Iowa Department of Transportation

DEVELOPMENTAL SPECIFICATIONS
FOR
ASPHALT CONCRETE MIXTURES

Effective Date
May 18, 2010

THE STANDARD SPECIFICATIONS, SERIES 2009, ARE AMENDED BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE DEVELOPMENTAL SPECIFICATIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

Replace all of Section 2303 of the Standard Specifications with the language below.

2303.01 DESCRIPTION.

A. Design, produce, place, and compact HMA mixtures. Use proper quality control practices for the construction of surface, intermediate, or base course on a prepared subbase, base, or pavement to the dimensions specified in the contract documents.

B. A surface course is the upper lift for a wearing surface of a designated thickness. An intermediate course is the next lower lift or lifts of a designated thickness. Use intermediate course mixtures for leveling, strengthening, and wedge courses. A base course is the lift or lifts placed on a prepared subgrade or subbase.

2303.02 MATERIALS.
Use materials meeting the following requirements:

A. Asphalt Binder.
The Performance Graded asphalt binder, PG XX -XX, will be specified in the contract documents to meet the climate, traffic, and pavement conditions. Use asphalt binder meeting the requirements of Section 4137. Unless otherwise specified in the contract documents, use a PG 58-28 for shoulder mixtures.

B. Aggregates.

1. Individual Aggregates.
a. Use virgin mineral aggregate as specified in Materials I.M. 510 and meeting the requirements of Section 4127.
b. When frictional classification of the coarse aggregate is required, the contract documents will specify the friction level and location. Furnish friction aggregate from sources identified in Materials I.M. T203.
1) Friction Classification L-2.
Use a combined aggregate such that:
- At least 80% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate, and
- At least 25% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 2 or better friction aggregate.

2) Friction Classification L-3.
Use a combined aggregate such that:
- At least 80% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate, and

- At least 45% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 3 or better friction aggregate, or if Type 2 is used in place of Type 3, at least 25% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 2.

3) Friction Classification L-4.
Use a combined aggregate such that at least 50% of the combined aggregate retained on the No. 4 (4.75 mm) sieve is Type 4 or better friction aggregate.

2. Blended Aggregates.

a. Use a blended aggregate meeting the combined aggregate requirements in Materials I.M. 510.

b. When mixtures include RAP, use a blended mineral aggregate gradation consisting of a mixture of RAP aggregate combined with virgin aggregate.

C. Recycled Asphalt Pavement.

1. RAP is salvaged asphalt pavement. Use RAP from a source designated in the contract documents, or furnish Classified RAP, Certified RAP, or Unclassified RAP from the Contractor's stockpile. The designations Classified, Certified, and Unclassified are exclusively for the use of RAP in HMA.

2. Identify each RAP stockpile and document Classified and Certified RAP stockpiles as directed in Materials I.M. 505. Include the following information when documenting Classified RAP material in a stockpile for future use in HMA:

- Identification of the project from which the material was removed,
- Mix data from the original project including mixture type,
- Aggregate classification,
- Location and depth in the pavement structure,
- Extracted gradation information, if available, and
- Description of stockpile location and quantity.

Do not add material to a Classified or Certified RAP stockpile without the approval of the District Materials Engineer.

3. The Engineer may reject a RAP stockpile for non-uniformity based on visual inspection. Work the stockpiles in such a manner that the materials removed are representative of a cross section of the pile.

4. Place stockpiles of RAP on a base sufficient to prevent contamination, as directed in Materials I.M. 505. Do not use RAP stockpiles containing concrete chunks, grass, dirt, wood, metal, coal tar, or other foreign or environmentally restricted materials. RAP stockpiles may include PCC (not to exceed 10% of the stockpile) from patches or composite pavement that was milled as part of the asphalt pavement. Track equipment may operate on the stockpile during its construction.

5. When RAP is taken from a project, or is furnished by the Contracting Authority, the contract documents will indicate quantity of RAP expected to be available and test information, if known. Salvage this material. Unless otherwise specified in the contract documents, RAP not used in HMA becomes the property of the Contractor.

6. For HMA mixture design purposes, the Contracting Authority will test samples of the RAP. The aggregate gradation and amount of asphalt binder in the RAP will be based on the Contract Authority's extraction tests. When the amount of recycled binder exceeds 20% of the total asphalt binder, change the asphalt binder grade as directed in Materials I.M. 510. No adjustments to the contract price for required changes to the asphalt binder grade.

a. Classified RAP.

1) Classified RAP is from a documented source with the aggregate meeting the appropriate quality requirements in Materials I.M. 510, and properly stockpiled.

2) Classified RAP may be used in the base, intermediate, and surface mixtures for which the RAP aggregate qualifies. Classified RAP may be used in accordance

with Table 2303.02-1.

3) Credit for the +4 proportion of frictional aggregate may be given for virgin aggregates used in the original pavement to be reclaimed. Types 4 and 5 frictional aggregate content in the RAP may be given full credit, while Types 2 and 3 content may be given credit for half the proportion in the original pavement. Credit may be used toward the total frictional aggregate requirement. No frictional credit shall be given beyond one generation of the RAP's service life.

b. Certified RAP.

Any stockpiled RAP not meeting the requirements of Classified RAP or from an unknown source may be given a Certified status when meeting quality control sampling, testing, and reporting requirements in Materials I.M. 505. Certified RAP may be used in accordance with Table 2303.02-1.

c. Unclassified RAP.

1) Any stockpiled RAP not meeting the requirements of Classified RAP or Certified RAP shall be designated as Unclassified RAP. Unclassified RAP may be used in accordance with Table 2303.02-1. No frictional aggregate credit or aggregate crushed particles credit will be given for Unclassified RAP.

2) When an Unclassified RAP stockpile is characterized by sampling and testing for mix design, no material can be added to the stockpile until the project is completed.

Table 2303.02-1: Allowable RAP Usage

Mix Designation	Aggregate Quality Type	Maximum Allowable Usage[2]		
		Unclassified RAP	Certified RAP	Classified RAP
HMA 100K S	B	0%	10%	15% (min. 70% virgin binder)[1]
HMA 100K I	B	10%	20%	No Limit
HMA 100K B	B	10%	20%	No Limit
HMA 300K S	B	0%	10%	15% (min. 70% virgin binder)[1]
HMA 300K I	B	10%	20%	No Limit
HMA 300K B	B	10%	20%	No Limit
HMA 1M S L-4	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 1M S	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 1M I	B	10%	20%	No Limit
HMA 1M B	B	10%	20%	No Limit
HMA 1M B (shoulder)	B	10%	20%	No Limit
HMA 3M S L-4	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 3M S L-3	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 3M S	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 3M I	A	0%	0%	No Limit
HMA 3M B	B	10%	20%	No Limit
HMA 10M S L-3	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 10M I	A	0%	0%	No Limit
HMA 10M B	B	10%	20%	No Limit
HMA 30M S L-3	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 30M S L-2	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 30M I	A	0%	0%	No Limit
HMA 30M B	B	10%	20%	No Limit
HMA 100M S L-2	A	0%	0%	15% (min. 70% virgin binder)[1]
HMA 100M I	A	0%	0%	No Limit
HMA 100M B	B	10%	20%	No Limit

Note:

1. More than 15% of Classified RAP may be used in the surface course when there is quality control sampling, testing, and reporting of the RAP meeting the requirements in Materials I.M. 505. At least 70% of the total asphalt binder in the surface mix shall be virgin.
2. Maximum percentages shown are not to be combined.

D. Hot Mix Asphalt Mixture.

1. The job mix formula (JMF) is the percentage of each material, including the asphalt binder, to be used in the HMA mixture. Ensure the JMF gradation is within the control points specified for the particular mixture designated. Use the JMF to establish a single percentage of aggregate passing each required sieve size.

2. The basic asphalt binder content is the historical, nominal mixture asphalt binder content, expressed as percent by weight (mass) of the asphalt binder in the total mixture. Apply the values in Table ~~2303.03-1~~ 2303.02-2 based on mixture size and type.

3. If the asphalt binder demand for the combination of aggregates submitted for an acceptable mix design exceeds the basic asphalt binder content (see ~~Table 2302.02-1~~ 2303.02-2) by more than 0.75%, include an economic evaluation with the mix design. Base this evaluation on past job mix history, possible aggregate proportion changes, and aggregate availability and haul costs for any changes or substitutions considered.

Table 2303.02-2: Basic Asphalt Binder Content (%)

Size	Aggregate Type	1 inch (25 mm)	3/4 inch (19 mm)	1/2 inch (12.5 mm)	3/8 inch (9.5 mm)
Intermediate and Surface	Type A	4.75	5.50	6.00	6.00
Intermediate and Surface	Type B	5.25	5.75	6.00	6.25
Base	Type B	5.25	6.00	6.00	6.25

4. Use an HMA mixture design meeting gyratory design and mixture criteria corresponding to the design level specified in the contract documents. The Engineer may approve the substitution of any mixture which meets requirements for a higher ~~mixture~~ design level than specified in the contract documents, at no additional cost to the Contracting Authority.

5. Use a 1,000,000 ESAL HMA base mixture for shoulders placed as a separate operation. For outside shoulders on Interstate projects, the Contractor has the option to substitute the mainline intermediate or surface mixture for a specified base mixture, at the Contractor's expense.

6. Prepare gyratory HMA mixture designs for base, intermediate, and surface mixtures. Follow the procedure outlined in Materials I.M. 510. Submit a mixture design complying with Materials I.M. 510.

7. Use a gyratory compacter for design and field control meeting the AASHTO protocol for Superpave gyratory compactors. Compactors for which compliance with this protocol is pending may be used at the discretion of the District Materials Engineer.

E. Other Materials.

1. Tack Coat.
Tack coat may be SS-1, SS-1H, CSS-1, or CSS-1H. Do not mix CSS and SS grades. RC-70 and MC-70 may also be used after October 1, at the Contractor's option.

2. Anti-strip Agent.

a. On Interstate and Primary highways designed for 30,000,000 ESALs and higher, perform ~~an AASHTO T 283~~ a moisture sensitivity evaluation of the proposed asphalt mixture design in accordance with Appendix B of this specification.

b. On all other Interstate and Primary highways, perform ~~an AASHTO T 283~~ a moisture sensitivity evaluation in accordance with Appendix B of this specification of the proposed asphalt mixture design if 25% or more of the plus No. 4 (4.75 mm) (virgin and RAP) aggregates or more than 40% of the total (virgin and RAP) aggregates is:

- Quartzite.
- Granite.
- Other siliceous aggregate (not a limestone or dolomite) which is obtained by crushing from ledge rock.

c. ~~AASHTO T283~~ Moisture susceptibility testing will not be required for base repair, patching, or temporary pavement.

d. A minimum tensile strength ratio (TSR) of 80~~.0~~% is required on plant produced mixture. When notified of non-compliant results, the Engineer may suspend paving operations until an approved "significant mix change" is implemented.

e. When the Contractor's mix design TSR results are greater than or equal to 80~~.0~~% and less than 90~~.0~~%, an anti-strip agent will be required until the Contracting Authority's TSR results on the plant produced mixture are equal to or exceeding 80~~.0~~%. Plant produced material without anti-strip shall be tested without penalty to confirm the need for an anti-strip agent. See Appendix C of this specification for additional information.

f. When the Contractor's mix design TSR results are below 80~~.0~~%, an anti-strip agent will be required. Plant produced material with anti-strip shall be tested to verify the minimum TSR is achieved. See Appendix C of this specification for additional information.

g. When there is a "significant mix change", the Engineer may require a re-evaluation of the ~~AASHTO T 283~~ test method in Appendix B of this specification.

h. ~~Use one of t~~The following anti-strip agents may be used:

1) **Hydrated Lime.**
Meet the requirements of AASHTO M 303, Type I. Do not apply Section 4193. Hydrated lime will not be considered part of the aggregate when determining the job mix formula and the filler/bitumen ratio.

2) Liquid Anti-strip Additives.
For each JMF, obtain approval for liquid anti-strip additives blended into the binder. Approval will be based on the following conditions:

a) The asphalt binder supplier provides test results that the additive does not negatively impact the asphalt binder properties, including short term and long term aged properties.

b) The design is to establish the optimum additive rate when comparing the dry strength of specimens prepared with asphalt binder not containing the anti-strip additive to conditioned specimens prepared with asphalt binder containing the anti-strip additive. See ~~Materials I.M. 510~~ Appendix C of this specification for additional information.

3) Polymer-based Liquid Aggregate Treatments.
For each JMF, obtain approval for polymer-based liquid aggregate treatments. Approval will be based on the design establishing the optimum additive rate when comparing the dry strength of specimens prepared without the anti-strip additive to conditioned specimens prepared with asphalt binder containing the anti-strip additive. See ~~Materials I.M. 510~~ Appendix C of this specification for additional information.

3. Sand for Tack Coats.
Use sand meeting the requirements of Gradation No. 1 of the Aggregate Gradation Table in Section 4109.02.

4. Fabric Reinforcement.
Use fabric reinforcement meeting the requirements of Article 4196.01, B, 4.

2303.03 CONSTRUCTION.

A. **General.**

1. The Contractor is responsible for all aspects of the project.

2. Provide quality control management and testing, and maintain the quality characteristics specified.

3. Apply Quality Management - Asphalt (QM-A) to asphalt mixture bid items greater than 1000 tons (1000 Mg) and all Interstate contracts. Follow the procedures and meet the criteria established in Articles 2303.02 and 2303.03, B; Section 2521; and Materials I.M. 510 and 511.

4. Apply Article 2303.03, E for asphalt mixture bid items of 1000 tons (1000 Mg) or less.

B. Equipment.

Provide sufficient equipment of the various types required to produce, place, and compact each layer of HMA mixture as specified, such that the mixture is workable at the minimum placement and compaction temperature desired, regardless of storage or haul distance considerations.

Use equipment meeting the requirements of Section 2001 with the following modifications:

1. **Plant Calibration.**
   - **a.** Calibrate each plant scale and metering system before work on a contract begins. Use calibration equipment meeting the manufacturer's guidelines and Materials I.M. 508.
   - **b.** The Engineer may waive calibration of permanent plant scales when a satisfactory operational history is available. The Engineer may require any scale or metering system to be recalibrated if operations indicate it is necessary.
   - **c.** Make calibration data available at the plant.
   - **d.** Calibrate each aggregate feed throughout an operating range wide enough to cover the proportion of that material required in the JMF. Make a new calibration each time there is a change in size or source of any aggregate being used.
   - **e.** For continuous and drum mixing plants, calibrate the asphalt metering pump at the operating temperature and with the outlet under pressure equal to that occurring in normal operations.

2. **Paver.**
   Apply Article 2001.19. Spreaders described in Article 2001.13, D, may be used to place paved shoulders. Spreaders used to place the final lift of paved shoulders shall meet additional requirements of Article 2001.19.

3. **Rollers.**
   - **a.** For initial and intermediate rolling, use self-propelled, steel tired, pneumatic tired, or vibratory rollers meeting the requirements of Article 2001.05, B, C, or F. Their weight (mass) or tire pressure may be adjusted when justified by conditions.
   - **b.** For finish rolling, use self-propelled, steel tired rollers or vibratory rollers in the static mode that meet the requirements of Article 2001.05, B, or F.

4. **Scales.**
   Apply Article 2001.07, B, to paving operations regardless of the method of measurement.

C. HMA Construction.

1. **Maintenance of the Subgrade and Subbase.**
   - **a.** Maintain completed subgrade and subbase to the required density, true cross section, and smooth condition, prior to and during subsequent construction activities.
   - **b.** If rutting or any other damage occurs to the subgrade or subbase as a result of hauling operations, immediately repair the subgrade and subbase. Such repair will include, if necessary, removal and replacement, at no additional cost to the Contracting Authority.
   - **c.** Should traffic by others authorized to do work on the project be specifically permitted by the Engineer to use loads which exceed the Contractor's established limit, the Contracting Authority will pay repair costs for repairs directed by the Engineer.

2. Preparation of Existing Surfaces.

a. Cleaning.

Clean and prepare existing surface according to Article 2212.03, B, 1.

b. Tack Coats.

1) Apply tack coats when the entire surface area on which the coat is to be applied is free of moisture. Do not apply them when the temperature on the surface being covered is less than 25°F (-4°C).

2) Place a tack coat to form a continuous, uniform film on the area to be covered. Unless directed otherwise, spread the tack coat at an undiluted rate of 0.02 to 0.05 gallon per square yard (0.1 to 0.2 L/m^2). The tack coat may be diluted with water to improve application.

3) Allow tack coat to adequately cure prior to placement of the HMA to assure bond to the underlying surface and avoid damage of the HMA being placed. If tack coat surface becomes dirty from weather or traffic, thoroughly clean and, if necessary, re-tack. A light application of sand cover may also be required, but this is anticipated only for excessive application rates, breakdowns, and short sections remaining at the end of a day's run.

4) On highways being constructed under traffic, use procedures that provide safety and convenience to the public (without soiling their vehicles) as controlling factors. Limit tack coat application lengths to minimize inconvenience to the public. Keep applications within the hot mixture placing work area that is controlled by flaggers at each end. Plan applications so they will be covered with hot mixture when the work area is opened to traffic at the end of the day's work.

5) Tack the vertical face of exposed, longitudinal joints as a separate operation at a rate from 0.10 to 0.15 gallon per square yard (0.5 to 0.7 L/m^2). Tack before the adjoining lift is placed. Lightly paint or spray vertical surfaces of all fixtures, curbs, bridges, or cold mixture with which the hot mixture will come in contact to facilitate a tight joint with the fresh mixture.

c. Fabric Reinforcement.

1) When fabric reinforcement is required, the locations will be designated in the contract documents.

2) Do not place fabric on wet or damp surfaces, or when the road surface is less than 50°F (10°C).

3) Apply fiberglass fabric only with an adhesive recommended by the manufacturer.

4) Place fabrics with an adhesive backing according to the manufacturer's recommendations.

5) Place other fabrics with a heavy coat of ~~the same~~ asphalt binder ~~grade used in the HMA and applied~~ at a rate of 0.20 to 0.25 gallons per square yard (0.9 to 1.1 L/m^2). Use the same binder grade used in the HMA mixture. Place at a temperature between 295°F and 315°F (145°C and 160°C).

6) Place fabric reinforcement according to the contract documents (full width or individual crack or joint treatment). Place fabric immediately following the adhesive or asphalt binder placement under the fabric. Placement may be by hand or by a mechanical method designed for this purpose.

7) Take precautions to avoid wrinkles in the fabric and to ensure that air bubbles are removed without breaking the fabric. Cut and lap wrinkles or folds which cannot be removed by brushing in order to provide a smooth surface.

8) Additional adhesive or asphalt binder may be required to produce a tight, bonded surface. When applied full lane width, use a minimum 12 inch (300 mm) transverse and longitudinal lap.

9) Avoid applying tack coat over longitudinally placed fabric.

10) To avoid damage to fabric, do not allow traffic over fabric during placement and during curing of the adhesive material. A light application of HMA mix may be hand sprinkled on the fabric to prevent damage from necessary equipment traffic.

11) When directed by the Engineer, repair damaged or soiled fabric prior to HMA overlay, at no additional cost to the Contracting Authority. The Engineer may also require sanding during this period, at no additional cost to the Contracting Authority.

3. Handling, Production, and Delivery.

Ensure plant operation complies with the following requirements:

a. Handling Mineral Aggregate and RAP.

1) Keep various aggregate products used separate from one another. Make adequate provisions to prevent intermingling.

2) Handle stockpiling and processing in a manner to ensure uniform incorporation of the aggregate into the mix.

3) Feed various aggregates separately in their proper proportions using feeders to the cold elevator. Feed them at a rate to permit correct and uniform temperature control of heating and drying operations.

b. Handling Asphalt Binder.

Bring asphalt binder to a temperature of 260°F to 330°F (125°C to 165°C) before being measured for mixing with the aggregates. The temperature between these limits may be further regulated according to the characteristics of the mixture, method of proportioning, and viscosity of the asphalt binder. Heat modified asphalt binder according to the supplier's recommendations.

c. Handling Anti-strip Agents.

1) Hydrated Lime.

Accurately proportion lime using a method acceptable to the Engineer.

a) Added to a Drum Mixer.

(1) Add hydrated lime at the rate of 0.75% by weight (mass) of the total aggregate (virgin and RAP) for Interstate and Primary projects. Add hydrated lime to a drum mixer using one of the following methods:

(a) Add to virgin aggregate on the primary feed belt, as a lime water slurry.

(b) Thoroughly mix with the total combined aggregate if the aggregate contains at least 3% total moisture.

(c) Add to the outer drum of a double drum system away from heated gas flow and prior to the addition of the virgin asphalt binder

(2) Alternative methods for mixing will be allowed only with the Engineer's approval. Do not introduce hydrated lime directly into a single drum mixer by blowing or by auger.

b) Added to a Batch Plant.

Add hydrated lime at the rate of 0.5% by weight (mass) of the total aggregate (virgin and RAP) for Interstate and Primary projects. Introduce it to a batch plant using one of the methods below. In any case, introduce the lime prior to the start of the dry mix cycle.

(1) Place on the recycle belt which leads directly into the weigh hopper.

(2) Add directly into the pugmill.

(3) Add directly into the hot aggregate elevator into the hot aggregate stream.

c) Added to the Aggregate Stockpile.

Add hydrated lime at a rate established by ~~the AASHTO T 283 test~~ moisture susceptibility testing. The instructions for establishing the rate are discussed in Materials I.M. 510. Add it to the source aggregates defined in Article 2303.02, E, 2, thoroughly mixed with sufficient moisture to achieve aggregate coating, and then place in the stockpile.

2) **Liquid.**

a) When liquid anti-strip additives are used, employ equipment complying with the anti-strip manufacturer's recommended practice to store, measure, and blend the additive with the binder.

b) The additive may be injected into the asphalt binder by the asphalt supplier or the Contractor. If the Contractor elects to add the liquid anti-strip agent, they assume the material certification responsibilities of the asphalt binder supplier. Ensure the shipping ticket reports the type and amount of additive and time of injection.

c) Ensure the asphalt supplier provides the Contactor and Engineer with the shelf life criteria defining when the anti-strip additive maintains its effectiveness. Do not use binder that has exceeded the shelf life criteria.

d) When using polymer-based aggregate treatment, comply with the manufacturer's recommended specifications and guidelines.

d. Production of Hot Mix Asphalt Mixtures.

1) Regulate the exact proportions of the various materials to be within the limits specified to produce a satisfactory bituminous coating and mixture. First dry mix the aggregates, then add the asphalt binder.

a) In batch plants, add the asphalt binder in an evenly spread sheet over the full length of the mixer box.
b) In continuous plants, spray the asphalt binder evenly into the aggregate within the first 30% of the length of the mixer box using a positive pressure spray.
c) In drum mixing plants, spray the asphalt binder evenly into the aggregate using a positive pressure spray.

2) Coating aids may be added with the Engineer's approval.
3) Operate the mixer so that the mixture is of consistently uniform temperature, and when discharged from the mixer does not vary more than 20ºF (11ºC).
4) Unless the Engineer approves, do not allow the temperature of the mixtures to exceed 330ºF (165ºC).
5) Use a rate of production that will not exceed the manufacturer's rated capacity for the mixer and will provide uniform coating. For batch mixers, use a dry mixing time of no less than 5 seconds and a wet mixing time of no less than 25 seconds. For continuous mixers, use a mixing time of no less than 30 seconds.
6) Control handling and manipulation of the hot mixture from the mixer to the final spread on the road in order to maintain uniform composition and minimize segregation of coarser particles. Minimize segregation to the extent that it cannot be visibly observed in the compacted surface. Apply only approved release agents to trucks and equipment, as specified in Article 2001.01.
7) Ensure mixture temperature allows for the specified compaction and ~~density~~ air void content to be attained. Do not discharge the HMA into the paver hopper when its temperature is less than:
- 245°F (120°C) for a nominal layer thickness of 1 1/2 inches (40 mm) or less, or
- 225°F (110°C) for a nominal layer thickness of more than 1 1/2 inches (40 mm).

8) Except for an unavoidable delay or breakdown, provide continuous and uniform delivery of hot HMA to any individual spreading unit. Deliver at a rate sufficient to provide as continuous an operation of the spreading unit as practical. Keep the paver hopper sufficiently full at all times to prevent non-uniform mixture flow to the screed.

4. Placement.

a. Clean the surface of each layer according to Article 2212.03, B, 1. If necessary, re-tack to provide bond with the succeeding course.
b. Prior to placing the final lift, correct bumps or other significant irregularities that appear or are evident in the intermediate course or other lower course.
c. Do not place HMA mixtures under the following circumstances:
1) On a wet or damp surface.
2) When road surface temperature is less than that shown in Tables 2303.03-1 and 2303.03-2.

Table 2303.03-1: Base and Intermediate Course Lifts of HMA Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, ºF (ºC)
1 1/2 (40)	40 (4)
2 - 3 (50 - 80)	35 (2)
Over 3 (Over 80)	25 (-4)

Table 2303.03-2: Surface Course Lifts of HMA Mixtures

Nominal Thickness - inches (mm)	Road Surface Temperature, ºF (ºC)
1 (30)	50 (10)
1 1/2 (40)	45 (7)
2 and greater (50 and greater)	40 (4)

3) After November 15, except with the Engineer's approval.
d. The Engineer may further limit placement if, in the Engineer's judgment, other conditions are detrimental to quality work.
e. When placing the mixture, maintain a finishing machine forward speed that will provide a continuous uniform operation. Minimize stopping.
f. Use a wire or string line to guide finishing machine and maintain alignment. Correct edge alignment irregularities immediately.

g. The contract documents will show the total thickness to be placed. Spread the mixture at a rate such that, when compacted, the layer(s) will be the required thickness.

h. Base the minimum layer thickness on Table 2303.03-3.

Table 2303.03-3: Minimum Lift Thickness

Design Mix Size - inches (mm)	Minimum Lift Thickness - inches (mm)
3/8 (9.5)	1 (25)
1/2 (12.5)	1 1/2 (40)
3/4 (19)	2 (50)
1 (25)	3 (75)

i. Ensure the compacted thickness of the top layer does not exceed 3 inches (75 mm). This restriction does not apply to HMA shoulders.

j. The maximum compacted thickness of lower layers may exceed 4 inches (100 mm) if it is demonstrated that the thicker layers have satisfactory ~~density~~ field voids. The riding characteristics of the thicker layers must be within conformance to that expected from a 3 inch (75 mm) layer.

k. Complete each layer to full width before placing succeeding layers.

l. While operating on the road surface, do not use kerosene, distillate, other petroleum fractions, or other solvents, for cleaning hand tools or for spraying the paver hopper. Do not carry containers of cleaning solution on or near the paver. When a solvent is used, do not use the paver for at least 5 hours after cleaning. Collect and remove all cleaning materials and cleaning residue from the project and plant site. The cleaning material and residue becomes the property of the Contractor.

m. Whenever practical, spread mixtures using a finishing machine. Irregular areas may be spread by hand. Spread the hot mixture uniformly to the desired depth with hot shovels and rakes. Do not dump loads faster than they can be spread properly. Do not allow workers to stand on the loose mixture while spreading.

n. After spreading, carefully smooth to remove all segregated coarse aggregate and rake marks. Use rakes and lutes designed for use on HMA mixtures.

o. Unless stated elsewhere in the contract documents, when placing two adjacent lanes, pave no more than 1 day of rated plant production before paving the adjacent lane(s). Place the adjacent lane to match the first lane during the next day of plant production.

p. Do not spread more mixture than can be compacted in the specified working hours of the same working day.

q. At the close of each working day, clear all construction equipment from the roadbed.

r. Prior to opening a lane to traffic, place fillets or full width granular shoulders according to Article 2121.03, C, 4. Place the material adjacent to and equal in thickness to the resurfacing. Fillet removal is incidental to the HMA mixture.

5. Compaction.

a. **General.**

1) Promptly and thoroughly compact each layer. Use mechanical tampers for areas inaccessible to the rollers.

2) Use a rolling procedure and compactive effort that will produce a surface free of ridges, marks, or bumps. Obtain the Engineer's approval for the rolling procedure and compactive effort.

b. Class I Compaction.

1) Applications.

a) ~~Intended for use on Interstate highways, and most Primary and Secondary highways.~~ Use Class I Compaction for base, intermediate, and surface courses for traffic lanes, ramps, and loops on Interstate, Primary, and Secondary highways.

b) For Class I compaction, the ~~roadway density (percent of laboratory density)~~ quality characteristic is in-place air void content and will be based on the ~~density~~ theoretical maximum specific gravity (G_{mm}) obtained from the Quality Control Program for that day's mixture.

~~**1) Class IA Compaction.**~~

~~**a)** Use Class IA compaction for intermediate and surface courses for the traffic lanes of:~~

- ~~Interstate highways,~~
- ~~Interstate-to-Interstate ramps, and~~
- ~~Primary highways as specified.~~

~~**b)** Compact to a minimum of 96% of laboratory density. Do not exceed 8% average air void level for roadway density specimens.~~

~~**2) Class IB Compaction.**~~

~~**a)** Use Class IB compaction for:~~

- ~~All Interstate and Primary base courses,~~
- ~~Primary travel lane intermediate and surface courses when Class IA compaction is not specified, and~~
- ~~Primary ramps connecting to Interstate and Primary highways when Class IA compaction is not specified.~~

~~**b)** Compact to a minimum of 95% of laboratory density. Do not exceed 8% average air void level for roadway density specimens.~~

~~**3) Class IC Compaction.**~~

~~**a)** Use Class IC compaction for:~~

- ~~HMA base widening,~~
- ~~Shoulder resurfacing when specified,~~
- ~~Traffic lanes of Secondary highways, and~~
- ~~Any other traffic lanes when Class IA and IB are not specified.~~

~~**b)** Compact to a minimum of 94% of laboratory density. Do not exceed 8% average air void level for roadway density specimens.~~

42) Test Strip Construction for Class ~~IA and IB~~ Compaction.

a) For the purpose of evaluating properties of the HMA mixtures and for evaluating an effective rolling pattern:

(1) ~~For Class IA compaction, construct a test strip at the start of intermediate course placement.~~ Construct a test strip of the surface mixture prior to its placement on the surface course for Interstate highways, Primary highways, and ramps connecting Interstate and Primary highways.

(2) ~~For Class IA and IB compaction, construct a test strip prior to the start of surface course placement.~~ Construct a test strip of the intermediate mixture at the start of its placement on the intermediate course for Interstate highways, interstate-to-interstate ramps.

(3) Test strips for base mixtures may be constructed, but are not required.

~~**b)** For multiple lifts using the same mix requiring Class IA compaction, when the thickness of the second lift varies from the first lift by 1 1/2 inches (40 mm) or more, perform a test strip for the second lift.~~

~~**c**~~**b)** When the contract documents specify both intermediate and surface courses and a test strip is required, place a surface course test strip in lieu of intermediate mixture in a section of the intermediate course prior to actual surface course placement.

~~**d**~~**c)** ~~Apply the test strip to each mixture which has a plan quantity of at least 3000 tons (3000 Mg).~~ Test strips are not required when the entire production of the mixture bid item is placed in a single day.

~~**e**~~**d)** The quantity of HMA mixture subject to ~~Class IA compaction, produced and placed for~~ the test strip production~~,~~ will be pre-established with the Engineer and limited to~~:~~ a half day's production.

~~**(1)** 750 tons (750 Mg) for lift thicknesses of 2 inches (50 mm) or less.~~

~~**(2)** 1000 tons (1000 Mg) for lift thicknesses greater than 2 inches (50 mm).~~

~~**f)** After test strip placement, suspend further mixing and laydown operations until the laboratory test results of the plant produced mixture and core densities are available.~~

~~**g**~~**e)** Only one test strip will be allowed for each mixture. The Engineer may require additional test strips if a complying HMA mixture or rolling pattern was not established.

~~**h**~~**f)** Use procedures and documentation during test strip construction that allow the Engineer and Contractor to confirm mixture design properties and effectiveness of compaction procedures.

~~i~~g) Use test strip production control that meets the requirements of Article 2303.03, D, 3, c. ~~The number of density core samples obtained for the test strip will be increased by one. The low core result will not be used in the Quality Index (Q.I.) formula for payment for the test strip quantity.~~ The test strip will be an independent lot. Determine sublots in accordance with Table 2303.03-4.

c. Class II Compaction.

Intended for paved shoulders, temporary crossovers, onsite detours, and other situations where Class I is not specified.

1) For all rollers, make initial contact with the hot mixture using the power driven wheels or drum.

2) Perform initial rolling at a temperature so the mixture will compact without excessive distortion. Except on longitudinal joints and super-elevated curves, begin rolling with the initial roller at the outer edges of the pavement. With each successive pass, progress inward toward the center. For each reverse trip, lap all but 4 to 6 inches (100 to 150 mm) of the previous track. When reversing direction, stop the initial roller at an angle with the longitudinal direction.

3) Following the initial rolling, give the layer an intermediate rolling with a pneumatic tired roller before the temperature falls below 225°F (110°C). Cover the area no less than six times with the intermediate roller.

4) Use a finish, steel tired roller to smooth out all marks and roughness in the surface.

5) For areas inaccessible to rollers, use mechanical tampers or other approved compaction methods.

6. Joints and Runouts.

a. Construct longitudinal joints for courses on resurfacing projects directly above the longitudinal joint in the existing pavement. Limit the offset distance between longitudinal joints in succeeding full depth HMA paving courses to 3 inches (75 mm) or less. Adjust hot mixture spreading along longitudinal joints to secure complete joint closure and full compression of the mixture with a smooth surface and joint after compaction.

b. Separate transverse construction joints in succeeding courses by at least 6 feet (1.6 m). Do not use wood or metal headers to form joint edge during rolling of the fresh mixture. Saw header to a straight line at right angles to the center line to provide a full thickness vertical edge before continuing paving. Provide a 10 foot (3 m) straightedge for checking transverse construction joints for smoothness. Before compaction, use hand methods to correct surface variations at transverse construction joints indicated by the straightedge.

c. When a transverse construction joint is open to traffic, install a temporary runout 10 feet (3 m) long per 1 inch (25 mm) of lift thickness. Use suitable paper or burlap (not sand, dirt, or wood) under the taper to prevent adhesion.

d. When required to end paving for winter shutdown, locate runouts adjacent to each other. Install a winter shutdown runout 25 feet (8 m) long per 1 inch (25 mm) of lift thickness.

e. For temporary runouts open to traffic for periods greater than 4 weeks or winter shutdown runouts, the Contractor may reduce the amount of top size aggregate in the transition taper. Remove temporary runouts and winter shutdown runouts before commencing paving. Runout removal is incidental to the HMA mixture.

7. Miscellaneous Operations.

a. Leveling and Strengthening Courses.

1) The contract documents will show course thickness. Place strengthening and leveling courses as indicated in the contract documents. Use the same mixture specified for the base or intermediate course.

2) When the width of strengthening or leveling course is 8 feet (2.4 m) or more, spread using a finishing machine.

3) Compact leveling courses using Class II compaction, except make all passes with a pneumatic roller.

b. Wedge Courses.

1) Use the base or intermediate mixture to construct wedge courses used to secure desired curve super-elevation. When possible, spread using a finishing machine.

2) Place wedge courses in compacted layers no thicker than 3 inches (75 mm). Avoid crushing the coarse aggregate. Place wedge courses to the full width of the pavement.

3) On super-elevated curves which require wedge course placement, stage the shoulder construction. After completing each day's wedge placement operations and prior to suspending that day's construction activities, construct a full width shoulder on the high side up to the completed wedge course elevation. Shoulder construction staging will be considered incidental to shoulder construction.

c. Fixtures in the Pavement Surface.

1) Adjust utility accesses, intakes, or other fixtures encountered within the area to be covered by HMA to conform to the final adjacent finished surface. Unless specified otherwise in the plans, adjust fixtures:

- Between placing the surface course and the layer preceding the surface course, or
- After placing the surface course using a composite patch or PCC patch.

2) Use PCC and HMA patch material complying with the requirements of Section 2529. Make patches large enough to accommodate the structure being adjusted.

3) Construct patches to be square. Orient them diagonally to the direction of traffic flow. Ensure the elevation of the adjusted fixture and patch does not differ from the elevation of the surrounding pavement surface by more than 1/4 inch (6 mm).

d. Fillets for Intersecting Roads and Driveways.

1) Shape, clean of loose material, and tack coat the surface adjacent to the pavement being surfaced when fillets are designated in the contract documents for driveways to homesteads and commercial establishments and at intersecting roads. On the tack coated surface, place and compact the hot mixture in layers equal to the adjacent layer. Extend from the edge of the pavement as shown on the plans.

2) Place and compact fillets at intersecting roads at the same time as the adjacent layer.

3) Entrance fillets that are 8 feet (2.4 m) or wider may be placed as a separate operation. Pave fillets which are 8 feet (2.4 m) or wider with a self propelled finishing machine described in Article 2001.19.

4) The Engineer may approve other equipment for placement of fillets, based on a demonstration of satisfactory results.

e. Stop Sign Rumble Strips.

If the plans include the bid item Rumble Strip Panel (In Full Depth Patch), apply Section 2529. To meet the requirements of placing Stop Sign Rumble Strips before opening roadway sections to traffic, the Contractor may construct temporary rumble strip panels meeting the final pattern and location of the Stop Sign Rumble Strip indicated in the plans

f. Paved HMA Shoulders.

1) Compact paved HMA shoulders using one of the following methods:

a) Class II compaction (Article 2303.03, C, 5, c),

b) Rolling pattern established during the first day of shoulder placement to achieve Class 1~~C~~ compaction (Article 2303.03, C, 5, b~~, 3~~), or

c) Same rolling pattern established for mainline lanes, as determined by density coring.

2) Shoulder area will not be included in PWL calculations for ~~density price adjustment~~ field voids on mainline. A price adjustment may be applied to shoulder areas that do not adhere to the established roller pattern.

D. Quality Assurance Program.

For each HMA mixture bid item of more than 1000 tons (1000 Mg), apply requirements of this article.

HMA mixture bid items of 1000 tons (1000 Mg) or less and patching bid items are both defined as small quantities. For those bid items, meet the requirements of Article 2303.03, E.

1. General.

Follow the procedures and meet the criteria established in Articles 2303.02 and 2303.03, B, Section 2521, and Materials I.M. 510 and 511.

2. Mix Design - Job Mix Formula.

a. The Contractor is responsible for the JMF for each mixture.

b. Submit a completed JMF, using the computer format of Form 956, for approval to the materials lab designated by the Contracting Authority. Submit supporting documentation demonstrating the design process was followed and how the recommended JMF was

determined. Include an economic evaluation when required. Include trial and final proposed aggregate proportions (Form 955) and corresponding gyratory data. In addition, submit sufficient loose mixture and individual material samples for approval of the design.

c. Personnel preparing the JMF shall be Iowa DOT certified in bituminous mix design.

d. If the JMF is not satisfactory, submit another JMF for review. An approved JMF will be required prior to beginning plant production. The Contractor will be charged $1000 for each JMF approval requested and performed which exceeds two per mix size, type, and proposal item on any individual project or group of tied projects.

3. Plant Production.

a. **General.**

1) Perform sampling and testing to provide the quality control of the mixture during plant production. Certified Plant Inspection according to Section 2521 is required.

2) Personnel performing production quality control testing shall be Iowa DOT certified for the duties performed.

3) Provide easy and safe access for Iowa DOT staff to the location in the plant where samples are taken.

4) All of the following qualify as a "significant mix change":

- A single occurrence of an aggregate interchange of greater than 5%
- A single occurrence of an asphalt content change greater than 0.2%
- Any complete removal of a material from the mixture
- An ~~deletion or~~ introduction of a new material into the mixture
- A change of additive dosage rate
- A change of binder, aggregate, or additive source

b. Sampling and Testing.

Submit a testing plan meeting the requirements of Materials I.M. 511, Appendix D prior to the preconstruction meeting.

1) Asphalt Binder

Sample and test the asphalt binder to verify the quality of the binder grade. Take asphalt binder samples at random times as directed and witnessed by the Engineer according to Materials I.M. 204.

2) Aggregate Gradation

i) Use cold feed gradation for aggregate gradation control to assure materials are being proportioned according to the specifications. Take aggregate quality control samples at random times ~~as directed and witnessed by the Engineer according to~~ in accordance with Materials I.M. 204. ~~The Engineer will secure the samples according to Materials I.M. 511.~~

ii) Take a minimum of one aggregate gradation for each day's production that exceeds 100 tons (Mg). Higher testing frequencies may be used when defined by a pre-determined quality control plan approved by the Engineer. When more than one sample in a day's production is tested, use the average gradation to determine compliance of the daily lot.

iii) Split a cold feed sample with the Engineer on the first day's production of each mixture. The Engineer will determine the need for a correction factor for the cold feed gradation based on the Engineer's cold feed gradation and ignition oven results. The Engineer may require additional cold feed split samples to evaluate the need or value of a correction factor for the cold feed and ignition oven gradation.

iv) Secure aggregate gradation samples transported to the lab for determination of the ignition oven correction factor in accordance with Appendix A of this specification.

3) Uncompacted Asphalt Mixture

i) Sample the hot HMA mixture at random locations as directed and witnessed by the Engineer according to Materials I.M. 322. Secure and test the samples according to ~~Materials I.M. 511~~Appendix A of this specification.

ii) Sampling frequency will be determined by the estimated daily production of each mixture placed. The number of sublots is defined in Table 2303.03-4:

Table 2303.03-4: Uncompacted Mixture Sublot Size

Estimated Daily Production, Tons (Mg)	Number of Sublots
101-500	1

501-1250	2
1251-2000	3
2001-4500	4
Over 4500	5

iii) The Contractor may request to have a quality control plan that indicates a higher testing frequency if pre-approved by the Engineer at the preconstruction meeting.

4iv) Assist the Engineer with material sampling for verification testing. When the Engineer provides notification that a sample is to be taken, ~~obtain sample~~ initiate sampling within 15 minutes. Sampling should normally be completed within 30 minutes of notification.

v) Do not take paired samples from the first 100 tons (100 Mg) of mix produced each day or the first 100 tons (100 Mg) of mix following a significant mix change.

5vi) ~~Each day's production of a mix design will be considered a lot.~~ For PWL analysis of laboratory voids, lot size is defined as follows:

- **a)** No less than 8 and no more than 20 sequential tests will constitute a lot (exceptions stated below).
- **b)** After the 8th test, all subsequent samples collected over the remainder of that week will also be included in the lot up to a maximum of 20.
- **c)** Once a lot has been established with at least 8 tests, a new lot will begin at the start of the following week or the day following the 20th sample, whichever occurs first. Lots shall not contain partial days. When the 20th sample is reached, include all samples taken that day in the lot.
- **d)** When determining PWL lot size for lab voids, Sunday through Saturday defines a week.
- **e)** If the bid item's production has ended and fewer than 8 tests are available, those tests may be combined with the previous lot provided the maximum lot size has not already been reached. When combining results, if the day to be combined contains the 20th sample, include all samples for that day. Do not combine partial day's results.
- **f)** If samples cannot be combined with the previous lot due to maximum lot size restrictions or if fewer than 8 tests are available for the entire production of a bid item, combine those tests into a single lot and use the AAD analysis in Materials I.M. 501.
- **g)** Test strips will be considered a separate lot.

~~**a)** When the anticipated quantity for the day is 2000 tons (2000 Mg) or more, divide that day's production into four sublots, with the first sublot being the first 500 tons (500 Mg) produced. The Engineer will divide the remaining anticipated quantity for the day into three equally sized sublots.~~

~~**b)** When the anticipated quantity for the day is less than 2000 tons (2000 Mg), use the first 500 tons (500 Mg) produced for the first daily sublot. The Engineer will establish 750 ton (750 Mg) daily sublots for mix production exceeding the first 500 tons (500 Mg).~~

~~**6)** No more than four paired hot HMA mixture samples will be required for acceptance of a lot.~~

~~**7)** Do not take paired samples from the first 100 tons (100 Mg) of mix produced each day or the first 100 tons (100 Mg) of mix following a significant mix change.~~

~~8~~vii) Test the quality control sample of each production paired sample as follows:

- **a)** Prepare and compact two gyratory specimens according to Materials I.M. 325G.
- **b)** Determine the ~~density~~ bulk specific gravity of compacted mixture (G_{mb}) at N_{design} for each specimen according to Materials I.M. 321. G_{mb} at N_{design} will be determined by compacting specimens to N_{max} and back calculating the bulk specific gravity at N_{design}. Average the results ~~to determine sample density~~.
- ~~**c)** Use the field quality control laboratory compaction for field density control. The laboratory density for field control will be the bulk specific gravity of compacted mixture (G_{mb}) at N_{design}. Bulk specific gravity at N_{design} will be determined by compacting specimens to N_{max} and back calculating the bulk specific gravity at N_{design}.~~

d) Determine the Theoretical Maximum Specific Gravity of the uncompacted mixture according to Materials I.M. 350 ~~or other test methods recognized by AASHTO or ASTM~~.

e) Determine laboratory air voids for each sample according to Materials I.M. 501.

viii) Use the target laboratory voids listed in Materials I.M. 510 Appendix A unless otherwise specified in the contract documents.

ix) Determine PWL for each lot as defined in Material I.M. 501. Use 1.0% below the target air voids as the lower specification limit and 1.0% above the target air voids as the upper specification limit.

x) Determine the pay factor using the absolute average deviation (AAD) procedure described in Materials I.M. 501 for proportions of a mixture bid item which are produced in irregular intervals and placed in irregular areas. The following items qualify as such and shall be combined into weekly lots:

- Asphalt mixture produced and placed on gores, detours, temporary pavements, turning lanes, and fillets,
- Asphalt mixture produced and placed on ramps that are not high-speed ramps,
- Asphalt mixture produced and placed on non-interstate shoulders.

To be considered irregular, the production rate for mixture bid items described above is not to exceed 1000 tons (10,000 square yards for items bid in square yards) in a single day.

~~9~~4) Moisture Susceptibility

i) The Engineer may obtain samples for ~~AASHTO T283~~ moisture susceptibility testing in accordance with Appendix B of this specification at any time for mixtures requiring moisture sensitivity testing ~~under Articles 2303.02,E, 2, a, and 2303.02, E, 2, b,~~ to verify the minimum TSR has been achieved.

~~10~~ii) When liquid anti-strip additives are added by the Contractor at the plant, satisfy one of the following methods to regulate the quantity of additive:

a) Present certification that the equipment used to measure and blend the liquid anti-strip additive:

- Meets the anti-strip supplier's recommended practice,
- Is directly tied to the asphalt binder supply system, and
- Has been calibrated to the equipment manufacturer's guidelines.

b) Test the binder to measure the quantity of liquid anti-strip additive in the binder for every 5000 tons (5000Mg) of HMA production. Obtain the Engineer's approval for the supplier's test method prior to use of the test.

c) Run ~~AASHTO T 283~~ the test method in Appendix B of this specification during production. If unable to certify or test for the presence and quality, run ~~AASHTO T 283~~ the test method in Appendix B of this specification each 10,000 tons (10,000 Mg) of production to measure the effectiveness of the additive. Ensure test results satisfy 80% TSR when compared to the dry strength of specimens prepared with asphalt binder containing the additive.

c. Production Control.

1) After the JMF is established, the combined aggregate furnished for the project, the quantity of asphalt binder, and the laboratory air voids should consistently comply with the JMF, as target values. Control them within the production tolerance given in Table 2303.03-~~4~~5.

Table 2303.03-~~4~~5: Production Tolerances

Measured Characteristic	Target Value (%)	Specification Tolerance (%) [(a)]
Cold feed gradation No. 4 (4.75 mm) and larger sieves	by JMF	± 7.0
Cold feed gradation No. 8 (2.36 mm)	by JMF	± 5.0
Cold feed gradation No. 30 (600 µm)	by JMF	± 4.0
Cold feed gradation No. 200 (75 µm)	by JMF	± 2.0 [(b)]

Daily asphalt binder content	by JMF	± 0.3
~~Field laboratory air voids~~	~~4.0 (c)~~	~~-0.5/+1.0 (d)~~
VMA (e)	by JMF	± 1.0 (f)

(a) Based on single test unless noted otherwise.

(b) Maintain the filler/bitumen ratio of the plant produced mixture between 0.6 and 1.4.

~~(c) Unless otherwise specified.~~

~~(d) Based on the moving average of four test values.~~

(e) Restricted to an asphalt film thickness as specified for the level of HMA mixture.

(f) Based on the daily lot average.

2) Control plant production so that the plant produced HMA mixture will meet mixture design criteria (within the test tolerances given in Table 2303.03-45) for Air Voids and VMA at N_{design} gyrations of the gyratory compactor. Monitor the slope of the gyratory compaction curve of plant produced material. Slope variations in excess of ±0.40 of the mixture design gyratory compaction curve slope may indicate potential problems with uniformity of the mixture.

3) The gyratory mix design gradation control points for the size mixture designated in the project plans will not apply to plant production control.

4) Strive for the target value of the percent air void and asphalt binder by adjusting gradation and asphalt binder content.

5) Produce a uniform composition mixture complying with the JMF.

6) Adjustments to the JMF target gradation and asphalt binder content values may be made.

- **a)** The Contractor determines from quality control testing that adjustments are necessary to achieve the specified properties.
- **b)** Consult with the Engineer regarding adjustments to the JMF.
- **c)** Notify the Engineer if the average daily gradation for a mixture bid item is outside the production tolerances. If other production tolerances and mixture requirements of Materials I.M. 510 Appendix A are acceptable, a change in gradation target can be requested.
- **d)** If filler/bitumen ratio exceeds the limits listed in Table 2303.03-5, change the JMF at the start of the next day's production for that mixture.
- **~~c~~e)** The Contractor's adjustment recommendations prevail, provided all specifications and established mix criteria are being met for plant production.

7) Measure estimated film thickness and voids in the mineral aggregate (VMA) for specification compliance every day of HMA production.

8) Prepare quality control charts according to ~~Materials I.M. 511~~ Appendix A of this specification. Keep the charts current and available showing both individual sample results and moving average values. Base moving average values on four consecutive sample results. ~~Moving averages may restart only in the event of a mandatory plant shutdown for failure to maintain the average within the production tolerance.~~ Include the target value and specification tolerances on control charts.

9) Calculate laboratory voids for individual samples according to Materials I.M. 501. Use the individual density and individual maximum specific gravity determined for each sample. To determine the moving average of laboratory voids, use the average of the last four individual sample laboratory voids.

10) Monitor the test results and make mix adjustments, when appropriate, to keep the mixture near the target values. Notify the Engineer whenever the process approaches a specification tolerance limit. ~~Cease operations when the moving average point for laboratory air voids is outside the specification tolerance limit. Assume responsibility to cease operations, including not incorporating material which has not been placed. Do not start the process again until notifying the Engineer of the corrective action proposed.~~

4. Construction.

a. ~~Density~~ Field Voids for Class I Compaction.

1) Take ~~density~~ samples to determine field voids from the compacted mixture and test no later than the next working day following placement and compaction.

2) A lot is considered to be one layer of one mixture placed during a day's operation. The Engineer may approve classifying multiple layers of construction placed during a single day as a lot provided only one mixture was used.

3) The Engineer may waive sampling for ~~density~~ field voids in the following situations, provided compaction has been thorough and effective:
- When the day's operation is not more than 2500 square yards (2500 m^2),
- When the day's operation is not more than 500 tons (500 Mg),
- When the mixture is being placed in irregular areas, or
- When placing wedge or strengthening courses.

4) The Engineer will obtain and test ~~density~~ 8 samples for each lot ~~according to Materials I.M. 204~~. The Contractor may request to have a quality control plan that indicates a higher testing frequency at no additional cost to the Contracting Authority if pre-approved by the Engineer at the preconstruction meeting. The minimum number of cores is ~~set forth in Materials I.M. 204, Appendix F~~ 8. The Engineer will determine the core locations. The length laid in each lot will be divided into approximately equal sublots. Obtain one sample at a random location, as directed and witnessed by the Engineer, in each sublot.

5) If a sample is damaged or measures less than 70% or more than 150% of the intended thickness, an alternate sampling location will be determined and used. Take samples from no less than 1 foot (300 mm) from the edge of a given pass of the placing equipment, from run-outs, or from day's work joints or structures.

6) ~~Determine the quality index for density of each lot using the following formula:~~

$$QI_{Density} = \frac{(Average\ G_{mb})_{Field\ Lot} - ((\%\ Density)_{Specified} \times (Average\ G_{mb})_{Lab\ Lot})}{(Standard\ Deviation\ G_{mb})_{Field\ Lot}}$$

~~where $QI_{Density}$ = Quality Index for density~~
~~G_{mb} = bulk Specific Gravity of the mixture~~

Determine PWL, as defined in Materials I.M. 501, for each lot using a lower specification limit (LSL) of 3.5% voids and an upper specification limit (USL) of 8.5% voids.

7) ~~When the quality index falls below 0.00, the Engineer may declare the lot or parts of the lot defective.~~ When the PWL falls below 80.0, use the procedure outlined in Materials I.M. 501 to identify outliers with 1.80 as the quality index criterion. Only one core may be considered an outlier in a single lot. If an outlier is identified, recalculate the PWL with the results of the remaining cores and determine whether the PWL is improved. Use the larger of the original and recalculated PWL to determine the pay factor.

8) ~~If one of the density test values from a lot is an outlier, identified according to the procedure described in Materials I.M. 501, do not use the outlier value to determine the quality index. Use the remaining density test values to determine the quality index.~~ When the PWL falls below 50.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable

~~**9)** If only one laboratory density value is obtained that day, combine that value with the next day's test results to evaluate both days' production. If two or more laboratory density values are obtained that day, then use the average of those tests alone. If a significant mix change has been made, only the appropriate laboratory density values should be used with the corresponding density cores.~~

b. Thickness.

1) The Engineer will measure the cores, exclusive of sealcoat, according to Materials I.M. 337. All areas of uniform and similar thickness and width for the project will be divided into lots.

2) Use the frequency specified for taking ~~density~~ G_{mb} samples from the surface lift when measuring for completed thickness. Samples for thickness not tested for ~~density~~ G_{mb}, because they are less than 70% of the intended thickness, are included for thickness. In these particular instances, do not measure the thickness of additional sufficiently thick samples used ~~for density tests~~ to determine field voids. Take thickness samples full depth of the completed course. After measurement, remove the ~~density~~ G_{mb} samples for the top layer from the core.

3) If any of the measurements for a lot is less than the designated thickness, the quality index for thickness of that lot will be determined by the following formula:

(English)

$$QI_{Thickness} = \frac{\text{Average Thickness}_{Measured} - (\text{Thickness}_{Plan} - 0.5)}{\text{Maximum Thickness}_{Measured} - \text{Minimum Thickness}_{Measured}}$$

(Metric)

$$QI_{Thickness} = \frac{\text{Average Thickness}_{Measured} - (\text{Thickness}_{Plan} - 12.7)}{\text{Maximum Thickness}_{Measured} - \text{Minimum Thickness}_{Measured}}$$

4) Provided there is reasonable assurance that the pavement complies with the required thickness, the Engineer may waive sampling for thickness for the following situations:
- **a)** When the day's operation is 2500 square yards (2500 m^2) or less.
- **b)** When the mixture is being placed in irregular areas.
- **c)** When the mixture is being placed next to structures.

5) When the quality index falls below 0.00, the Engineer may declare the lot or parts of the lot defective.

c. Smoothness.

Apply Section 2317 to HMA surface mixture bid items of a Primary project if any individual HMA mixture bid item is 1000 tons (1000 Mg) or greater or 5000 square yards (4200 m^2) or greater. Apply Section 2316 to all other Primary projects with a surface course and when specifically required for other projects.

5. Sampling and Testing.

a. **General.**

1) Maintain and calibrate the quality control testing equipment using prescribed procedures. Sample and test according to the specified procedures as listed in the applicable Materials I.M. and Specifications. When the results from a Contractor's quality control lab are used as part of product acceptance, the Contractor's quality control lab is required to be qualified.

2) Identify, store, and retain all quality control samples and field lab gyratory specimens used for acceptance until the lot is accepted. The Contracting Authority will prescribe the method of securing the identity and integrity of the verification samples according to ~~Materials I.M. 511~~ Appendix A of this specification. Store verification samples for the Contracting Authority until delivery to the Contracting Authority's lab.

3) Identify all samples using a system the Engineer approves.

b. Individual Materials and ~~Loose~~ Uncompacted Mixture.

1) Complete the following as designated by the Engineer:
- Identify samples of asphalt binder, aggregate, and tack coat material.
- Secure and promptly deliver the samples to the appropriate laboratory.

2) Take paired samples of ~~loose~~ uncompacted HMA mixture (each box of the pair weighing at least 30 pounds (14 kg)) according to Materials I.M. 322.

3) Conduct quality control tests for mixture properties using representative portions of the mix from the quality control sample of each sublot.

4) Split samples for specimen preparation according to Materials I.M. 357.

5) Paired sampling may also be accomplished by taking a bulk sample and immediately splitting the sample according to Materials I.M. 322 on the grade.

6) Record and document all test results and calculations on data sheets approved by the Contracting Authority. Record specific test results on the Daily Plant Report the Contracting Authority provides. Also include a description of the quality control actions taken (adjustment of cold feet percentages, changes in JMF, and so forth) on the Daily Plant Report.

7) Facsimile, or deliver by other methods the Engineer approves, the Daily Plant Report to the Engineer and the designated laboratory daily. At project completion, provide the Engineer a copy of the electronic file containing project information generated during the progress of the work.

8) When sampling for ~~AASHTO T 283~~ moisture susceptibility testing, obtain a ~~50~~ 70 pound (~~25~~ 35 kg) sample according to Materials I.M. 322. If the Contractor's TSR results from the mixture design are less than 90%, sample at a minimum frequency of 1/10,000 tons of plant production until a complying test result is achieved, after which the minimum frequency may be reduced to 1/50,000 tons. A single sample shall

represent no more than 10,000 tons of mixture. The Engineer will select, at random, the sample location. Split the sample and deliver half to the Central Materials Laboratory.

c. Compacted Pavement Cores.

1) Cut and trim samples under the direction of and witnessed by the Engineer for tests of ~~density~~ G_{mb}, thickness, or composition by using a power driven masonry saw or by drilling a minimum 4 inch (100 mm) nominal diameter core.

2) Restore the surfaces the same day. Dry, fill with the same material, and properly compact core holes.

3) Pavement core samples will be identified, taken possession of by the Engineer, and delivered to the Contractor's quality control field laboratory.

4) The Engineer may either:

- Transport the cores directly to the lab, or
- Secure the cores and allow the Contractor to transport the cores to the lab.

5) The compacted HMA pavement will be tested in a timely manner by the Engineer's personnel who are Iowa DOT Certified to perform the test.

6) Prepare and test the cores according to Materials I.M. 320, 321, and 337.

d. Verification and Independent Assurance Testing.

1) The Contractor's quality control test results ~~from paired samples~~ will be validated by the Engineer's verification test results on a regular basis using guidelines and tolerances set forth in Materials I.M. 216 and ~~511~~ Appendix A of this specification.

2) If the Engineer's verification test results validate the Contractor's test results, the Contractor's results will be used for material acceptance. Disputes between the Contractor's and Engineer's test results will be resolved according to ~~Materials I.M. 511~~Appendix A of this specification.

3) The Engineer will randomly select~~,~~ one or more of the daily ~~hot mix~~ production verification samples. Some or all of the samples selected will be tested in the materials laboratory designated by the Engineer. The Engineer will use the verification test results to determine if the Contractor's test results can be used for acceptance.

4) The Engineer will test each lot of cores~~. These will be tested~~ at the Contractor's field quality control laboratory. Cores may also be tested by the Contractor~~,~~; ~~but~~ however, the Contractor's test results will not be used for material acceptance.

5) Personnel and laboratories performing tests used in the acceptance of material are required to have participated in the statewide Independent Assurance Program according to Materials I.M. 208.

E. Quality Control for Small HMA Paving Quantities.

1. Mix Design.

Prepare the JMF. Prior to HMA production, obtain the Engineer's approval for the JMF. Comply with Article 2303.02 and Materials I.M. 510.

2. Plant Production.

a. Ensure HMA production plant calibration for the JMF is current and no more than 12 months old.

b. Use certified asphalt binder and approved aggregate sources meeting the JMF. Ensure the plant maintains an asphalt binder log to track the date and time of binder delivery. Ensure HMA delivery tickets identify the JMF.

c. Monitor the quality control test results and make adjustments to keep the mixture near the target JMF values.

3. Construction.

a. Take compacted mixture ~~density~~ G_{mb} measurements, except when Class II compaction is specified, no later than the next working day following placement and compaction. Use the field quality control laboratory compaction for field ~~density~~ G_{mb} control, as specified in Article 2303.03, D. The Engineer may accept the ~~density~~ void content of the compacted layer based on cores or calculations from density gauge measurements. The Engineer may waive ~~density measurement~~ field void sampling provided the compaction has been thorough and effective. ~~Take compacted mixture density measurements no later than the next working day following placement and compaction.~~

b. For small quantities, a lot will be the entire quantity of each HMA mixture bid item.
c. The ~~quality index~~ PWL for ~~density~~ field voids will not apply to small quantities.

4. Sampling and Testing.
a. Material sampling and testing is for production quality control only. Acceptance of mixture is based on Contractor certification. Perform a minimum of one aggregate cold-feed and one ~~loose~~ uncompacted HMA test per lot. Sampling and testing of ~~loose~~ uncompacted HMA mixture is only required for mechanically placed mixture. Sample and test according to the Standard Specifications and Materials I.M.s using certified technicians and qualified testing equipment. The Engineer may approve alternative sampling procedures. Take the sample between the first 100 to 200 tons (100 to 200 Mg) of production. No split samples for agency verification testing are required.
b. Asphalt binder will be accepted based on the asphalt supplier's shipment certification. No binder sampling or testing is required.
c. Material sampling or testing is not required for daily HMA production of less than 100 tons (100 Mg) of any mixture on any project.

5. Certification.
a. Provide a certification for the production of any mixture in which the requirements in this article are applied. Place the test results and the following certification statement on the Daily HMA Plant Report (Form 800241).
"The HMA mixture contains certified asphalt binder and approved aggregate as specified in the approved mix design and was produced in compliance with the provisions of Article 2303.03, E"
b. The Daily HMA Plant Report for certified HMA may be submitted at the end of the project for all certified HMA quantities, or submitted at intervals for portions of the certified quantity.

2303.04 METHOD OF MEASUREMENT.

A. Hot Mix Asphalt Mixture.

1. General.
a. Removal of fillets is incidental to the contract unit price for the mixture.
b. If the Contractor chooses to place intermediate or surface mixture in lieu of base for the outside shoulders, the quantity will be calculated from the pavement and shoulder template. If placed as a separate operation, the quantity will be calculated from scale tickets. If the substitute mixture placed on the shoulder is for an intermediate course fillet only, include the quantity in the fillet for payment in the quantity placed in the adjacent intermediate course.
c. Payment for the quality control requirements for small quantities will not be measured separately.

2. Measurement by Weight (Mass).
a. The quantity of the type specified, expressed in tons (megagrams), will be determined from the weight (mass) of individual loads, including fillets, measured to the nearest 0.01 tons (0.01 Mg).
b. Loads may be weighed in trucks, weigh hoppers, or from the weight (mass) from batch plants computed by count of batches in each truck and batch weight (mass). Article 2001.07 applies. Segregate the weights (mass) of various loads into the quantities for each pay item.

3. Measurement by Area.
a. The quantity of the type specified, expressed in square yards (square meters), will be shown in the contract documents to the nearest 0.1 square yard (0.1 m^2).
b. When constructing shoulders on a basis of payment of square yards (square meters), inspection of the profile and elevation will be based on the completed work relative to the pavement edge. The Contractor is responsible for the profile and elevation of the subgrade and for thickness.

B. Asphalt Binder.

1. Measure the amount of asphalt binder used from batch plants, continuous plants, or drum mixing plants by stick measurement in the Contractor's storage tank or in-line flow meter reading, according to Article 2001.07, B.

2. Compute the asphalt binder quantity added to the storage tank using a supplier certified transport ticket accompanying each load.

3. The quantity of asphalt binder not used in the work will be deducted.

4. When the quantity of asphalt binder in a batch is measured by weight (mass) and is separately identified by automatic or semi-automatic printout, the Engineer may compute the quantity of asphalt binder used from this printout. By mutual agreement, this method may be modified when small quantities or intermittent operations are involved.

5. The Engineer will calculate and exclude the quantity of asphalt binder used in mixtures in excess of the tolerance specified in Article 2303.03, D, 3, c.

6. When payment for HMA is based on area, the quantity of asphalt binder used will not be measured separately for payment.

C. Recycled Asphalt Pavement.

1. A completed Daily HMA Plant Report with the certification statement is required for measurement and payment for Contractor Certified HMA. The quantity of asphalt binder will be based on the approved JMF and any plant production quality control adjustments.

2. The quantity of asphalt binder in RAP incorporated into the mixture, will be calculated in tons (megagrams). This quantity shall be based on the actual asphalt binder content determined for the mix design from the results of the Engineer's extraction tests.

3. The quantity of asphalt binder in RAP, which is incorporated into the mix, will be included in the quantity of asphalt binder used.

D. Anti-strip Agent.
Will not be measured separately. The quantity will be based on tons (megagrams) of HMA mixture with anti-strip agent added.

E. Tack Coat.
Will not be measured separately.

F. Fabric Reinforcement.
The quantity, in square yards (square meters) to the nearest 0.1 square yard (0.1 m^2), will be shown in the contract documents.

G. Adjustment of Fixtures.
The Engineer will count the number of fixtures adjusted to the finished grade.

H. Hot Mix Asphalt Pavement Samples.
Will not be individually counted for payment if furnished according to Article 2303.03, D, 5, or required elsewhere in the contract documents,

2303.05 BASIS OF PAYMENT.
The costs of designing, producing, placing, and testing bituminous mixtures and the cost of furnishing and equipping the QM-A field laboratory will not be paid for separately, but are included in the contract unit price for the HMA mixes used. The application of tack coat and sand cover aggregate are incidental and will not be paid for separately. Pollution testing is at the Contractor's expense. The installation of temporary Stop Sign Rumble Strips will not be paid for separately, but is incidental to the price bid for the HMA course for which it is applied.

The quality control requirements for small quantities are incidental to the items of HMA mixtures in the contract.

A. ~~Hot Mix~~ Asphalt Concrete Mixture.

1. Payment will be the contract unit price for Hot Mix Asphalt Mixture of the type specified per ton (megagram) or square yard (square meter).

2. Payment for surface course test strip placement in an intermediate lift will be the contract unit price for Hot Mix Asphalt Mixture, Surface Course, per ton (megagram).

3. Payment will be adjusted by the ~~percentages in Table 2303.05-1 for the quality index for density~~ following Pay Factor for field voids and laboratory voids determined for the lot.

~~**Table 2303.05-1: Payment Adjustment**~~

~~Quality Index (Density) 7 Samples [(a)]~~	~~Percent of Full Payment~~
~~Greater than 0.72~~	~~100~~
~~0.40 to 0.72~~	~~95~~
~~0.00 to 0.39~~	~~85~~
~~Less than 0.00~~	~~75 maximum~~
~~(a) 4 or 6 samples and 1 outlier. Only one outlier will be allowed.~~	

Multiply the unit price for the HMA bid item by the Pay Factor rounded to 3 decimal places.

a) Laboratory Voids

i) Payment when PWL is used for acceptance:

PWL	Pay Factor
95.1 – 100.0	PF = 0.006000*PWL + 0.430
80.0 – 95.0	1.000
50.0 – 79.9	PF = 0.008333*PWL + 0.3333
Less than 50.0	0.750

When PWL is less than 50.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

ii) Payment when AAD is used for acceptance:

AAD from Target Air Void	Pay Factor
0.0 to 1.0	1.000
1.1 to 1.5	0.900
1.6 to 2.0	0.750
Over 2.0	0.500 maximum

When the AAD is more than 2.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

iii) Use the following payment schedule when a test strip is constructed:

AAD from Target Air Void	Pay Factor
0.0 to 1.5	1.000
1.6 to 2.0	PF = 2.5 - AAD
Over 2.0	0.500 maximum

When the AAD is more than 2.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

b) Field Voids

i) Payment when PWL is used for acceptance:

PWL	Pay Factor
95.1 – 100.0	PF = 0.008000*PWL + 0.240
80.0 – 95.0	1.000
50.0 – 79.9	PF = 0.008333*PWL + 0.3333
Less than 50.0	0.750

When PWL is less than 50.0, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

ii) Payment when a test strip is constructed:

Average Field Voids (Pa), %	Pay Factor
0.0 to 9.0	1.000
9.1 to 9.5	PF = 10 - Pa
Over 9.5	0.500 maximum

When the average air void content from a test strip exceeds 9.5%, the Engineer may declare the lot or parts of the lot deficient or unacceptable.

4. When the basis of payment is by area, payment will be further adjusted by the appropriate percentage in Table 2303.05-2 below according to the quality index for thickness determined for that lot:

Table 2303.05-2: Payment Adjustment (by Area) for Thickness

Quality Index (Thickness) ~~78~~ Samples	Percent of Payment (Previously Adjusted for ~~Density~~ Field Voids)
Greater than 0.34	100
0.14 to 0.34	95
0.00 to 0.13	85
Less than 0.00	75 maximum

5. Payment for courses for which quality index (thickness) is not determined because of size or shape, and courses which are found to be deficient in average width, will be according to Article 1105.04.

6. When ~~AASHTO T 283~~ moisture susceptibility testing in accordance with Appendix B of this specification is performed on plant produced mixture, the payment for asphalt mixture will be adjusted according to Table 2303.05-3:

Table 2303.05-3: Asphalt Mixture Payment Adjustment for Moisture Susceptibility

Contracting Authority's Results (Percent TSR)	Pay Factor
TSR ≥ 80	1.00
70 < TSR < 80	PF = 0.025*TSR - 1
TSR ≤ 70	0.75 maximum

B. Asphalt Binder.

1. Payment will be the contract unit price per ton (megagram) for the number of tons (megagrams) of asphalt binder used in the work.

2. Payment for asphalt binder will be for new asphalt binder and the asphalt binder in the RAP which is incorporated in the mixture. The quantity of asphalt binder in ~~classified or unclassified~~ RAP, which is incorporated into the mix, will be calculated in tons (megagrams) of asphalt binder in the RAP. This will be based on the actual asphalt binder content determined for the mix design from the results of the Engineer's extraction test.

3. When the basis of payment for HMA is in square yards (square meters), compensation for asphalt binder will be included in the contract unit price per square yard (square meter).

C. Recycled Asphalt Pavement.

RAP owned by the Contracting Authority will be made available to the Contractor for the recycled mixture at no cost to the Contractor other than loading, hauling, and processing as required for incorporation into the mix.

D. Anti-strip Agent.

1. When anti-strip agent is required ~~according to Article 2303.02, E, 2~~, the incorporation of the anti-strip agent into the asphalt mixture will be considered as extra work ordered by the Engineer if the Contracting Authority's TSR results from the field produced mixture meet or exceed the minimum requirement. Payment will be made at the rate of $2.00 per ton (megagram) of asphalt mixture in which the anti-strip agent is incorporated. For HMA mix

designs with a TSR greater than or equal to 80~~.0~~%, payment will stop when the Contracting Authority's TSR results of the field produced mixture without the agent are greater than or equal to 80~~.0~~%.

2. Payment will be full compensation for designing, adding, and testing for anti-strip agent.

E. Tack Coat.
Incidental to HMA.

F. Fabric Reinforcement.

1. Payment will be the contract unit price for Fabric Reinforcement per square yard (square meter).

2. Payment is full compensation for furnishing all materials, labor, and equipment necessary for installing the fabric as required, including the adhesive or heavy tack coat of asphalt binder used as the adhesive.

G. Adjustment of Fixtures.

1. Payment will be the contract unit price for each.

2. If the contract contains no price for Adjustment of Fixtures, this work will be paid for as provided in Article 1109.03, B.

H. Hot Mix Asphalt Pavement Samples.

1. Payment will be the lump sum contract price for cutting HMA Pavement Samples to determine ~~density~~ field voids or thickness according to the specifications, when either of these is the responsibility of the Contractor, and elsewhere when required by the contract documents.

2. Payment is full compensation for furnishing all such samples for all courses or items of work, and for delivery of samples as specified in Article 2303.03, D, 5.

Appendix A – Control of Asphalt Mixtures

Replace Materials I.M. 511 (appendices excluded) and Materials I.M. 204 Appendix F with the following:

1. SCOPE

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

2. REFERENCE DOCUMENTS

~~Standard Specification 2303 Hot Mix Asphalt~~

AASHTO R 9-90 Acceptance Sampling Plans for Highway Construction

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

3. RESPONSIBILITIES

Materials I.M. 511 Appendix A contains an outline of the responsibilities required for all parties.

The Table of Responsibility, in Materials I.M. 511 Appendix A, is broken up into two main categories, Quality Action and Type of Project. The Type of Project is further broken down into two sub-categories, Certified Plant Inspection (CPI) and QMA, and projects with small quantities. The Quality Action is subdivided into the types of work needing to be performed. These areas are General, Asphalt Binder, Aggregate, Loose Hot Mix, Compacted Hot Mix and Revisions. The table is organized in a way to represent how the work would progress during a Hot Mix Asphalt paving operation.

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

In accordance with Materials I.M. 205, submit a Quality Control Plan to the Engineer prior to the preconstruction meeting. The plan shall include as a minimum items mentioned in Materials I.M. 511 Appendix D.

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

4. SAMPLING & TESTING

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

Only the information obtained from random samples as directed and witnessed by the Engineer and validated by comparison to one or more of the paired samples tested by the Contracting Authority will be used for specification compliance ~~and included in the moving averages~~. Additional samples of aggregate and ~~loose hot mix~~ uncompacted asphalt mixture may be taken to provide better quality control. The results of testing done on additional samples will

be for informational purposes only. Any proposed changes in the quality control and verification sampling/testing frequencies require the approval of the District Materials Engineer.

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

Retain ~~S~~samples taken for acceptance purposes ~~shall be retained~~ until the lot has been accepted.

A. Asphalt Binder

Sample the asphalt binder in accordance with Materials I.M. 323 at the frequency defined in Materials I.M. 204. ~~The procedure used in the sampling of asphalt binder is found in I.M. 323.~~ AASHTO procedures are used in the testing of asphalt binder. ~~The frequencies for taking asphalt binder samples are found in I.M. 204.~~

B. Aggregate

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

1. Sample the aggregate randomly in accordance with Materials I.M. 301 at the frequency defined in Materials I.M. 204.
2. Test the aggregate in accordance with Materials I.M. 335 and Materials I.M. 302.
3. When results from one or more sieves of the specified gradation sample are outside the allowable gradation tolerances, the Engineer may direct and witness one additional aggregate sample or process one loose ~~mix~~ asphalt mixture sample to include in the gradation acceptance decision.

C. ~~LOOSE HOT MIX~~ Uncompacted Asphalt Mixture

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

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

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

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

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

1. **Sampling**
   a. The specific ton or truckload to begin sampling will be determined by the Engineer using a random number system. Obtain production samples as directed and witnessed by the Engineer.
   b. Sample the uncompacted asphalt mixture in accordance with Materials I.M. 322 at the frequency defined in Article 2303.03, D, 3, iii (or higher frequency pre-approved by the Engineer) quality control. Sample at the frequency defined in Materials I.M. 204 for quality assurance.
2. **Testing**
   a. Test the uncompacted asphalt mixture in accordance with Materials I.M. 357, Materials I.M. 350, Materials I.M. 325G, and Materials I.M. 338.
   b. Compact two Gyratory specimens to the number of gyrations specified in the contract documents. The laboratory G_{mb} of each production sample will be determined by averaging the G_{mb} results of the compacted specimens.
   c. Laboratory voids, P_a, for each production sample will be determined from the results of laboratory G_{mb} and the corresponding individual Rice, G_{mm}, results.

d. Calibrate the Rice pycnometer at the beginning of a project and anytime that a correlation problem occurs.

3. Lot Size Determination

For PWL analysis of laboratory voids, lot size is defined as follows:

a. No less than 8 and no more than 20 sequential tests will constitute a lot (exceptions stated below).
b. After the 8th test, all subsequent samples collected over the remainder of that week will also be included in the lot up to a maximum of 20.
c. Once a lot has been established with at least 8 tests, a new lot will begin at the start of the following week or the day following the 20th sample, whichever occurs first. Lots shall not contain partial days. When the 20th sample is reached, include all samples taken that day in the lot.
d. When determining PWL lot size for lab voids, Sunday through Saturday defines a week.
e. If the bid item's production has ended and fewer than 8 tests are available, those tests may be combined with the previous lot provided the maximum lot size has not already been reached. When combining results, if the day to be combined contains the 20th sample, include all samples for that day. Do not combine partial day's results.
f. If samples cannot be combined with the previous lot due to maximum lot size restrictions or if fewer than 8 tests are available for the entire production of a bid item, combine those tests into a single lot and use the AAD analysis in Materials I.M. 501.
g. Test strips will be considered a separate lot.
h. Use Table 2303.03-4 Uncompacted Mixture Sublot Size for determining sublots unless otherwise approved by the Engineer.

D. Compacted Asphalt Mixture ~~HOT MIX~~

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

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

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

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

~~The Quality Index is a statistical measure of the difference between the field density and the minimum required density. The index identifies and compensates for values falling outside the statistical norm (outliers). If the QI results in less than 100% pay, the calculations to identify outliers will be performed. If the calculations identify an outlier at least 2.0 standard deviations from the mean, the outlier will be eliminated and a new QI calculated with the remaining cores. The new QI will be used to determine payment unless it results in a greater penalty. The Quality Index is based on AASHTO R 9-90. The equations used in the determination of the Quality Index are located in the Specifications. Examples on how to calculate the QI as well as outliers are located in IM 501.~~

1. Sampling

a. Sample the compacted asphalt mixture in accordance with Materials I.M. 320 at the frequency of 8 per day (or higher frequency pre-approved by the Engineer).
b. The Engineer will provide inspection staff to direct and witness the sampling and perform G_{mb} measurement during a time agreed between the Engineer and the Contractor. The Engineer should make every effort to meet the Contractor's schedule.
c. The Engineer will transport the cores in accordance with Materials I.M. 320, or secure the cores for transport by the contractor. The Engineer and Contractor will determine that cores are not damaged. The Engineer will decide if a core is damaged prior to testing.

2. Testing

a. Test the compacted asphalt mixture in accordance with Materials I.M. 321 and Materials I.M. 337.
b. Field voids will be based on the average of at least 8 cores taken for each lot. Field voids will be determined using the average field G_{mb} result compared to the average maximum theoretical specific gravity, G_{mm}, obtained from samples, which correspond to the pavement from which the cores were taken.
c. PWL will be calculated using the method described in Materials I.M. 501. The upper and lower specification limits for field voids are 3.5% and 8.5% respectively. If the PWL results in less than 100% payment, the calculations to identify outliers will be performed. If the calculations identify an outlier with a Quality Index (QI) of at least 1.80, the outlier will be eliminated and a new PWL calculated with the remaining cores. The new PWL will be used to determine payment unless it

results in a greater penalty. The Quality Index is based on AASHTO R 9-90. Examples on how to calculate PWL, QI and outliers are located in Materials I.M. 501.

d. Results must be determined and reported within the period of time specified in this Appendix.

3. Lot Size Determination

A lot shall be considered as one layer of one mixture placed during a day's production.

5. VALIDATION

A. Defined

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

B. Aggregate Gradation Correction Factor

When comparing the cold-feed gradation to the ignition oven extracted gradation, a correction factor to adjust the extracted gradation must be determined in accordance with Materials I.M. 501. Validation of the cold-feed gradation will be determined by comparing the cold-feed gradation and the corrected extracted gradation as shown on the comparison report for Cold-Feed & Ignition Oven in Material I.M. 216 Appendix A. The correction factors will be established by comparing an Agency cold-feed sample to an Agency ignition oven extracted sample.

C. Validation Requirements

1. When any of the following events occur, validation has not been achieved or maintained~~.~~:
   a. The difference between test results on each of two consecutive split/paired samples exceeds the Materials I.M. 216 tolerance.
   b. The difference between test results on any two of three consecutive split/paired samples exceeds the Materials I.M. 216 tolerance.
   c. The test results in a series of split/paired samples (minimum of 3 samples, normally no more than 5) are not variable and random (results are consistently higher or results are consistently lower) and the difference between each split/paired test result is greater than half of the Materials I.M. 216 tolerance.
2. Consecutive samples may be either validation samples tested sequentially with another lab or mix specific samples when other mixes are being tested for validation between the two labs. It may be necessary to examine validation of test results on consecutive samples **of the same mix** if more than one mix is being tested between the two labs. Validation problems sometimes only occur during testing of specific mix samples.
3. When validation for a particular test has not been achieved, all results for that day are considered invalid for that test.
4. To achieve or reestablish validation, a minimum of two consecutive test results must meet Materials I.M. 216 tolerances, or when previous split/paired sample results were not variable and random, be within half of the Materials I.M. 216 tolerances.

6. DISPUTE RESOLUTION

A. Investigation

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

1. Retest the same sample
2. The District labs will test additional verification samples.
3. The District Materials Engineer will review the sampling and testing procedures of both labs
4. The District Materials Engineer will immediately test samples sent in by the Contractor without allowing cool down and reheating (hot-to-hot testing).
5. Both labs will test samples using comparable reheat periods.
6. The District Materials Engineer will establish a correction factor based on the reheat evaluation outlined in Materials I.M. 511 Appendix B.
7. Both labs will test a sample that was taken and split by the Engineer.
8. Both labs and a third laboratory designated by the Contracting Authority will test a sample split three ways. The 3rd lab for state projects will normally be the Central Materials Lab.
9. The District Materials Engineer will establish a correction factor for the Contractor's gyratory compactor based on the procedure described in Materials I.M. 511 Appendix C. The correction factor for G_{mb} should not exceed 0.030.

B. Quality Assurance Protocol

1. Resolution decisions by the Iowa DOT Central Materials Laboratory will be final.
2. During the period of production when validation cannot be achieved, the Engineer's test results will be used for acceptance of the lot. Except in the case of Appendix A, 5, C, 1, c, the use of the Engineer's test values for acceptance will be retroactive to the time when the first sample exceeded the validation tolerance. Similarly, when validation is regained, the use of the Contractor's test results for acceptance is retroactive to the first test used to reestablish validation.
   a. Over the period which ~~if~~ validation cannot be achieved for aggregate gradation, the Engineer's test results will be used for the entire gradation and applied to any calculations involving the

gradation for the entire lot.

b. If validation cannot be achieved between the ignition oven extracted gradation and the Contractor's cold-feed gradation, the Agency will run cold-feed gradations for validation in place of the ignition oven.

c. Over the period which ~~If~~ validation cannot be achieved on ~~loose hot mix~~ uncompacted asphalt mixture tests for G_{mm} or G_{mb}, the Engineer's test results will be used ~~for any calculations involving that particular test value for the entire lot~~ as follows:

i. For lots under the PWL acceptance plan,

a) The Engineer's results and any other valid contractor's results for the lot will be used in the calculations for average field voids and average lab voids.

b) If an F-test shows the variance of the Contractor's results for the lot is significantly different (α=0.05) than that of the Engineer's results, and the Engineer's sample size is greater than 3, the Engineer's results will replace all results used in standard deviation calculations for the lot. If not, the Contractor's results will be used in standard deviation calculations for lab voids regardless of whether or not validation is achieved.

c) Use a maximum pay factor of 1.00 for lab voids when the Engineer's results are used.

ii. For all other lots, the Engineer's results will be used for any calculations involving that particular test value.

3. The following tables illustrate an example for implementing the dispute resolution QA protocol. In this example, the Contractor's G_{mb} is invalid on 7/13, 7/15, and 7/16. The Contractor's G_{mm} is invalid on 7/8 and 7/9. Therefore the Engineer's results are used effective on the first day of noncompliance until Article 2303 Appendix A, 5, C, 4 is satisfied.

			Gmb					Gmm				
Day	Lot	Test No.	Contractor	Engineer	Diff	Meet IM 216?	Prevailing Result	Contractor	Engineer	Diff	Meet IM 216?	Prevailing Result
7/8	1	1	2.494	2.499	0.005	Yes	2.494	2.589				
7/8	1	2	2.492				2.492	2.580	2.591	0.011	No	2.591
7/8	1	3	2.487				2.487	2.592				
7/9	1	4	2.478				2.478	2.597				
7/9	1	5	2.499	2.498	0.001	Yes	2.499	2.595	2.606	0.011	No	2.606
7/9	1	6	2.491				2.491	2.586				
7/9	1	7	2.504				2.504	2.583				
7/12	1	8	2.502				2.502	2.567				2.567
7/12	1	9	2.505	2.497	0.008	Yes	2.505	2.580	2.575	0.005	Yes	2.580
7/12	1	10	2.503				2.503	2.580				2.580
7/13	1	11	2.478					2.601				2.601
7/13	1	12	2.480					2.587				2.587
7/13	1	13	2.468	2.489	0.021	No	2.489	2.592	2.590	0.002	Yes	2.592
7/13	1	14	2.476					2.580				2.580
7/14	1	15	2.412					2.583				2.583
7/14	1	16	2.470					2.593				2.593
7/14	1	17	2.484	2.483	0.001	Yes	2.483	2.587	2.580	0.007	Yes	2.587
7/15	1	18	2.461	2.482	0.021	No	2.482	2.581	2.582	0.001	Yes	2.581
7/15	1	19	2.461					2.585				2.585
7/15	1	20	2.471					2.591				2.591
7/16	2	21	2.466	2.487	0.021	No	2.487	2.587	2.590	0.003	Yes	2.587
7/16	2	22	2.484					2.587				2.587
7/16	2	23	2.479					2.594				2.594
7/19	2	24	2.470	2.461	0.009	Yes	2.470	2.584	2.578	0.006	Yes	2.584

The air voids are then calculated using the valid results. For days where the Contractor's G_{mm} was valid, but the G_{mb} was not, the air voids were calculated for each test using the Engineer's G_{mb} for that day and Contractor G_{mm} for that test. The same applies when G_{mb} is valid and G_{mm} is not. Voids are also calculated using just Contractor results and just the Engineer's results for further analysis of variability.

			Lab Voids		
Day	Lot	Test No.	Validated Results	Contractor	Owner
7/8	1	1	3.7	3.7	3.6
7/8	1	2	3.8	3.4	

7/8	1	3	4.0	4.1	
7/9	1	4	4.9	4.6	
7/9	1	5	4.1	3.7	4.1
7/9	1	6	4.4	3.7	
7/9	1	7	3.9	3.1	
7/12	1	8	2.5	2.5	
7/12	1	9	2.9	2.9	3.0
7/12	1	10	3.0	3.0	
7/13	1	11	4.3	4.7	
7/13	1	12	3.8	4.1	
7/13	1	13	4.0	4.8	3.9
7/13	1	14	3.5	4.0	
7/14	1	15	3.9	6.6	
7/14	1	16	4.2	4.7	
7/14	1	17	4.0	4.0	3.8
7/15	1	18	3.8	4.6	3.9
7/15	1	19	4.0	4.8	
7/15	1	20	4.2	4.6	
7/16	2	21	3.9	4.7	4.0
7/16	2	22	3.9	4.0	
7/16	2	23	4.1	4.4	
7/19	2	24	4.4	4.4	4.5

Because the owner has more than 3 test results, an F-test determines which standard deviation to use (Contractor's or Engineer's) in the PWL calculation. Since the F-test p-value is greater than 0.05, the variances are not considered significantly different and the Contractor's standard deviation is used. F-test is calculated in excel as "=FTEST(Contractor's air voids range, Owner's air voids range).

Lot 1 Stdev (contractor)	0.922
Lot 1 Stdev (owner)	0.385
Lot 1 F-test (p-value)	0.06

The validated results are used to calculate the average field voids as shown:

Avg	3.8
Stdev	0.922
Qil	0.916
Qiu	1.252
PWL	71.7

The PWL for Lot 1 is 71.7. Because the Engineer's results were used to calculate the average (and/or standard deviation) for lab voids, the maximum pay factor is 1.00. The G_{mm} used for Field Void calculations also only considers valid results for the lot. The average G_{mm} for valid results is 2.587 for Lot 1.

This example also illustrates when to begin a new lot. The first lot began on Thursday, 7/9/09. Since only 7 tests were run that week (Sun-Sat defines week), the lot carries over to the following week. The 8th test was run on 7/12/09 (Sunday), so the lot includes all tests for the remainder of that week until either the 20th test is reached or Saturday 7/18/09 is reached, whichever comes first. The 20th test was reached on 7/15/09 so the next lot begins on the first test of the following working day (7/16/09). Had more tests been run on 7/15/09 all tests that day would have been included in the lot even though the total lot size would exceed 20. Lots are not divided in the middle of a working day.

7. PRODUCTION TOLERANCES

Production tolerances are listed in the specifications.

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

8. REPORTING

For each production sample of loose ~~HMA~~ asphalt mixture the Contractor will determine, report, and plot (per QMA specification), G_{mb}, G_{mm} and P_a. Binder content measurement by an approved method will be determined, reported,

and plotted daily. Gradation will be determined, reported and plotted daily. Make ~~T~~the inter lab correlation reports ~~shall be made~~ available.

Test results are to be recorded and plotted in the computer programs provided by the Iowa DOT. Copies of the completed Daily HMA Plant Report (Form #800241) summarizing all test results including the field density QI shall be provided to the District Materials Engineer and the Engineer within 4 hours of beginning operations on the next working day. Copies of computer files containing the project information shall be furnished to the Engineer on a CD upon project completion. An additional copy of the files shall be furnished to the DME on a CD.

9. ADJUSTING (TROUBLESHOOTING)

As stated in ~~Standard Specification 2303~~ Article 2303.01, "The Contractor shall be responsible for all aspects of the project, provide Quality Control management and testing, and maintain the quality characteristics specified".

The Contractor is responsible for making changes, as necessary, to achieve target values specified on the JMF. These changes can include adjusting the proportions of aggregate and asphalt binder necessary to meet the JMF. If a change in the target gradation is desired, ~~the Contractor~~ ~~must~~ obtain approval of a new JMF from the District Materials Engineer. Changes in the target gradation cannot be set outside of the control points. The Contractor may change the target binder content to maintain the required mixture characteristics, provided the appropriate documentation and reporting is performed. Report ~~A~~all changes in proportions ~~must be reported~~ on the Daily HMA Plant Report (Form #800241).

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

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

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

10. GUIDANCE TABLES

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

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

Lab Problem Table

The first step is to identify which lab problem is occurring. If “Low Voids” is the identified problem, move down the column to the “Step 1 Check”. Assuming the first check is to be made on the “Binder Content”, move down the column to “Step 2 If”. If the Binder Content is high proceed to “Step 3 Verify”. Each of the shaded items identified in the “Step 3 Verify” should be looked at before proceeding further. Assuming that the items in “Step 3 Verify” are on target, go to “Step 4 Do”. In this case, the action to be taken in “Step 4 Do” is to “Lower Binder” in the mix. In all cases, the items in the “Step 3 Verify” are assumed to be within the allowable tolerances and won’t fall outside of allowable tolerances if the action in “Step 4 Do” is taken.

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

Field Problem Table

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

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

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

Appendix B – Method of Test for Determining Moisture Susceptibility of Asphalt Mixtures

SCOPE

This test method is intended to determine the moisture susceptibility of asphalt paving mixtures by measuring the tensile strength ratio (TSR). The apparatus and procedures are identical with those specified in AASHTO T283-07 with the following variations.

1. 150mm diameter gyratory compacted specimens will be used unless it is determined that the saturation of the conditioned specimens does not penetrate completely to the center of the specimen or if the sample size is insufficient to provide enough material to fabricate 150mm diameter specimens, in which cases 100mm diameter gyratory compacted specimens may be used.

2. When evaluating anti-strip agents for laboratory produced asphalt mixture designs, the wet strength of the conditioned specimens containing the anti-strip agent will be compared to the unconditioned dry strength of specimens without any anti-strip agent to determine the tensile strength ratio (TSR).

NOTE

Additional information on methods of determining the moisture susceptibility of asphalt paving mixtures may be found in Appendix C of this Specification.

Appendix C – Evaluating and Optimizing Anti-Strip Additives

Replace Materials I.M. 510 Appendix C with the following:

When the specifications require a moisture susceptibility evaluation of the asphalt mixture, the Contractor shall test the laboratory mixture design without any anti-strip additive according to Appendix B of this Specification including the cure time and freeze cycle specified. The Engineer will obtain plant-produced samples for acceptance.

During the mixture design phase, if the contractor's TSR results **are greater than or equal to 90%:**

- The contractor may, at the contractor's expense, choose to include an anti-strip additive in the plant produced mixture until moisture susceptibility testing is completed by the Central Laboratory. The contractor shall provide a means to obtain a sample of the plant produced mixture without any anti-strip additive. The Contractor may produce the mixture for sampling as part of the construction of an approved test strip, for shoulders or base, during the initial approximately 500 tons (Mg) of mix production, or during construction off the project if approved by the Engineer. Mixture produced for construction off the project will not be included for payment on the project.

- If the Central Laboratory test results on the plant produced mix without any anti-strip agent indicate a TSR less than 80%, an anti-strip additive evaluated and optimized as indicated below will be required for all subsequent production of the mix, and the Contractor will be paid at the specified rate for incorporating the anti-strip additive into the mixture if the agent is effective in achieving the minimum TSR. The Engineer may obtain samples of the mix containing the anti-strip additive for moisture susceptibility testing at any time. If the Central Laboratory test results on the plant produced mix without any anti-strip agent indicate a TSR greater than or equal to 80%, no anti-strip agent is required and no payment for anti-strip will be made.

During the mixture design phase, if the contractor's TSR results **are between 80% and 90%:**

- If the contractor is unable to provide samples of the plant produced mixture with the JMF far enough in advance of paving to accommodate moisture susceptibility testing by the Central Laboratory, the Contractor shall select an anti-strip additive for use in the mixture. The anti-strip additive shall be evaluated and optimized as indicated below.

- The contractor shall provide a means to obtain a sample of the plant produced mixture without any anti-strip additive as detailed above. Once a sample without any anti-strip additive is obtained for testing in the Central Laboratory, the Contractor shall incorporate the selected anti-strip additive at the optimum dosage into the mixture for all subsequent production until test results from the Central Laboratory are available. The Contractor will be paid at the specified rate for incorporating the anti-strip additive into the mixture until Central Laboratory test results are available. Payment will be made provided the agent is effective in achieving the minimum TSR.

- If the Central Laboratory test results on the plant produced mixture without any anti-strip additive indicate a TSR of 80.0% or greater, the anti-strip additive will no longer be required and no further payment for the anti-strip additive will be made after the test results are provided to the contractor. If the Central Laboratory test results on the plant produced mixture without any anti-strip additive indicate a TSR of less than 80.0%, the anti-strip additive shall be used for all subsequent production of the mixture. No price adjustment for failing TSR will be applied to the plant produced mixture required to be provided for sampling and testing without an anti-strip additive.

During the mixture design phase, if the contractor's TSR results **are less than 80%:**

- The Contractor shall select an anti-strip additive for use in the mix. The anti-strip additive shall be evaluated and optimized as indicated below. The contractor will be paid at the specified rate for incorporating the anti-strip additive into the mixture provided it is effective in achieving the minimum TSR. The Engineer will obtain samples of the plant produced mixture for moisture susceptibility testing in the Central Laboratory. If the Contractor elects to incorporate hydrated lime into the total combined aggregate at the rates specified no testing of the plant produced mixture will be required. The Engineer may obtain samples for testing at any time.

Evaluation and optimization of anti-strip additives:

- If the Contractor elects to incorporate hydrated lime into the total combined aggregate at the rates required by the specifications, no further testing by the contractor will be required. If the contractor elects to use a liquid anti-strip additive, a polymer-based liquid aggregate treatment, or pre-coats part of the aggregate with hydrated lime, the contractor shall test the mixture at a minimum of three different dosages of the anti-strip additive to determine the effectiveness and optimum rate of addition to the mix. The dosages tested shall

cover the range of dosages recommended by the supplier of the anti-strip additive or, in the case of hydrated lime, at dosages agreed to by the District Materials Engineer (DME). The Contractor shall include the data from the moisture susceptibility testing in the electronic file (SHADES) and submit the file to the DME. The DME will evaluate the data and recommend an optimum dosage of anti-strip additive based on effectiveness and economic evaluation.

- When testing to evaluate or optimize the anti-strip additive, the test procedure in AASHTO T283 is modified as follows: The indirect tensile strength of the conditioned specimens containing the anti-strip additive shall be compared to the dry strength obtained during the initial testing of the mix design without any anti-strip additive to calculate the TSR value. This is necessary because some anti-strip additives have been shown to lower the dry strength of the mixture rather than increase the wet strength in order to improve the TSR. When liquid anti-strip additives are used, the anti-strip additive shall be added to the asphalt binder, thoroughly mixed, and placed in an oven at 275°F for a minimum of 16 hours prior to mixing with the aggregates. The supplier of the asphalt binder may provide samples of the binder with the anti-strip additive already blended and aged.