Consultant will perform the TSR testing for the design. The Contractor/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 MDOT 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:

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

- 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)

** = Grams of mixture to achieve 115mm ± 3mm height at* N_{des}

1 – 2500 gram representative RAP sample

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

Individual Aggregate Wear Index (AWI) samples for each aggregate, which requires an AWI value. An AWI sample of RAP 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 RAP, 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 unless otherwise directed by Aggregate Quality Control.

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

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

1 - 2000 gram sample of aggregate retained No. 8 (2.36 mm) sieve.
(Washed and 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

  NOTE: At least one full test point (0.5% asphalt) above and below optimum asphalt content is required.
- 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
- Temperature - Viscosity Graph/Table showing mixing and compaction temperatures
- Copy of the project proposal cover page, schedule of items page showing the required mix and HMA application table.

- Copy of the mixture specification that differs from the standard MDOT mixture specification.

- Project office notification.

NOTE: Current MDOT forms are required on the mix design submittal. If the Contractor/Consultant duplicates the form, 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 minimum specification for project.
- 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% (± 4.0% for 2E Mixes)
- Sieve No. 4 (4.75 mm) through No. 50 (300 µm) ± 2.0% (± 3.0% for 2E Mixes)
- Sieve No. 100 (150 µm) through No. 200 (75 µm) ± 1.0%.
- The Tensile Strength Ratio (TSR) 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 work days to review the Superpave mix design.

The 10 work day 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 work day time period stopped, for the following situations (but not limited to):

- Evaluation of Superpave Mix Design results indicates a failing design.
- Incorrect or insufficient material is submitted.
- Incomplete documentation.
- Aggregate(s) do not meet physical requirements specified for the project.

- The Contractor/Consultant requested combined gradation does not meet Table 10 Aggregate Gradation Requirements of the Special Provision for Superpave Bituminous Mixtures.
- No project office notification.
- Invalid Los Angeles Abrasion Number.
- Contractor/Consultant suspends interest in submitted material.

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

The Contractor/Consultant, Region 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.

8. Re-submittals – Superpave Mix Design

If the mix design fails and the Contractor/Consultant wish to resubmit, the maximum number of mix designs per course, per project, that any one Contractor/Consultant laboratory may submit is two. 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

** = Grams of mixture to achieve 115mm ± 3mm height at* N_{des}

NOTE: On failing mix designs, MDOT will notify the Contractor/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:

- The mix design laboratory must meet all requirements specified in the Hot Mix Asphalt (HMA) Mix Design Laboratory Qualifications, Section 1 of this Manual.

- Mix design submittal requirements for Superpave Express Status qualification

    - 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.)

    - 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.

- The last five consecutive Superpave mix design submittals must be in compliance with the criteria stated in the above bullets and a minimum of fifteen Superpave designs submitted.

- 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, twelve (12) out of the past fifteen (15) Superpave mix design submittals must be in compliance with items in the first two bullets 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 above 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 (Section A).

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 the Superpave Mix Design Checklist (Form 1862), 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

Individual Aggregate Wear Index (AWI) samples shall be provided for each aggregate requiring an AWI value.

NOTE: This should be submitted even if a nomograph exists for that aggregate unless a waiver is obtained from Aggregate Quality Control.

4. Submittal Time Frame

Upon acceptance, MDOT will have 5 work days to evaluate the Superpave Mix Design. Superpave Mix Designs received after 11:45 a.m. will start the 5-day work clock on the next scheduled work day.

The five work day 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 laboratories that are removed from Superpave Express Submittal Status.

CALCULATIONS

1. Marshall Volumes

The *MS-2 Manual** recommends that the correct size of a compacted four inch Marshall is 63.5 mm $\pm$ 1.27 mm. This is equivalent to a volume of 515 $\pm$ 8 cm^3. If the Marshall height or volume falls outside the limits, the amount of mixture used for the specimen may be adjusted using:

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

**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 $\pm$ 3 mm. If the gyratory sample height falls outside the limits, the amount of mixture used for the sample may be adjusted, using:

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

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

3. Mix Designs with Reclaimed Asphalt Pavement (RAP)

The Contractor/Consultant 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 *MDOT Standard Specifications for Construction*, or as modified herein.

Documented evidence of testing and accumulated tonnage in the stockpile (tonnage may be estimated) must be provided to MDOT Construction Field Services laboratory before a mix design will be processed.

When RAP is used in a mix design, in which the Angularity Index (NAA Method A) and Void in Mineral Aggregate (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:

$$\text{RAP Gsb} = (1.097 \times \text{RAP Gse}) - 0.32$$

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 GRADATION
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.

$$Virgin\ Aggregate\ Adjusted\ Percentage = \frac{(Mix\ Design\ Virgin\ Aggregate\ Percentage\ from\ Mix\ Design)}{(100 - RAP\ Percentage)} \times 100$$

$$\boldsymbol{Example}\ for\ 3/8 - 4\ Aggregate\ from\ Pit\ 41-117 = \frac{(18)}{(100-20)} \times 100 = 22.5\%$$

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. Mix Designs with Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS).

When RAS and RAP combine to contribute more than 17% by weight of asphalt binder in any HMA mixture, the asphalt binder grade will be determined by using a blending chart. The blending chart will determine the critical high, intermediate, and low temperature properties of the asphalt binder. The Contractor must supply the blending chart used in determining the asphalt binder selection according to AASHTO M 323. Sections X1.3. and X1.4. of AASHTO M 323 will be replaced with the following equation:

TBlend = TVirgin + (%RAP)x(TRAP-TVirgin) + (%RAS)x(TRAS-TVirgin)
Where:
TBlend = critical temperature of blended asphalt binder (high, intermediate, or low)
TVirgin = critical temperature of virgin asphalt binder (high, intermediate, or low)
%RAP = percentage of RAP expressed as a decimal
TRAP = critical temperature of recovered RAP binder (high, intermediate, or low)
%RAS = percentage of RAS expressed as a decimal
TRAS = critical temperature of recovered RAS binder (high, intermediate, or low)

5. Bulk Aggregate Specific Gravities

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

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

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 and 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%

Combined Virgin Fine and RAP Gsb:

56.6 × 0.15 = 8.5%

23-8.5 = 14.5%

8.5/.23 = 37%

14.5/0.23 = 63.0%

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

Combined Virgin Coarse and RAP Gsb:

43.4 × 0.15 = 6.5%

77-6.5 = 70.5%

6.5/.77 = 8.4%

70.5/0.77 = 91.6%

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

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

6. Tensile Strength Ratio (TSR) Samples

When submitting TSR data, the Contractor/Consultant need to submit a worksheet showing compacted bulk specific gravity calculations, theoretical maximum density (TMD) at optimum asphalt content, 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% air voids:

- A good starting point is around 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 was 7% air voids achieved? A quick check is to take this formula and keep trying different heights.

$$\frac{X}{Y} \times Original\ Gmb = \frac{95.0}{96.4} \times 2.375 = 2.340$$

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

Once the height of 7% air voids has been achieved the Contractor/Consultant can substitute the mass of the sample in for the G_{mb}.

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

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

Highlights of the TSR test (AASHTO DESIGNATION T 283)

- Preparation of the samples
    1. Mix mixture and cool at room temperature for two hours ± 0.5 hours.
    2. Place mixture in oven at 140°F (60°C) for 16 hours of curing.
    3. After curing, place mixture in oven at 275°F (135°C) for two hours prior to compaction.
    4. Compact mixture to 95 mm height.
- Conditioning of specimens
    1. Three specimens will be stored at room temperature until testing.
    2. 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.

3. The other three specimens will be vacuum saturated so that 55% to 80% of original air voids are filled with water.
4. If samples are less than 55% saturated, put back under vacuum until at least 55% is obtained.
5. If specimens are greater than 80% saturated, must discard specimens and compact new ones.
6. 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.
7. 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.
8. 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
    1. Remove from 77°F (25°C) water bath and place between two bearing plates.
    2. Apply load to specimens by means of constant rate movement, two inches (50 mm) per minute.
    3. Record maximum compressive strength.
- Calculations
    1. 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/Consultant 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[1]

Los Angeles (L.A.) Abrasion values are required on all new and existing aggregate sources. An L.A. 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%. An aggregate source with an L.A. Abrasion value lower than 35% is valid for five years; provided there are three L.A Abrasion Numbers 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 Number is required, contact your Region Materials Unit to obtain the sample for submission to the laboratory.

3. Aggregate Wear Index (AWI) Samples - BOH-IM 2003-01 and BOH-IM 2003-09 and MTM 112-04

The following procedure applies for each aggregate component in a blended Hot Mix Asphalt (HMA) Top or Leveling Course mixture with an AWI requirement that retains more than 5% 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 Sample Identification (Form 1923) and Contractor's Bituminous Mix Design Communication (Form 1820) completely filled out.

NOTE:

a) AWI will not be assigned to previously approved mix designs. MDOT will assign AWI for any design that can be used as a top course.
b) Individual Aggregate Wear Index (AWI) shall samples shall be provided for each aggregate requiring an AWI value. This should be submitted even if a nomograph exists for that aggregate unless directed otherwise by Aggregate Quality Control.

4. 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 Recycled Asphalt Pavement (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.

1 Information on L.A. Abrasion Number, AWI Number and Aggregate Nomograph can be found on the MDOT public website *http://mdotcf.state.mi.us/public/bitmix/*.

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

5. Aggregate Bulk Specific Gravities

Verification testing will be performed 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:

- Coarse bulk gravity on each individual aggregate that retains ≥25% on the No. 4 (4.75 mm) sieve.
- No. 8 bulk gravity on each individual aggregate that retains ≥25% on the No. 8 (2.36 mm) sieve.
- Fine bulk gravity on each individual aggregate that has ≥25 passing the No. 8 (2.36 mm) sieve.

There is a ± 0.028 tolerance on the combined bulk specific gravity.

A sample may be taken (requested by the Mix Design Unit) by MDOT during the project plant production of the mixture. The Bulk Specific Gravity will then be tested. If the Bulk Specific Gravity fails to meet the specification criteria, the Project Engineer will be contacted

6. Soft Particle Content

The Contractor/Consultant will conduct the testing to ensure that the soft particle content of the blended aggregate meets specifications. The Michigan Department of Transportation (MDOT) will conduct the 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.

7. 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 its discretion for verification to specification.

8. Nomograph[2]

If a nomograph exists for an aggregate which requires an Aggregate Wear Index (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

See Website for current list of contacts.

Nathan Maack 517-322-1184
- Submission of Marshall and Superpave Mix Designs

Eric Oudsema 517-322-5692
- Aggregate Bulk Gravity - TSR's
- Sand Equivalent Test
- Mixture Testing

Samara Bartz 517-322-5675
- Assigning Pit Numbers - AWI's
- Nomographs
- Existing Los Angeles Abrasion Numbers
- Status of Newly Submitted Los Angeles Abrasion Test results

Marc Beyer 517-749-9758
- Region Mix Inspectors (RMI)
- Plant Certification
- MDOT Form 1911

Adnan Iftikhar, P.E.
- MDOT HMA Lab and Technician Qualification Program 517-322-1228

SECTION 2: CERTIFICATION PROCEDURE OF HOT MIX ASPHALT (HMA) PLANTS

CERTIFICATION PROCEDURE

All HMA facilities must be certified prior to furnishing HMA to the Michigan Department of Transportation (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.

1. Notification

- Permanent plant location: The Contractor/Consultant 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.

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

2. Inspection

The RMI will notify the Project Engineer of the inspection arrangements. Either the Project Engineer or his/her representative may participate in the inspection. The inspection will encompass all components of the HMA facility. The Contractor/Consultant 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.

3. 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.

4. 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 Project Engineer receiving HMA mixture from the plant at the time of decertification will receive both verbal and written notification.

The Contractor/Consultant 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

1. 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/Consultant shall provide adequate and safe 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 Michigan Occupational Safety and Health Administration (MIOSHA) regulations at the time of certification. The placement, structure, and adequacy of the sampling platforms shall be approved by the Region Traveling Mix Inspector. HMA plants shall meet the requirements specified herein.

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

- 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 904-7 of the 2012 MDOT Standard Specifications for Construction. Thermometers shall be installed in such locations so as to accurately indicate the temperature of the asphaltic binder material at all times.

- 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 than the maximum aggregate size in the HMA mixture being produced.

- 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/Consultant 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.

- 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/Consultant 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.

- 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.

- Air Quality Permit: All HMA plants shall be covered by a Michigan Air Pollution control permit. For any portable HMA plant, the Contractor/Consultant 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/Consultant shall apply directly to the Wayne County Air Pollution Control Division instead of MDEQ.

- 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.

- 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.

- 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.

- 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.

- Scales: Scales for weighing HMA mixtures must meet requirements of Section 109.01B6 of the 2012 *MDOT Standard Specifications for Construction*.

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

  - 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.

  - 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.

  - 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.

2. Batch Plants

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

- 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.

- Batch Scales: The scales in batch plants shall meet the requirements specified herein:

  - 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:

    - 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 five (5) pounds (2.3 kg), except that the minimum graduated interval for the scale, which weighs the asphalt binder, shall not be greater than two (2) pounds (0.746 kg).

    - 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% of the nominal capacity of the scale.

  - Accuracy - The tolerance value for all plant scales shall be two (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 Project Engineer may direct, the Contractor/Consultant shall suspend operations and shall provide such devices and assistance as are required to enable the Project Engineer to check the accuracy of the scales.

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

- 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 (1) inch, either the blades or liner, or both, shall be replaced to reduce the clearance. Paddle blades reduced by wear in excess of 25% 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.

- 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.

- 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 work day in which the breakdown or

- malfunction occurs plus one additional work day, provided this method of operation will produce results meeting the specification requirements. If the Contractor/Consultant 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 Project Engineer is assured that the automatic proportioning and cycling controls operate properly.

- 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.

3. 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.

- 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 according to Section 109.01B6 of the 2012 MDOT Standard Specifications for Construction. 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.

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

- 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.

- 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.

- 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/Consultant prior to the start of the initial production of HMA mixture for the project and at other intervals as directed by the Project 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.

- Aggregate -The Contractor shall provide means for diverting and weighing the aggregate for a time period not to exceed five (5) minutes. The Contractor/Consultant 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.

- 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/Consultant 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 five 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.

- 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 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.

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

4. Combination/Specialized Plants

Will be inspected and certified on an individual basis based on modification or changes. This will be done with the Region Traveling Mix Inspector and Bituminous Field Office staff.

QUALITY CONTROL PLAN (QCP)

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

1. Project

- Company name, plant location, Michigan Department of Transportation (MDOT) plant number, plant phone and fax numbers, laboratory phone and fax numbers, office phone and fax numbers:
- Sampling plan, aggregate, binder, mixture, etc., will include location, method, frequencies:
- How the random number will be selected:
- When and how daily belt samples will be taken:
- Quality control of aggregate stockpiles including Recycled Asphalt Pavement (RAP) stockpiles:
- How daily moisture sampling will be done:
- Signatures and date, Contractor/Consultant and MDOT:

2. Personnel

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

3. Documentation

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

4. Quality Control

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

SECTION 3: HMA QC/QA PROCEDURES FOR FIELD TESTING

BITUMINOUS PRE-PRODUCTION MEETING ATTENDANCE FORM

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

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

- HMA addendums or changes
- Random number sheets signed by MDOT and Contractor/Consultant
- Signed certification statement submitted by Contractor/Consultant
- Plant location(s) and certification status
- Project HMA Mixtures
- Contractor Quality Control (QC)
    - Contractor QC Plan submitted
        - QC Plan Administrator contact info
        - Foreman contact info
    - Random sampling method
    - Mixture sampling and testing frequencies
    - Core sampling and testing frequencies
    - Tolerances
        - Action and Suspension limits (PWL)
        - Single Test and Running avg. of 5 (Marshall)
    - Documentation (1903C, Core Density, PWL Spreadsheet, Control Charts)
    - Distribution of test results
    - Timeframes
    - Binder samples
- MDOT Quality Assurance (QA)
    - MDOT QA Plan submitted
        - QA Plan Administrator contact info
        - MDOT Lead inspector contact info
    - Documentation (1903B, 1907, PWL Spreadsheet)
    - Distribution of test results
    - Timeframes
    - Four cores per sublot (marked after final rolling)
    - Core location based on longitudinal and transverse measurements
    - MDOT must witness coring and take immediate possession of cores
    - Damaged cores
    - Core thickness
    - No cores in driveways, hand patching or sampling area’s

  - If center of core is less than five inches from pavement edge, use next transverse random number.
  - Free standing water to be removed from core hole. Core hole must be tacked prior to filling.
  - As cores are taken, holes filled in with HMA and compacted by the Contractor/Consultant.
  - Core outlier
- Binder Content Procedure
  - Ignition
    - Correction Factor Samples
  - Vacuum Extraction
    - Document number of washes
- Initial Production Lot
  - Mixture sampling (QA splits, Dispute Resolution, QC)
  - Cores (QC, QA)
  - Testing timeframes and tolerances
  - Requirements for moving into full production
- Alternate Acceptance Methods
  - Mixtures with small tonnages
  - Hand Patching material
  - Sublot sizes
  - Density
  - Visual Inspection (VI) limits
- Mixture Sampling
  - Qualified samplers (MDOT and Contractor/Consultant)
  - Mixture sampling methods
    - Plates and shovel
    - Shovel only
    - Mini-stockpile
  - Sample area documentation
    - 10’ max sample area (per sample)
    - No cores within 5’ before through 5’ after sample areas
  - Sample Identification
    - QA / Dispute Resolution (D.R.)
    - Initial Production Lots (IPL’s)
    - Full production

- Suspension of Production
    - Sublot RQL or Suspension limits are exceeded
    - Lot PWL below 50% (QC, QA)
    - Visible pavement distress
    - QC plan not followed
- JMF Changes
- Dispute Resolution
    - Timeframes
    - Requests submitted in writing
    - Signed certification that test results are true and accurate
    - Independent Random QC samples (IPL’s / mixture / cores)
    - QC conducted in the same manner as QA
    - QC pay factor higher than QA pay factor
    - Dispute Resolution test results replace the original QA test results
    - Testing Costs
- Construction Items
    - Traffic Control
    - Flagging
    - Milling
    - Bond Coat
    - Paving
    - Rolling
    - Start date for production

LABORATORY 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 Laboratory Correlation Procedure shall consist of both the paired-t test and the mean difference tolerance. The Quality Assurance and Quality Control (QA/QC) 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 laboratory 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 and 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 Laboratory 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)				
				$X_{d\ Mean}$	***0.38***	Degree of Freedom	3
1	5.51	5.01	0.50	S_d	0.25	Prob. α	**1%**
2	5.52	5.02	0.50	t_{pair}	**3.07**	$t_{critical}$	5.84
3	5.53	5.03	0.50	**Split Sample Results:**		**Correlates**	
4	5.05	5.04	0.01				

G_{mm}

Split Sample Number	Contractor	Agency	Difference (Xd)				
				$X_{d\ Mean}$	**0.025**	Degree of Freedom	3
1	2.546	2.600	0.054	S_d	0.029	Prob. α	**1%**
2	2.456	2.500	0.044	t_{pair}	**1.71**	$t_{critical}$	5.841
3	2.400	2.400	0.000	**Split Sample Results:**		**Do not Correlate**	
4	2.300	2.300	0.000				

G_{mb}

Split Sample Number	Contractor	Agency	Difference (Xd)				
				$X_{d\ Mean}$	***0.009***	Degree of Freedom	3
1	2.399	2.407	0.008	S_d	0.003	Prob. α	**1%**
2	2.398	2.404	0.006	t_{pair}	**5.56**	$t_{critical}$	5.841
3	2.414	2.424	0.010	**Split Sample Results:**		**Correlates**	
4	2.402	2.416	0.014				

V_a

Split Sample Number	Contractor	Agency	Difference (Xd)				
				$X_{d\ Mean}$	***0.34***	Degree of Freedom	3
1	4.37	4.14	0.230	S_d	0.09	Prob. α	**1%**
2	4.49	4.18	0.310	t_{pair}	**7.51**	$t_{critical}$	5.84
3	3.96	3.58	0.380	**Split Sample Results:**		**Do not Correlate**	
4	4.26	3.82	0.440				

VMA

Split Sample Number	Contractor	Agency	Difference (Xd)				
				$X_{d\ Mean}$	***0.35***	Degree of Freedom	3
1	15.94	15.56	0.380	S_d	0.12	Prob. α	**1%**
2	15.78	15.60	0.180	t_{pair}	**6.03**	$t_{critical}$	5.84
3	15.19	14.77	0.420	**Split Sample Results:**		**Do not Correlate**	
4	15.82	15.39	0.430				

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/Consultant can make changes to the process controls of the HMA plant without requesting an adjustment.

Use the following procedure when a Contractor/Consultant 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, the Contractor/Consultant cannot submit a subsequent Form 1911 change until the effects on production of the initial change are established.

The Contractor/Consultant 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 Traveling Mix Inspector. Should the Project Engineer approve the requested change to Form 1911, the Contractor/Consultant'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 Region Traveling Mix Inspector. 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:

- The Contractor/Consultant may propose a change to the existing JMF based on Quality Control (QC) and/or Quality Assurance (QA) test results.

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

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

- When the aggregate blend proportions are changed by 10% 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.

- For changes greater than 10%, production must stop and the Contractor/Consultant must re-determine the Gsb for the mixture and submit it to the Region Traveling Mix Inspector. MDOT Region Materials personnel will take a sample from the aggregate belt and perform verification testing on the Gsb. If MDOT's sample result verifies the Contractor/Consultant's Gsb within + or – 0.028, the Contractor/Consultant's Gsb will be accepted for the new Form 1911 and production will resume. If MDOT's sample result does not verify the Contractor/Consultant'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% total change from the blend percentages listed on the original mix design. For example, remove 10% of aggregate #1 + add 10% of aggregate #2 = 20% total.

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

- 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.

- Adjustments to the effective specific gravity of aggregate (Gse) will require a new mix design. However, if there has been an approved Gsb change, a new Gse is calculated without requiring a new mix design.

HMA LOOSE MIXTURE SAMPLING METHOD

For mainline paving, loose mixture sampling will be in accordance with either MTM 324 "Sampling Behind the Paver" or MTM 313 "Sampling HMA Loose Mix from Mini-stockpile". The method will be mutually agreed upon at the Pre-Production Meeting and documented in the HMA QC Plan. For all other types of paving, loose mixture sampling will be in accordance with MTM 313 "Sampling HMA Loose Mix from Mini-stockpile".

HMA SAMPLE REDUCTION PROCEDURE

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.
4 Divide the flattened pile into eight, approximately equal, pie-shaped segments.
5 Scrape any fines clinging to the tools and equally distribute them back into eighths.
6 Test samples must be obtained from two opposite diagonals (including fines). Each opposite diagonal must be approximately one eighth up to a maximum of one quarter of the flattened pile to ensure proper sample size. In all cases, use full length of segment.
7 Opposite eighths shall be combined to equal one Gmb specimen (See Figure 1). The Gmb sample shall be placed into oven immediately.
8 Without being returned to the oven, opposite eighths shall be combined for the Gmm sample and placed on smooth, non-porous surface to cool.
9 Opposite eights shall be combined for the HMA mixture analysis sample. The HMA mixture analysis sample shall be placed into oven to achieve a constant weight.
10 Retain excess material until testing is complete.

Examples of proper test sample selections

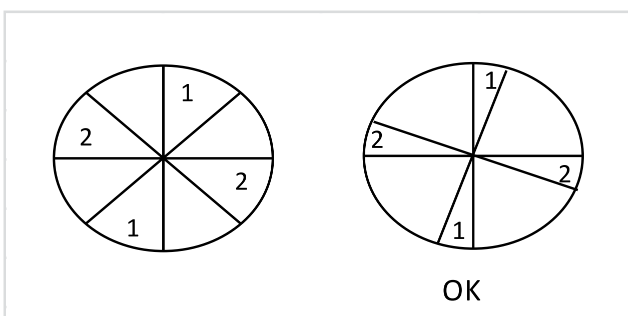

Figure 1: Opposite Eighth's

CHECKLIST FOR THEORECTICAL MAXIMUM DENSITY (TMD) DETERMINATION

1. Checklist for Calibration of Pycnometer

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

NOTE:

- All pycnometer weights required for this procedure ***do not*** include a pycnometer lid.
- The pycnometer calibration should be verified a minimum of once per week.
- 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							

2. Checklist for Theoretical Maximum Density (TMD) Determination

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)
3/8” (9.5mm)	1500
3/4" (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 or non-porous surface 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 min± 30 seconds (must be measured with a separate lab timer) 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

1. Checklist for Gyratory Compactor

PROCEDURE REFERENCE DOCUMENT: ASTM- D6925

The desired height of the gyratory specimen is 115mm ± 3mm. Approximately 4900 ± grams. Place gyratory molds in oven set at compaction temperature identified on the JMF, Form 1911.

1. Place the two quartered samples into separate mold loading devices (see Figure 4) and place into oven to bring samples to compaction temperature as stated on JMF. It is required 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.
2. Oven temperature shall be set at an upper limit of mixing temperature range for an individual mix.

   NOTE: Perform steps 4 thru 6 as expeditiously as possible; this will eliminate any need to re-verify temperature.
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. 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.
5. 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.
6. Start the gyratory compactor.
7. 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 will 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.
8. Allow samples to reach ambient temperature. Then carefully clean top and bottom of all loose particles and label samples. .
9. Gmb specimen's must be at 77°F ± 1.8°F (25°C ±1°C) before testing. Place the first Gmb specimen on top of the scale. Read and record the dry weight of the specimen on a gyro Gmb worksheet.
10. Repeat step 10 for the remaining Gmb specimens. Tare the scale and place the Gmb specimen in the suspended weighing basket under this scale. Allow the scale to settle. Read and record the weight of the specimen in water.
11. The specimen should be kept upright throughout all weighing positions. Submerge the Gmb 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 by gentle agitation. (Water bath should be maintained at 77°F ± 1.8°F (25°C ±1°C)

12. Remove the specimen from the bath and place on a damp[2] towel/terry cloth and quickly blot all surfaces to obtain a saturated surface dry condition.

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

14. Repeat steps 12 through 14 for the remaining two specimens.

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

16. Average the Gmb values.

17. Complete the calculation.

Figure 4: Mold Loading Devi

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

2 Definition of "damp" is to saturate completely and then wring out to the extent that no more water can be wrung from the terry cloth towel. Prior to first Gmb sample, and every fourth specimen thereafter, the terry cloth towel shall be saturated and wrung out. Care shall be taken not to use a towel that is worn out.

EXTRACTION PROCEDURES

1. Checklist for HMA Mixture Analysis Vacuum Extraction

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. 9-12 inch diameter (No. 8 or No.16) sieve shall be used as guard sieve.

7 The HMA mixture analysis sample shall be heated and dried to a constant weight. The sample is allowed to cool to ambient temperature, and then carefully weighed to closest 0.1 gram and weight recorded on worksheet (see Note B). Minimum size of sample to be used are shown in Table 1 of AASHTO T164-01 and also shown below for reference.

Table 1 – Size of Sample

Nominal Maximum 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 If the sample weight exceeds 2000 grams, it shall be split into two extractions. The weights from both extractions shall be combined before calculating percentages.

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

10 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.

11 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.

12 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.

13 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.

14 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.

15 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).

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

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

18 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.

19 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. 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.

20 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.

21 Weight is recorded on worksheet.

22 Sample is placed in a set of sieves and shaken for the calibrated time amount.

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

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

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

26 Crushed particles are weighed and weight recorded.

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

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

29 Equipment is cleaned and put back in organized manner.

<<<< **NOTES 1** >>>>

- Weights retained, when totaled, should be equal to the weight of dry extracted aggregate.
- Fraction retained should total 100 %.
- 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 aggregate of HMA column.
- Percent of crushed particles should be noted on work sheet.
- Dispose asphalt/solvent mixture and water/solvent mixture as directed by the Region Traveling Mix Inspector (RMI) or by the Consultant/Contractor.

30 Complete all computations on worksheet.

<<<< **NOTES 2** >>>>

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

2. Checklist for Ignition Furnace

2.1 Procedure

PROCEDURE REFERENCE DOCUMENT:

MTM 319-12 - Determination of Asphalt Content from Asphalt Paving Mixtures by the Ignition Method. Newest MTM should be used.

All aspects of the test procedure will be covered by the latest version of the AASHTO T-308: Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method except as modified below:

3.2 There will be no correction for moisture.

4.1 Aggregate obtained by this test method may be used for gradation analysis according to ASTM D 5444 and Crushed particle content according to MTM 117.

6.1 Obtain QC and QA Samples in accordance with MTM 324 or MTM 313 (Sampling HMA Loose Mix from Mini-stockpile).

6.2 Quarter in accordance with HMA Sample Reduction procedure as outline in the HMA Production Manual.

6.4 The size of the test specimen shall be governed by the nominal-maximum aggregate size of the specified HMA Superpave mixture and shall conform to the mass requirement shown in Table 1.

A1.1 Change the 5 percent to 10 percent. Changes in RAP percentage greater than 10 percent and new mix design also require a new correction factor.

A1.1 Change the 5 percent to 10 percent. Any changes greater than 10 percent in stockpiled aggregate proportions shall require a new correction factor.

A2.1 Add Note A. Include other additives that may be required by the JMF.

2.2 Contractor's Responsibilities for the Establishment of Ignition Oven Correction Factors

When the Contractor choose Method 1 for determining "Composition of the Mixture" in accordance with Frequently Used Special Provision 12SP501(U) or 12SP501(V) the following will be the procedure for the establishment of the correction factor.

2.2.1 The Contractor will provide the Engineer with the QC oven correction factor at the pre-production meeting or 14 calendar days prior to production, whichever is longer. The correction factor will be determined in accordance with MTM 319. The contractor will need to submit FHWA Form 1648 (Rev. 01-11), found at: http://www.cflhd.gov/resources/materials/documents/1648_v4.pdf with the submittal of any correction factor.

2.2.2 The Contractor will provide enough sample material in order for MDOT to meet the requirements of MTM 319 in determining a correction factor for one Region QA Acceptance and Acceptance Laboratory oven and one Central Dispute Resolution Laboratory oven. This will include eight samples for each correction factor determination per mix design; four samples for QA Acceptance and four samples for Dispute Resolution and one blank sample (aggregate only) batched at the JMF for the corresponding correction factor. These eight mix samples and one blank sample constitute a Correction Factor Sample. These samples must be submitted in either plastic cylinder molds or cardboard release boxes. In those instances where additional samples may be required to meet the requirements of A2.8 and A2.8.1 of AASTHO 308, the contractor will supply additional samples. Initial samples will be provided to the Engineer 14 calendar days prior to HMA production. Samples shall be delivered in clean/new 6 inch concrete cylinder molds. The Region QA Acceptance Laboratory will determine the correction factors within seven calendar days.

2.2.3 When new correction factor samples are required for JMF changes or changes in gradation as required by MTM 319 the Contractor will provide the samples to the Engineer at the time of request for the JMF change or new mix design. The Engineer will determine the new correction factors within three work days of the Region QA Acceptance Laboratory receiving the samples.

2.2.4 As noted in AASHTO 308-10, "Correction factors must be determined before any acceptance testing is performed".

2.2.5 The QA Acceptance Laboratory, QC Laboratory, and the Central Dispute Resolution Laboratory will note the specific Ignition Oven used in determining the correction factor and will use the same noted oven for all testing of QA, QC and Dispute Resolution samples for the corresponding mix.

2.2.6 Correction factors are Ignition Oven specific. The same mix design being tested by a different oven or laboratory will require another correction factor per items one and two above.

2.2.7 If the Region QA Acceptance Laboratory has operational needs to test using a different ignition oven the Contractor must provide additional correction factor samples or the Contractor may select to have testing changed to Method 2 for determining AC content.

FLH Addendum to AASHTO 308 - Standard Method of Test for Correction Factors for Hot Mix Asphalt (HMA) Containing Recycled Asphalt Pavement (RAP) by the Ignition Method can be located online at the following link:

http://www.cflhd.gov/resources/materials/documents/FLH_Addendum_T308.pdf

A copy of the AASHTO T308 procedure can be purchased online at the following link:

https://bookstore.transportation.org/

2.3 Calibration of Balance

The furnace balance will be calibrated every 12 months or when the equipment is moved or when test results cast doubt on the working of the balance. The calibration could either be done through in-house procedure or by using an outsourced qualified vendor.

The furnace balance will be calibrated every 12 months or when the equipment is moved or when test results cast doubt on the working of the balance. The calibration could either be done through in-house procedure or by using an outsourced qualified vendor.

A. In-house Procedure

A.1 Switch the power switch to “OFF”.

A.2 Allow furnace to cool down to room temperature. Open the furnace door. NOTE: Furnace door should remain open during the balance calibration.

A.3 Remove and clean any debris from the load plate/s and load supports. Replace after cleaning.

A.4 Using the instructions provided in the equipment manufacturer’s operator’s manual, calibrate the balance by placing a known weight on the load plate. The weight is usually specified in the user’s manual. If weight is not specified in the user’s manual, then use 8000 grams. NOTE: The weight used in calibration must be traceable to NIST.

B. Calibration by Vendor

An outsourced qualified vendor will be used for the calibration.

2.4 Lift Test

IMPORTANT: Equipment setup should be performed using Manufacturers’ recommendations.

Lift test will be performed a minimum of every 6 months or when the equipment is moved or when there is doubt regarding the efficiency of the blower. The efficiency of the blower and/or exhaust system is indirectly monitored by the lift test as mentioned in sections 2.1 through 2.4 below.

2.4.1 Fully assemble tester with exhaust system attached, hearth tray is mounted on the four support tubes, and at room temperature with no load. Furnace chamber should be at room temperature.

2.4.2 Depress power switch to the “on” position. Depress “0” key to tare balance display.

2.4.3 Push program “start button”. Blower will turn “on”. Observe balance display reading. Display should read -3.2 to -8.2 grams. Detach the exhaust system and repeat the test to determine if the exhaust system is restricting the tester air exchange, if the initial test is out of spec or is borderline spec on the -3.5 grams low side.

2.4.4 If the lift test indicates a decline in the blower efficiency, perform the following:

2.4.4.1 Cleaning and oiling motor: Expose the motor by detaching the exhaust duct, removing the top cover and fume hood. Place high temperature lubricant (included in the accessory kit) into the small oil ports located on the blower motor.

2.2.4.2 Check for excessive air leakage around the door insulation: Adjust the door fit and/or replace door insulation. Door fit adjustment is performed by loosening the top and bottom hinge screws, adjusting the door, and refastening the screws.

2.4.4.2 Door lock adjustment may also be required to ensure proper door seal. The latch hook on the door, hooks the latch pin in the closed position. The latch pin is adjustable. The two Phillips screws located above the latch pin port tighten the doors fit when turned counter clockwise. One screw should be turned a half turn followed by turning the second screw a half turn. This adjustment procedure will ensure proper latch pin position and prevent binding.

2.5 Temperature Verification inside the Ignition Furnace (In-House Procedure)

The ignition furnace chamber temperature will be calibrated, at a minimum, every 12 months or when the equipment is moved or when test results cast doubt on the accuracy of the furnace chamber temperature readouts.

Equipment Needed: Digital thermometer (thermocouple) with Penetration Probe calibrated up to 1000°F and readable to 0.1 degree, and traceable to NIST. The temperature verification kit (TM-9999) as illustrated in the link below could be used for this purpose.

http://www.hmalabsupply.com

2.5.1 Penetrate sensor through the covered stainless steel tube located at the rear of the furnace and extend the probe into the chamber.

2.5.2 Make sure that the probe insertion is at the same depth as that of the chamber control thermocouple.

2.5.3 Set furnace chamber and filter temperature at 500°C and allow furnace to stabilize at set point in the idle mode. Once stabilized, wait for one hour and note the temperatures on both the furnace and the digital thermometer.

2.5.4 Using the procedure provided in the equipment manufacturer's operator's manual set the furnace temperature to read the same temperature as the digital thermometer.

2.5.5 When using a thermocouple to verify the temperature in an Ignition Furnace, it is necessary to change the filter element temperature, regularly set at 750°C DOWN to 500°C, as well as changing the chamber temperature to 500°C, prior to checking the chamber temperature, and allow at least one hour for the temperatures to equalize before reading. Failure to do so will lead to inaccurate temperatures.

2.6 Maintenance

Always allow the furnace to cool to room temperature before performing any maintenance, servicing or calibration. Also, disconnect the furnace before performing any maintenance, servicing or calibration.

The refractory plates may develop hairline cracks. This does not necessitate element plate replacement if the mechanical strength is not compromised.

2.6.1 Periodically, fire the chamber at 650°C for two hours in the idle. Allow to cool down to room temperature. Clean the element plates and vacuum chamber as needed.

2.6.2 Periodically check that the locking mechanism of the furnace door is functioning.

2.6.3 Service the blower motor every six months or whenever the blower efficiency is low (see **Section 2.4 Lift Test** above).

2.6.4 Check door insulation every six months or whenever the blower efficiency is low (see S**ection 2.4 Lift Test** above).

2.6.5 The basket assembly shall be kept clean to increase accuracy of results. Clean basket assembly thoroughly after each sample. A wire brush works best.

2.7 Quality System Manual

2.7.1 All calibration, maintenance and repair records shall be housed in the laboratory's quality system manual.

2.7.2 If the ignition furnace cannot be calibrated, then it will be taken out of service and the affected component/s either repaired or replaced, before bringing the furnace back into service.

2.7.3 All measurement standards (formerly referred to as reference standards) used during in-house calibration procedures for the ignition furnace (thermometer and weight/s) must be listed in the lab's quality system manual. They will be calibrated on regular basis to maintain traceability to NIST.

3. Checklist for Sieve Analysis

PROCEDURE REFERENCE DOCUMENT:

Newest MTM should be used.

Refer to these test methods and procedures.

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

1. Sample is placed on burner to dry. 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.
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 dried 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. Make sure maximum weight retained per sieve meets ASTM C136 Paragraph8.3. 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 VOLUMETRIC PROPERTIES OF HMA

1. Air Voids, Va

$$Va = 100 \times \left(\frac{Gmm - Gmb}{Gmm} \right)$$

Where:

Va = Percent Air Voids in Asphalt Mixture

Gmb = Bulk Specific Gravity of Compacted Mixture

Gmm = Maximum Theoretical Specific Gravity of Mixture

2. Voids Filled with Asphalt, VFA

$$VFA = 100 \times \left(\frac{VMA - Va}{VMA} \right)$$

Where:

VFA = Voids Filled with Asphalt

VMA = Voids in Mineral Aggregate, Percent of Bulk

3. Voids in the Mineral Aggregate (GSB), VMA

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

Where:

VMA = Voids in the Mineral Aggregate (%)

Gmb = Bulk Specific Gravity of Compacted Mixture

Pb = Asphalt Content (%)

Gsb = Bulk Specific Gravity of Total Aggregate (MDOT Form 1911)

4. Asphalt Absorption, Pba

$$\mathrm{Pba} = 100 \times \left(\frac{\mathrm{Gse} - \mathrm{Gsb}}{\mathrm{Gsb} \times \mathrm{Gse}}\right) \times \mathrm{Gb}$$

Where;

Pba	=	absorbed asphalt, percent by weight of aggregate
Gse	=	effective specific gravity of aggregate
Gsb	=	bulk specific gravity of aggregate
Gb	=	specific gravity of asphalt

5. Fines to Asphalt Ratio, F/A

$$\mathrm{F}/\mathrm{A} = \mathrm{P\#200} \div \left(\frac{1}{\mathrm{Pb} - \left(\frac{\mathrm{Pba} \times (100 - \mathrm{Pb})}{100}\right)}\right)$$

Where;

F/A	=	Fines to Asphalt Ratio
P#200	=	Weight of Material Retained on #200 sieve
Pb	=	Asphalt Content, %
Pba	=	absorbed asphalt, percent by weight of aggregate

PROCEDURE FOR DETERMINING PAVEMENT DENSITY

1. Checklist for Determining Pavement Density (Cores)

1. Check for proper preparation of cores for testing.

   - Identification
     - Mixture type (i.e. wearing, base, etc.)
     - Lot No., Sublot No.
     - Core No.
   - Condition
     - Bottom surface must be sawed.
     - Proper handling and storage of core samples is critical for accurate density results. The Contractor responsibility is carefully cutting the core and handing over to the owner/Agency. The owner/Agency must follow the core handling procedure.
     - Any loose material should be removed from core samples before weighing.

Dry specimens to constant weight using one of the following methods:

A. Dry Back Method:

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). Cores specimens shall be at 77 F +- 1.8 F before weights are taken.

3. Place core in bath for a three to five minutes time period. Make sure to remove all air bubbles from outside of specimens by gentle agitation.

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[3] 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.

3 Definition of "damp" is to saturate completely and then wring out to the extent that no more water can be wrung from the terry cloth towel. Prior to first specimen, and every fourth specimen thereafter, the terry cloth towel shall be saturated and wrung out. Care shall be taken not to use a towel that is worn out.

9. Remove the core from the oven and allow cooling 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.

B. <u>Core Dry Method:</u>

Refer to ASTM D7227-06 for the core dry method.

ROUNDING METHOD

1. *Rounding Method; Per ASTM E29-08* - for HMA Mixture Testing

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

Rounding Method of ASTM E29-08 Sections 4.1.3, 6.4 and 6.5 shall apply. The procedure is restated below.

1.1When 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

1.2 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

1.3 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

1.4 When the figure next beyond the last place to be retained is 5 and there are non-zero digits beyond this 5; increase by one the figure in the last place retained.

EXAMPLES:	Actual	Rounded to tenths	Rounded to hundreds	Rounded to thousands
	93.3365001			93.337
	93.3365005			93.337
	93.3365009			93.337
	93.3375001			93.338
	93.3375005			93.338
	93.3375009			93.338

a. 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 rounding.

b. Most Precise Value Available:

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

NOTE 1: 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 2: 3.5549 rounded to the nearest 0.01 is 3.55; do NOT round first to 3.555 and then to 3.56.

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 starting the reheating procedure. Note cooling under fan for one hour is not sufficient. 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 for extended periods (maximum of three hours total oven time). Splitting of the sample should take place between one and two hours of oven time. The sample to be used for determining Theoretical Maximum Density shall be processed immediately after splitting 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.
   - Date core taken.
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. <u>When cores are received at the testing site, they shall be checked for identification, proper paperwork and that they are not damaged.</u>
9. Contractor may provide his own core transport/storage device.
10. If no core transport/storage device is provided, the core transporting procedures will be agreed upon at the pre-production meeting.

SECTION 4: HMA LABORATORY and TECHNICIAN QUALIFICATION PROGRAM

Refer to Section 5.03.01 of the *MDOT Materials Quality Assurance Procedures Manual (MDOT MQAPM).*

APPENDIX

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