

SECTION 23 – ASPHALT CONCRETE

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SECTION 23 - ASPHALT CONCRETE

23-1 GENERAL

Section 23 includes general specifications for producing and placing hot mix asphalt (HMA).

HMA includes one or more of the following types:

HMA-LG

RHMA-G

HMA activity not covered by this section shall conform to the most current edition of Section 39 of the State of California Department of Transportation Standard Specifications.

“AC” is the same as “Hot Mix Asphalt” or HMA”. “Asphalt Rubber Hot Mix” or “ARHM” is the same as “Rubberized Hot Mix Asphalt” or “RHMA”.

The Contractor's operations must be conducted in a manner that will not harm or damage existing facilities or improvements.

At locations where public traffic is routed over the base grade, the Contractor must plan the paving operations to minimize the delay of traffic.

The Contractor, when required to provide for the passage of public traffic through the work, must do so in accordance with the provisions of Section 12, "Construction Area Traffic Control", of these Specifications.

23-1.01 Description

Section 23 includes specifications for producing and placing HMA. The Contractor may produce HMA using an authorized WMA technology.

HMA-LG is not for HMA to be used for asphalt dikes. Dike mix will be in accordance with Caltrans Section 39.

The Contractor may not use Section 23 for HMA to be produced and placed on a State (Caltrans) Highway. HMA for production and placement on a State Highway must conform to Section 39 of the Caltrans Standard Specifications, and corresponding Revised Standard Specifications and Special Provisions, as specified and required by Caltrans.

References to the Caltrans Standard Specifications are to the most current edition of the State of California Department of Transportation Standard Specifications.

23-1.02 Abbreviations

Abbreviations used in Section 23 are those listed in 1-1.06 of the Caltrans Standard Specifications and Section 1-2 of these specifications.

23-1.03 Definitions

The following terms as used in Section 23 are defined as follows:

binder replacement: Binder from RAP expressed as a percent of the total binder in the mix.

coarse aggregate: Aggregate retained on a No. 4 sieve.

fine aggregate: Aggregate passing a No. 4 sieve.

manufactured sand: Fine aggregate produced by crushing rock or gravel.

non-manufactured sand: Fine aggregate not produced by crushing gravel or rock.

Reclaimed Asphalt Pavement (RAP): Removed and/or reprocessed pavement materials containing asphalt and aggregates

processed RAP: RAP that has been fractionated.

supplemental fine aggregate: Mineral filler consisting of rock dust, slag dust, hydrated lime, hydraulic cement, or any combination of these and complying with AASHTO M 17.

Warm Mix Asphalt (WMA): HMA produced using a warm mix asphalt technology.

Additional terms are as defined in Section 1-1.07 of the Caltrans Standard Specifications.

23-1.04 Submittals

Submittals are required in various sections of Section 23. The Contractor shall submit the required submittals on or prior to the time specified.

23-1.05 Prepaving Conference

Before paving operations begin, the Agency holds a prepaving conference with the Contractor to discuss HMA production and placement.

23-2 QUALITY ASSURANCE**23-2.01 General**

Quality Assurance as used in Section 23 is composed of Contractor Quality Control, Independent Assurance, Dispute Resolution, Personnel Qualification, and Laboratory Qualification.

23-2.02 Laboratories

Laboratories testing aggregate and HMA qualities used to prepare the mix design and JMF, and Independent Third Party laboratories performing dispute resolution testing, must be qualified under the AASHTO resource program and the Caltrans Independent Assurance Program. A list of qualified laboratories is shown in the Caltrans Statewide Independent Assurance Database:

<https://sia.dot.ca.gov/index.php>

23-2.03 Hot Mix Asphalt Plants

Before production, the HMA plant must conform to all requirements of Section 39 of the Caltrans Standard Specifications.

23-2.04 Test Methods

The year of publication for referenced test methods shall be as specified in Section 39 of the Caltrans Standard Specifications. Use the most current edition of any test method not specified in Section 39 of the Caltrans Standard Specifications.

The Contractor shall take samples under California Test 125. Reduce samples of HMA to testing size under California Test 306.

23-2.05 Quality Control**23-2.05.A General**

The Contractor is responsible for Quality Control. Quality Control activities are required in various sections of Section 23.

23-2.05.B Quality Control Plan

At least 5 business days prior to the pre-paving meeting, the Contractor shall submit a QC plan for HMA. The QC plan must describe the organization and procedures for:

1. Controlling HMA quality characteristics
2. Taking and splitting samples, including sampling locations
3. Establishing, implementing, and maintaining QC
4. Determining when corrective actions are needed
5. Implementing corrective actions
6. Using methods and materials for backfilling core locations

The QC plan must address the elements affecting HMA quality, including:

1. Aggregates
2. Asphalt binder
3. Additives

4. Production

5. Paving

The Contractor shall allow 5 business days for review of the QC plan.

If the Contractor changes QC procedures, personnel, or sample testing locations, they must submit a QC plan supplement before implementing the proposed change. The Contractor shall allow 3 business days for review of the QC plan supplement.

23-2.06 Dispute Resolution

The Contractor and the Engineer must work together to avoid potential conflicts and to resolve disputes regarding test result discrepancies. The Contractor and the Engineer may only dispute each other's test results if one party's test results pass, and the other party's test results fail.

If there is a dispute, the Contractor shall submit test results and copies of paperwork including testing worksheets used to determine the disputed results within 3 business days of receiving Engineer's test results. An independent third party performs referee testing. Before the third party participates in a dispute resolution, it must be qualified under AASHTO resource program and the California Department of Transportation's Independent Assurance Program for the tests being disputed. The independent third party must have no prior direct involvement with this Contract. By mutual agreement, the independent third party is chosen from among laboratories not currently employed by the Contractor or the Contractor's HMA producer. The independent third party laboratory shall be identified prior to the start of work. Independent third party testing shall be performed at the Contractor's expense, and no additional compensation will be paid.

The Agency is responsible for receiving and maintaining split samples. If the Agency's portion of the split acceptance samples are not available, the independent third-party samples and uses any available material agreed on by the Contractor and the Engineer as representing the disputed HMA for evaluation. When addressing disputes related to density, only cores shall be used.

The results of the tests performed by the independent third party shall prevail.

23-3 MATERIALS

23-3.01 Aggregates

23-3.01.A General

Aggregates must be clean and free from deleterious substances.

23-3.01.B Quality

Before the addition of asphalt binder, the aggregates must comply with the requirements shown in the following table:

Aggregate Quality - HMA-LG

Quality Characteristic	Test Method	Requirement
Percent of crushed particles: Coarse aggregate (min, %) One-fractured face Two-fractured faces Fine aggregate (min, %) (Passing No. 4 sieve and retained on No. 8 sieve.) One-fractured face	AASHTO T 335	95 90 70
Los Angeles Rattler (max, %) Loss at 100 Rev. Loss at 500 Rev.	AASHTO T 96	12 40
Sand equivalent (min) ^a	AASHTO T 176	47
Flat and elongated particles (max, % by weight at 5:1)	ASTM D4791	10
Fine aggregate angularity (min, %) ^b	AASHTO T 304, Method A	45
<p>A. The reported value must be the average of 3 tests from a single sample. Use of a sand reading indicator is required as shown in AASHTO T 176, Figure 1. Sections 4.7, "Manual Shaker," 7.1.2, "Alternate Method No. 2," and 8.4.3, "Hand Method," do not apply. Prepare the stock solution as specified in section 4.8.1, "Stock solution with formaldehyde," except omit the addition of formaldehyde.</p> <p>B. The Engineer waives this specification if the HMA-LG contains 10 percent or less of non-manufactured sand by weight of total aggregate, except if the Contractor's JMF fails verification.</p>		

23-3.01.C Gradations

The aggregate gradations of HMA-LG must comply with the requirements shown in the following table:

Aggregate Gradation Requirements

HMA-LG pavement thickness shown	Gradation
0.10 foot	3/8 inch
Greater than 0.10 to less than 0.20 foot	1/2 inch
0.20 foot or greater	3/4 inch

Aggregate gradation must be within the Target Value (TV) limits for the specified sieve size shown in the following tables:

Aggregate Gradations for HMA-LG**3/4 inch**

Sieve size	Target value limit	Allowable tolerance
1"	100	--
3/4"	90-98	TV \pm 5
1/2"	70-90	TV \pm 6
No. 4	42-58	TV \pm 5
No. 8	29-43	TV \pm 5
No. 30	10-23	TV \pm 4
No. 200	2.0-7.0	TV \pm 2.0

1/2 inch

Sieve size	Target value limit	Allowable tolerance
3/4"	100	--
1/2"	95-98	TV \pm 5
3/8"	72-95	TV \pm 5
No. 4	52-69	TV \pm 5
No. 8	35-55	TV \pm 5
No. 30	15-30	TV \pm 4
No. 200	2.0-8.0	TV \pm 2.0

3/8 inch

Sieve size	Target value limit	Allowable tolerance
1/2"	100	--
3/8"	95-98	TV \pm 5
No. 4	55-75	TV \pm 5
No. 8	30-50	TV \pm 5
No. 30	15-35	TV \pm 5
No. 200	2.0-9.0	TV \pm 2.0

23-3.02 Reclaimed Asphalt Pavement

The Contractor shall provide enough space at the Contractor's plant for complying with all RAP handling requirements.

The Contractor shall provide a clean, graded base, well drained area for stockpiles.

If RAP is from multiple sources, the Contractor shall blend the RAP thoroughly and completely before fractionating.

For RAP substitution of 15 percent of the aggregate blend or less, fractionation is not required.

For RAP substitution greater than 15 percent of the aggregate blend, the contractor shall fractionate RAP stockpiles into 2 sizes, a coarse fraction RAP retained on 3/8-inch sieve and a fine fraction RAP passing 3/8-inch sieve.

The RAP fractionation must comply with the requirements shown in the following table:

RAP Stockpile Fractionation Gradation Requirements

Size	Test method	Requirement
Coarse (% passing the 1-inch sieve)	California Test 202 ^a	100
Fine (% passing the 3/8-inch sieve)	California Test 202 ^a	98-100

A. Maximum mechanical shaking time is 10 minutes.

The Contractor may use the coarse fractionated stockpile, the fine fractionated stockpile, or a combination of the coarse and fine fractionated stockpiles.

The Contractor shall isolate the processed RAP stockpiles from other materials. Store processed RAP in conical or longitudinal stockpiles. Processed RAP must not be agglomerated or be allowed to congeal in large stockpiles.

23-3.03 Asphalt Binder

Asphalt binder must comply with section 92 of the Caltrans Standard Specifications.

The grade of asphalt binder for HMA-LG shall be PG 70-10.

RHMA-G shall use PG 64-16 base.

23-3.04 Liquid Antistrip

The Contractor shall not use liquid antistrip as a substitute for asphalt binder.

Total amine value for amine-based liquid antistrip must be a minimum of 325 when tested under ASTM D2074. Dosage for amine-based liquid antistrip must be from 0.25 to 1.00 percent by weight of asphalt.

Non-volatile content of organosaline-based liquid antistrip must be 40 percent minimum when tested under ASTM D5095. Dosage for organosaline-based liquid antistrip must be from 0.05 to 0.15 percent by weight of asphalt.

The Contractor shall use only 1 liquid antistrip type or brand at a time. Do not mix liquid antistrip types or brands.

The Contractor shall store and mix liquid antistrip under the manufacturer's instructions.

23-3.05 Tack Coat

Tack coat must comply with the specifications for asphaltic emulsion or asphalt binder in the Caltrans Standard Specifications. The Contractor shall choose the type and grade of emulsion or binder.

23-4 MIX DESIGNS

23-4.01 General

The HMA mix design must comply with the Superpave HMA mix design as described in Asphalt Institute publication MS-2, "Asphalt Mix Design Methods", 7th Edition.

The Contractor Hot Mix Asphalt Design Data form must show documentation on aggregate quality.

Where more than one source or supplier is designated to supply AC, those mixes must be kept separate. The mixes must not be intermixed in the same lift or section of pavement. At least 20 working days before incorporating the materials in the work, the Contractor must submit paving plans showing where the mixes from each source will be used. This plan will be subject to approval by the Agency and will be reviewed and returned to the Contractor within 10 working days.

23-4.02 Requirements

23-4.02.A General

The mix design for HMA-LG must comply with the requirements shown in the following table:

HMA-LG

Quality Characteristic	Test Method	Requirement
Air voids content (%)	AASHTO T 269 ^a	$N_{\text{initial}} > 8.0$ $N_{\text{design}} = 4.0$ $N_{\text{max}} > 2.0$
Gyrations compaction (no. of gyrations)	AASHTO T 312	$N_{\text{initial}} = 8$ $N_{\text{design}} = 85.0$ $N_{\text{max}} = 130$
Voids in mineral aggregate (min, %) ^b Gradation: 3/8-inch 1/2-inch 3/4-inch	MS-2 Asphalt Mixture Volumetrics	15.5–18.5 14.5–17.5 13.5–16.5
Dust proportion	MS-2 Asphalt Mixture Volumetrics	0.6–1.3
Hamburg wheel track (min number of passes at 0.5-inch rut depth) Binder grade: PG 58 PG 64 PG 70 PG 76 or higher	California Test 389 ^c	10,000 15,000 20,000 25,000

- A. Calculate the air voids content of each specimen using AASHTO T 275, Method A, to determine bulk specific gravity. Use AASHTO T 209, Method A, to determine theoretical maximum specific gravity. Use a digital manometer when performing AASHTO T 209.
- B. Measure bulk specific gravity using AASHTO T 275, Method A.
- C. Test plant-produced HMA-LG.

23-4.02.B Reclaimed Asphalt Pavement

You may substitute RAP for part of the virgin aggregate in a quantity up to 25 percent of the aggregate blend.

For HMA-LG mixtures using RAP, the maximum allowed binder replacement is 25.0 percent in the upper 0.2 foot and 40.0 percent below. The binder replacement is calculated as a percentage of the approved JMF target asphalt binder content.

For RAP substitution of 15 percent or less, the grade of the virgin binder must be the specified grade of asphalt binder for HMA-LG.

For RAP substitution greater than 15 percent and not exceeding 25 percent, the grade of the virgin binder must be the specified grade of asphalt binder for HMA-LG with the upper and lower temperature classification reduced by 6 degrees C. Hamburg wheel track requirements are based on the grade of asphalt binder specified for HMA-LG.

23-4.02.C Treatments

If the proposed JMF indicates the HMA is being treated with liquid antistrip, then testing the mix with untreated aggregate in accordance with California Test 389 is not required.

If HMA treatment is required or being used by the Contractor, determine the plasticity index of the aggregate blend in accordance with California Test 204.

The Contractor shall not use an aggregate blend with a plasticity index greater than 4.

If the plasticity index is less than 4, The Contractor shall treat the HMA with liquid antistrip.

Liquid antistrip must be from 0.25 to 1.0 percent by weight of asphalt binder. The Contractor shall not use liquid antistrip as a substitute for asphalt binder.

23-4.02.D Warm Mix Asphalt Technology

For HMA with WMA additive technology, The Contractor shall produce HMA mix samples for the Contractor's mix design using the Contractor's methodology for inclusion of WMA admixture in laboratory-produced HMA. The mix samples shall be cured in a forced-air draft oven at 275 degrees F for 4 hours \pm 10 minutes.

For WMA water injection foam technology, the use of foamed asphalt for mix design is not required.

23-4.03 Job Mix Formulas**23-4.03.A General**

The JMF must be based on the Superpave HMA mix design as described in "*Asphalt Institute publication MS-2, "Asphalt Mix Design Methods"*, 7th Edition as modified herein.

23-4.03.B Submittals**23-4.03.B.1 General**

The Contractor shall submit the proposed JMF for each type of HMA to be used. The JMF must be submitted on Caltrans form CEM-3511, Contractor Job Mix Formula Proposal, along with:

1. Mix design documentation on a Caltrans form CEM-3512, Contractor Hot Mix Asphalt Design Data, dated within 24 months of the submittal date.
2. When required by Special Provisions, JMF verification on a Caltrans Hot Mix Asphalt Verification form and the Contractor Hot Mix Asphalt Design Data form that was submitted for the JMF verification, if applicable.
3. When required by Special Provisions, JMF renewal on a Caltrans Job Mix Formula Renewal form, if applicable.
4. SDS for:
 - 4.1. Asphalt Binder
 - 4.2. Supplemental fine aggregate except fines from dust collectors
 - 4.3. Antistrip additives

The Caltrans Contractor Hot Mix Asphalt Design Data form must identify the AASHTO re:source accredited lab responsible for the mix design and show documentation on aggregate quality.

Submit a new JMF if the Contractor changes any of the following:

1. Target asphalt binder percentage greater than \pm 0.2 percent
2. Asphalt binder supplier
3. Combined aggregate gradation
4. Aggregate sources
5. Liquid antistrip producer or dosage
6. Average binder content in a new processed RAP stockpile by more than \pm 2.00 percent from the average RAP binder content reported on page 4 of the Contractor Hot Mix Asphalt Design Data form

7. Any material in the JMF

Allow the Engineer 20 business days from a complete JMF submittal for document review of the design data (if submitted) and the JMF. The Engineer will notify the Contractor if the proposed JMF submittal is accepted.

23-4.03.B.2 Liquid Antistrip Treatment

If liquid antistrip treatment is used, the Contractor shall submit the following with the Contractor's proposed JMF submittal:

1. Certificate of Compliance for each liquid antistrip shipment. On each Certificate of Compliance, include:
 - 1.1. The Contractor's signature and printed name
 - 1.2. Shipment number
 - 1.3. Material type
 - 1.4. Material specific gravity
 - 1.5. Manufacturer
 - 1.6. Consignee
 - 1.7. Destination
 - 1.8. Quantity
 - 1.9. Contact or purchase order number
 - 1.10. Shipment date
2. Proposed proportions for the liquid antistrip

23-4.03.B.3 Warm Mix Asphalt Technology

If a WMA technology is used, the Contractor shall submit the following with the Contractor's proposed JMF submittal:

1. SDS for the WMA technology
2. For water injection foam technology:
 - 2.1. Name of technology
 - 2.2. Proposed foaming water content
 - 2.3. Proposed HMA production temperature range
 - 2.4. Certification from binder supplier stating no antifoaming agent is used
3. For additive technology:
 - 3.1. Name of technology
 - 3.2. Percent admixture by weight of binder and percent admixture by total weight of HMA as recommended by the manufacturer
 - 3.3. Methodology for inclusion of admixture in laboratory-produced HMA
 - 3.4. Proposed HMA production temperature range

23-4.03.C Verification

The Agency may verify the JMF. Verification will be performed by the Agency. The cost of verification is paid by the Agency. The Contractor shall perform the sampling at the Contractor's own expense as follows:

The production set point at the plant must be within ± 0.2 from the asphalt binder percentage TV shown in the Contractor Job Mix Formula Proposal form. The Contractor shall notify the Engineer at least 2 business days before sampling materials. Samples may be taken from a different project including a non-Agency project if the Contractor makes arrangements for the Engineer to be present during sampling.

In the Engineer's and Agency Lab's presence and from the same production run, the Contractor shall take samples of:

1. Aggregates. Coarse, fine, and supplemental fine aggregates must be taken from the

2. combined cold-feed belt or the hot bins. Samples must be at least 120 pounds for each coarse aggregate, 80 pounds for each fine aggregate, and 10 pounds for each type of supplemental fine aggregate. For hot-bin samples, the Department combines these aggregate samples to verify the TV submitted on a Contractor Job Mix Formula Proposal form.
3. Asphalt binder. Take at least two 1-quart samples. Each sample must be in a cylindrical-shaped can with an open top and friction lid. If the asphalt binder is modified or rubberized, the asphalt binder must be sampled with the components blended in the proportions to be used.
4. RAP. Samples must be at least 50 pounds from each fractionated stockpile used or 100 pounds from the belt.
5. Plant-produced HMA. The HMA samples must be at least 250 pounds.

For aggregate, RAP, and HMA, the Contractor shall split the samples into at least 4 parts and label their containers. The Contractor shall submit 3 parts and keep 1 part.

After acceptance of the JMF submittal, the Agency will verify each proposed JMF within 20 days of receiving all verification samples.

For JMF verification, the Agency Lab will test the following for compliance with the specifications:

1. Aggregate quality
2. Aggregate gradation
3. HMA quality characteristics for Agency acceptance

To verify the HMA for air voids, voids in mineral aggregate, and dust proportion, the Agency Lab will use an average of 3 briquettes. The Agency Lab will test plant-produced material.

If the Agency Lab verifies the JMF, the Engineer will furnish the Contractor a Hot Mix Asphalt Verification form.

The Contractor may submit an adjusted aggregate gradation TV on a Contractor Job Mix Formula Proposal form before verification testing. Aggregate gradation TV must be within the TV limits specified.

If the Agency Lab test results on plant-produced samples do not show compliance with the specifications, the Engineer will notify the Contractor. The Contractor shall submit an adjusted JMF after verification of failure based on the Contractor's testing unless the Engineer authorizes reverification without adjustments. The adjusted JMF must include a new Contractor Job Mix Formula Proposal form, Contractor Hot Mix Asphalt Design Data form, and the results of the failed verification testing. Engineer-authorized reverification without adjustment is not JMF adjusted after verification failure. A JMF adjusted after verification failure may include a change in:

1. Asphalt binder content TV up to ± 0.20 percent from the OBC value submitted on the Contractor Hot Mix Asphalt Design Data form
2. Aggregate gradation TV within the TV limits specified in the aggregate gradation table

The Contractor may adjust the JMF only once due to a failed verification test.

The Agency Lab will verify up to 2 proposed JMF submittals including a JMF adjusted after verification failure. The Contractor shall not resubmit any of the 2 proposed submittals including a JMF adjusted after verification failure that failed verification on any other Agency projects.

A verified JMF is valid for 24 months.

In lieu of Agency-performed verification testing, the Agency may accept the results of verification testing performed by another City or County within 24 months for the same HMA JMF, aggregate size and source, and asphalt binder.

23-4.03.D Authorization

The Contractor may start HMA production if:

1. The Engineer's review of the JMF shows compliance with the specifications.
2. Verification is required, the JMF has been verified within 24 months before HMA production

3. The Agency performs verification testing; the Engineer authorizes the verified JMF.
4. The Contractor QC plan has been reviewed and approved.

23-4.03.E Renewal

The JMF must be verified for renewal from samples taken from the plant to be used. The laboratory who performs the verification must be qualified under the AASHTO resource program and the Caltrans Independent Assurance Program. The Contractor shall pay the cost of the JMF renewal.

The Contractor may request a JMF renewal by submitting:

1. Proposed JMF on a Contractor Job Mix Formula Proposal form
2. Previously verified JMF documented on a Caltrans Hot Mix Asphalt Verification form dated within 24 months
3. Mix design documentation on a Contractor Hot Mix Asphalt Design Data form used for the previously verified JMF

For a JMF renewal and upon request, in the Engineer's presence and from the same production run, the Contractor shall take samples of:

1. Aggregates. Coarse, fine, and supplemental fine aggregates must be taken from the combined cold-feed belt or the hot bins. Samples must be at least 120 pounds for each coarse aggregate, 80 pounds for each fine aggregate, and 10 pounds for each type of supplemental fines. For hot-bin samples, the Agency combines these aggregate samples to verify the TV submitted on a Contractor Job Mix Formula Proposal form.
2. Asphalt binder. Take at least two 1-quart samples. Each sample must be in a cylindrical-shaped can with an open top and friction lid. If the asphalt binder is modified or rubberized, the asphalt binder must be sampled with the components blended in the proportions to be used.
3. RAP. Samples must be at least 50 pounds from each fractionated stockpile.
4. Plant-produced HMA. The HMA samples must be at least 250 pounds.

The Contractor shall notify the Engineer at least 2 business days before sampling materials. For aggregate, RAP, and HMA, the Contractor shall split samples into at least 4 parts. The Contractor shall submit 3 parts and use 1 part for Contractor testing.

The Contractor shall allow the Agency 20 business days from a complete JMF reverification submittal for document review of the aggregate qualities, mix design, and JMF.

The most recent aggregate quality test results within the past 12 months may be used for verification of JMF renewal.

The Agency may verify the JMF for renewal, at its own expense, in accordance with Section 23-4.03.C except:

1. The Engineer keeps the samples until the Contractor provides test results for the Contractor's part on a Contractor Job Mix Formula Renewal form.
2. The Agency Lab tests samples of materials obtained from the HMA production until after you submit test results that comply with the mix design specifications.
3. After completion of the JMF verification renewal document review, the Agency Lab verifies each proposed JMF within 20 days of receiving the verification renewal samples and the complete Contractor Job Mix Formula Renewal form.
4. The Contractor may not adjust the JMF due to a failed verification.

The Engineer will furnish the Contractor an HMA Verification form.

The HMA Verification form is valid for 24 months.

23-4.03.F Modification

For an authorized JMF, the Contractor shall submit a modified JMF if there are changes to any of the following:

1. Asphalt binder supplier
2. Liquid antistrip producer
3. Liquid antistrip dosage

The Contractor may change any of the above items only once during the Contract.

The Agency may authorize a JMF modification based upon review or require verification. The laboratory who prepares the JMF modification and, if requested, verification, must be qualified under the AASHTO resource program and the Caltrans Independent Assurance Program. The Contractor shall pay the cost of the modified JMF verification.

The Contractor shall submit the modified JMF request at least 20 days before production. Each modified JMF submittal must include:

1. Proposed modified JMF on Contractor Job Mix Formula Proposal form, marked *Modified*.
2. Mix design records on Contractor Hot Mix Asphalt Design Data form for the authorized JMF to be modified.
3. JMF verification on Hot Mix Asphalt Verification form for the authorized JMF to be modified.
4. Test results for the modified JMF in compliance with the mix design specifications. Perform tests at the mix design OBC as shown on the Contractor Asphalt Mix Design Data form.

With an accepted modified JMF submittal, the Agency Lab will verify each modified JMF within 20 days of receiving all verification samples.

The Agency Lab will verify the modified JMF after the modified JMF HMA is placed and verification samples are taken within the first 500 tons. The Agency Lab will test verification samples for compliance with:

1. Air void content
2. Voids in mineral aggregate on plant-produced HMA mix design specifications
3. Dust proportion mix design specifications

If the modified JMF is verified, the Engineer will revise the Contractor's Hot Mix Asphalt Verification form to include the new asphalt binder source, new liquid antistrip producer, or new liquid antistrip dosage. The Contractor's revised form will have the same expiration date as the original form.

23-5 PRODUCTION**23-5.01 General**

The Contractor shall not start HMA production before authorization of the JMF.

Weighing and metering devices used for the production of HMA modified with additives must conform to all requirements of Section 39 of the Caltrans Standard Specifications.

If a loss-in-weight meter is used for dry HMA additive, the meter must have an automatic and integral material delivery control system for the refill cycle.

The loss-in-weight meter shall be calibrated by:

1. Including at least 1 complete system refill cycle during each calibration test run
2. Operating the device in a normal run mode for 10 minutes immediately before starting the calibration process
3. Isolating the scale system within the loss-in-weight feeder from surrounding vibration
4. Checking the scale system within the loss-in-weight feeder for accuracy before and after the calibration process and daily during mix production

5. Using a minimum 15 minute or minimum 250-pound test run size for a dry ingredient delivery rate of less than 1 ton per hour.
6. Complying with the limits of Table B, "Conveyor Scale Testing Extremes," in the Caltrans' MPQP.

Aggregate shall be proportioned by hot or cold-feed control.

HMA-LG asphalt binder temperature must be from 275 to 375 degrees F when mixed with aggregate.

HMA ingredients shall be mixed into a homogeneous mixture of coated aggregates.

HMA-LG must be produced at the temperatures shown in the following table:

HMA-LG Production Temperatures		
HMA compaction		Temperature (°F)
HMA-LG		
	Density based	≤ 325
HMA-LG with WMA technology		
	Density based	240–325

If RAP is used, the asphalt plant must automatically adjust the virgin asphalt binder to account for RAP percentage and RAP binder.

During production, the Contractor may adjust hot- or cold-feed proportion controls for virgin aggregate and RAP. For RAP substitution of 15 percent or less, RAP must be within ± 3 of RAP percentage shown in the Contractor Job Mix Formula Proposal form without exceeding 15 percent. For RAP substitution of greater than 15 percent, RAP must be within ± 3 of RAP percentage shown in the Contractor Job Mix Formula Proposal form without exceeding 25 percent.

23-5.02 Warm Mix Asphalt Technology

All ingredients shall be proportioned by weight. The HMA plant process controller must be the sole source of ingredient proportioning control and be fully interfaced with all scales and meters used in the production process. The addition of the HMA additive must be controlled by the plant process controller.

Liquid ingredient additive, including a normally dry ingredient made liquid, must be proportioned with a mass flow meter at continuous mixing plants. A mass flow meter or a container scale to proportion liquid additives at batch mixing plants shall be used.

Continuous mixing plants using HMA additives must comply with the following:

1. Dry ingredient additives for continuous production must be proportioned with a conveyor scale or a loss-in-weight meter.
2. HMA plant process controller and ingredient measuring systems must be capable of varying all ingredient-feed rates proportionate with the dry aggregate delivery at all production rates and rate changes.
3. Liquid HMA additive must enter the production stream with the binder. Dry HMA additive must enter the production stream at or before the mixing area.
4. If dry HMA additives are used at continuous mixing HMA plants, bag-house dust systems must return all captured material to the mix.
5. HMA additive must be proportioned to within ± 0.3 percent of the target additive rate.

Batch mixing plants using HMA additives must comply with the following:

1. If a container scale is used, weigh additive before combining with asphalt binder. Keep the container scale separate from other ingredient proportioning. The container scale capacity must be no more than twice the volume of the maximum additive batch size. The container scale's graduations must be smaller than the proportioning tolerance or

2. 0.001 times the container scale capacity.
3. Dry HMA additive proportioning devices must be separate from metering devices for the aggregates and asphalt binder. Proportion dry HMA additive directly into the pugmill, or place in an intermediate holding vessel to be added to the pugmill at the appropriate time in the batch cycle. Dry ingredients for batch production must be proportioned with a hopper scale.
4. Zero tolerance for the HMA additive batch scale is ± 0.5 percent of the target additive weight. The indicated HMA additive batch scale weight may vary from the preselected weight setting by up to ± 1.0 percent of the target additive weight.

23-5.03 Production Start-Up Evaluation

The agency may perform production start-up evaluation. The contractor is responsible for sampling and splitting all required materials.

Within the first 500 tons produced on the 1st day of HMA production, in the Engineer's presence, and from the same production run, the Contractor shall take samples of:

1. Aggregates
2. Asphalt binder
3. RAP
4. HMA

The Contractor shall sample aggregates from the combined cold-feed belt or hot bin. The Contractor shall take RAP samples from the RAP system.

For aggregates, RAP, and HMA, the Contractor shall split the samples into at least 4 parts and label their containers. The Contractor shall submit 3 parts to the Engineer and keep 1 part. The Engineer must retain 2 parts in the event of dispute resolution.

The Contractor and the Engineer must test the samples and report test results, except for California Test 389 and AASHTO T 283. The Contractor shall allow the Agency 10 business days from the receipt of samples to report the test results of the production start-up evaluation. If the Contractor proceeds with paving before receipt of the test results, the Engineer may consider the HMA placed to be represented by these test results.

California Test 389 and AASHTO T 283 is not required.

If production stops for more than 60 days, the Contractor shall perform a production start-up evaluation.

If production start-up evaluation fails, the Contractor shall stop production.

23-5.04 Quality Control

23-5.04.A General

QC test results must comply with the specifications for Agency acceptance.

The Contractor shall condition each at-the-plant sample of HMA mixture when composite aggregate absorption factor is greater than 2.0 percent as indicated by the JMF in compliance with sections 7.1.2, 7.1.3, and 7.1.4 of AASHTO R 30.

The Contractor shall prepare 3 briquettes for air voids content and voids in mineral aggregate determination. The Contractor shall report the average of 3 tests. If 2 consecutive material QC test results or any 3 material QC test results for 1 day's production do not comply with the specifications, the Contractor shall:

1. Stop HMA production
2. Notify the Engineer
3. Take corrective action
4. Demonstrate compliance with the specifications before resuming production and placement

For QC tests performed under AASHTO T 27, results are considered 1 QC test regardless of

number of sieves out of compliance.

The Contractor shall not resume production and placement until the Engineer authorizes the Contractor's corrective action proposal.

23-5.04.B Aggregate

23-5.04.B.1 General

The Contractor shall test the quality characteristics of aggregates under the test methods and frequencies shown in the following table:

Aggregate Testing Frequencies

Quality characteristic	Test method	Minimum testing frequency
Gradation ^a	AASHTO T 27	1 per 500 tons and any remaining part
Sand equivalent ^{b, c}	AASHTO T 176	
Moisture content ^d	AASHTO T 255	
Crushed particles	AASHTO T 335	1 per 10,000 tons or 2 per project whichever is greater
Los Angeles Rattler	AASHTO T 96	
Flat and elongated particles	ASTM D4791	
Fine aggregate angularity ^e	AASHTO T 304 Method A	

- A. If RAP is used, test the combined aggregate gradation under California Test 384.
- B. Reported value must be the average of 3 tests from a single sample.
- C. Use of a sand reading indicator is required as shown in AASHTO T 176, Figure 1. Sections 4.7, "Manual Shaker," 7.1.2, "Alternate Method No. 2," and 8.4.3, "Hand Method," do not apply. Prepare the stock solution as specified in section 4.8.1, "Stock solution with formaldehyde," except omit the addition of formaldehyde.
- D. Test at continuous mixing plants only. If RAP is used, test the RAP moisture content at continuous mixing plant and batch mixing plant.
- E. Waived if 10% or less non-manufactured sand.

23-5.04.B.2 Gradations

Aggregate gradation must be determined before the addition of asphalt binder and must include supplemental fine aggregates. Test for aggregate gradation under AASHTO T 27. The Contractor shall not wash the coarse aggregate. The Contractor shall wash the fine aggregate only And shall use a mechanical sieve shaker. Aggregate shaking time must not exceed 10 minutes for each coarse and fine aggregate portion.

Gradations are based on nominal maximum aggregate size.

23-5.04.C Reclaimed Asphalt Pavement

The Contractor shall sample and test mix design RAP stockpile under California Test 384. The Contractor shall report the average AASHTO T 308 uncorrected binder content on page 4 of the Contractor's Hot Mix Asphalt Design Data form. When the mix design RAP stockpile is augmented, the Contractor shall sample RAP used to augment the stockpile at a minimum frequency of 1 sample per 1,000 tons under California Test 384 before augmenting the stockpile. The Contractor shall test each sample to determine the uncorrected binder content under AASHTO T 308 and average the results of the 3 tests. When tested under AASHTO T 308, the uncorrected binder content of each augmented RAP sample must be within ± 2.00 percent of the average uncorrected asphalt binder content reported on page 4 of the Contractor's Hot Mix Asphalt Design Data form. The Contractor must use the same ignition oven used to determine the uncorrected asphalt binder content reported on page 4 of the Contractor's Hot Mix Asphalt Design Data form.

The augmented RAP sample when tested under AASHTO T 209 must be within ± 0.06 of the average maximum specific gravity reported on page 4 of the Contractor's Hot Mix Asphalt Design Data form.

The combined RAP sample when tested under AASHTO T 209 must be within ± 0.06 of the average

maximum specific gravity reported on page 4 of the Contractor's Caltrans Contractor Hot Mix Asphalt Design Data form.

During HMA-LG production, the Contractor shall sample RAP twice daily and perform QC testing for:

1. Aggregate gradation at least once a day under California Test 384
2. Moisture content at least once a day

The Contractor shall submit QC test results for gradation with the combined aggregate gradation within 2 business days of taking RAP samples during HMA-LG production.

23-5.04.D Liquid Antistrip Treatment

For each delivery of liquid antistrip to the HMA production plant, the Contractor shall submit a 1-pint sample to the Engineer. The Contractor shall submit shipping documents and label each liquid antistrip sampling container with:

1. Liquid antistrip type
2. Application rate
3. Sample date
4. Contract number

At the end of each day's production shift, the Contractor shall submit production data in electronic and printed media; present data on electronic media in a tab delimited format; use line feed carriage return with 1 separate record per line for each production data set; allow enough fields for the specified data; and include data titles at least once per report. For each HMA mixing plant type, the Contractor shall submit the following information in the order specified:

1. For batch plant mixing:
 - 1.1. Production date
 - 1.2. Time of batch completion
 - 1.3. Mix size and type
 - 1.4. Each ingredient's weight
 - 1.5. Asphalt binder content as a percentage of the total weight of mix
 - 1.6. Liquid antistrip content as a percentage of the asphalt binder weight
2. For continuous mixing plant:
 - 2.1. Production date
 - 2.2. Data capture time
 - 2.3. Mix size and type
 - 2.4. Flow rate of wet aggregate collected directly from the aggregate weigh belt
 - 2.5. Aggregate moisture content as a percentage of the dry aggregate weight
 - 2.6. Flow rate of asphalt binder collected from the asphalt binder meter
 - 2.7. Flow rate of liquid antistrip collected from the liquid antistrip meter
 - 2.8. Asphalt binder content as a percentage of the total weight of mix calculated from:
 - 2.8.1. Aggregate weigh belt output
 - 2.8.2. Aggregate moisture input
 - 2.8.3. Asphalt binder meter output
 - 2.9. Liquid antistrip content as a percentage of the asphalt binder weight calculated from:
 - 2.9.1. Asphalt binder meter output
 - 2.9.2. Liquid antistrip meter output

For continuous mixing or batch-plant mixing, the Contractor shall sample asphalt binder before adding liquid antistrip. For continuous mixing, the Contractor shall sample the combined asphalt binder

and liquid antistrip after the static mixer.

If 3 consecutive sets of recorded production data show that the actual delivered liquid antistrip weight is more than ± 1 percent of the authorized mix design liquid antistrip weight, the Contractor shall stop production and take corrective action.

If a set of recorded production data shows that the actual delivered liquid antistrip weight is more than ± 2 percent of the authorized mix design liquid antistrip weight, the Contractor shall stop production. If the liquid antistrip weight exceeds 1.2 percent of the asphalt binder weight, the Contractor shall not use the HMA represented by that data.

The continuous mixing plant controller proportioning the HMA must produce a production data log. The log must consist of a series of data sets captured at 10-minute intervals throughout daily production. The data must be a production activity register and not a summation. The material represented by the data is the quantity produced 5 minutes before and 5 minutes after the capture time. For the duration of the Contract, the collected data must be stored by the plant controller or a computer's memory at the plant.

The Engineer will order proportioning activities stopped for any of the following reasons:

1. The Contractor fails to submit data
2. The Contractor submits incomplete, untimely, or incorrectly formatted data
3. The Contractor fails to take corrective actions
4. The Contractor takes late or unsuccessful corrective actions
5. The Contractor fails to stop production when proportioning tolerances are exceeded
6. The Contractor uses malfunctioning or failed proportioning devices

If the Contractor stops production, they shall notify the Engineer of any corrective actions taken before resuming.

23-5.04.E Warm Mix Asphalt Technology

The Contractor shall collect and hold data for the duration of the Contract and submit the electronic media daily. The snapshot of production data must include the following:

1. Production date
2. Production location
3. Time of day the data is captured
4. HMA mix type being produced and target binder rate
5. HMA additive type, brand, and target rate
6. Temperature of the binder and HMA mixture
7. For a continuous mixing plant, the rate of flow of the dry aggregate calculated from the wet aggregate flow rate as determined by the conveyor scale
8. For a continuous mixing plant, the rate of flow of the asphalt meter
9. For a continuous mixing plant, the rate of flow of HMA additive meter
10. For batch plant mixing, actual batch weights of all ingredients
11. Dry aggregate to binder ratio calculated from metered ingredient output
12. Dry aggregate to HMA additive ratio calculated from metered output

At the end of each day's production shift, the Contractor shall submit electronic and printed media from the HMA plant process controller and present data on electronic media in comma-separated values or tab-separated values format. The captured data for the ingredients represented by the production snapshot must have allowances for sufficient fields to satisfy the amount of data required by these specifications and include data titles at least once per report.

23-5.04.F Hot Mix Asphalt Mixtures

The Contractor shall test the quality characteristics of HMA under the test methods and frequencies shown in the following table:

HMA-LG Production Testing Frequencies

Quality characteristic	Test method	Minimum testing frequency
Asphalt binder content	AASHTO T 308, Method A	1 per 500 tons and any remaining part
HMA moisture content	AASHTO T 329	1 per 2,500 tons but not less than 1 per paving day
Air voids content	AASHTO T 269	1 per 4,000 tons or 2 every 5 paving days, whichever is greater
Voids in mineral aggregate	MS-2 Asphalt Mixture Volumetrics	1 per 10,000 tons or 2 per project whichever is greater
Dust proportion	MS-2 Asphalt Mixture Volumetrics	

The Contractor shall submit QC test results within 3 business days of a request.

23-6 CONSTRUCTION**23-6.01 General**

The Contractor shall not place HMA on wet pavement or frozen surface.

HMA must be free of:

1. Segregation
2. Coarse or fine aggregate pockets
3. Hardened lumps
4. Marks
5. Tearing
6. Irregular texture

If widening existing pavement, the Contractor shall construct new pavement structure to match the elevation of the existing pavement's edge before placing HMA over the existing pavement.

Until the adjoining through lane's top layer has been paved, the Contractor shall not pave the top layer of:

1. Shoulders
2. Tapers
3. Transitions
4. Road connections
5. Driveways
6. Curve widenings
7. Chain control lanes
8. Turnouts
9. Turn pockets

If the number of lanes changes, the Contractor shall pave each through lane's top layer before paving a tapering lane's top layer. Simultaneous to paving a through lane's top layer, the Contractor may pave an adjoining area's top layer, including shoulders. The Contractor shall not operate spreading equipment on any area's top layer until completing final compaction.

If shoulders or median borders are shown, the Contractor shall pave shoulders and median borders adjacent to the lane before opening a lane to traffic.

If shoulder conform tapers are shown, the Contractor shall place conform tapers concurrently with the adjacent lane's paving.

If a driveway or a road connection is shown, the Contractor shall place additional HMA along the pavement's edge to conform to road connections and driveways, hand rake, if necessary, and compact

the additional HMA to form a smooth conform taper.

23-6.02 Equipment

23-6.02.A Spreading Equipment

Paving equipment for spreading must be:

1. Self-propelled
2. Mechanical
3. Equipped with a screed or strike-off assembly that can distribute HMA the full width of a traffic lane
4. Equipped with a full-width compacting device
5. Equipped with automatic screed controls and sensing devices that control the thickness, longitudinal grade, and transverse screed slope

The Contractor shall install and maintain grade and slope references.

The screed must be heated and produce a uniform HMA surface texture without tearing, shoving, or gouging.

The paver must not leave marks such as ridges and indentations unless the Contractor can eliminate them by rolling.

Rollers must be equipped with a system that prevents HMA from sticking to the wheels. The Contractor may use a parting agent that does not damage the HMA or impede the bonding of layers.

23-6.02.B Material Transfer Vehicle

If a material transfer vehicle is specified, the material transfer vehicle must have sufficient capacity to prevent stopping the paver and must be capable of:

1. Either receiving HMA directly from trucks or using a windrow pickup head to load it from a windrow deposited on the roadway surface
2. Remixing the HMA with augers before transferring into the paver's receiving hopper or feed system
3. Transferring HMA directly into the paver's receiving hopper or feed system

23-6.02.C Hauling Equipment

Vehicles used for hauling HMA mixtures must have tight, smooth, metal beds, and must be free from dust, screenings, excessive petroleum oils, volatiles, or other mineral spirits that may affect the mix being hauled. Trucks must be provided with tarpaulins or cargo covers of sufficient size and weight to protect the entire load.

23-6.03 Surface Preparation

The Contractor shall prepare subgrade to receive HMA under the sections for the material involved. Subgrade must be free of loose and extraneous material.

Before placing HMA, the Contractor shall remove loose paving particles, dirt, and other extraneous material by any means.

The full-width of a surface to which tack coat is to be applied shall be cleaned with a self-propelled, truck-mounted sweeper equipped with both power brooms and a vacuum system to remove loose dirt, sand, dust and other objectionable material. The surface to which tack coat is to be applied shall be dry prior to application.

23-6.04 Tack Coat

Prior to applying tack coat, the Contractor shall submit calculations for the minimum spray rate required to achieve the minimum residual rate.

The Contractor shall apply a tack coat:

1. To existing pavement including planed surfaces
2. Between HMA layers
3. To vertical surfaces of:
 - 3.1. Curbs
 - 3.2. Gutters
 - 3.3. Construction joints

The surfaces of structures and trees adjacent to the areas being treated shall be protected to prevent their being splashed or damaged.

Equipment for the application of tack coat must comply with section 37-1.03B of the Caltrans Standard Specifications.

For gore points and other areas not accessible to a truck distributor bar, the Contractor shall apply by hand spraying.

The Contractor shall close areas receiving tack coat to traffic and shall not allow the tracking of tack coat onto pavement surfaces beyond the job site.

If the Contractor uses an asphalt binder for tack coat, the asphalt binder temperature must be from 285 to 350 degrees F when applied.

A certificate of compliance for each truckload of emulsion or asphalt binder shall be provided to the Engineer before the application of tack coat starts. The Engineer may obtain and retain samples for testing.

Immediately after cleaning the surface, except if water was used, the Contractor shall apply a tack coat in one application at the minimum residual rate shown in the table. If water was used, the Contractor shall not apply a tack coat until immediately after the surface is dry. The distributor truck spray bar shall be pressurized during application and discharge tack coat material in a fan shape (spray cone) from each nozzle. The spray bar shall be set at a height above the existing pavement which results in each interior spray cone overlapping a minimum of twice before coming into contact with the underlying pavement. Streaking or streaked applications will not be accepted.

Tack Coat Application Rates for HMA

HMA over:	Minimum residual rates ¹ (gallons/square yard)		
	CSS-1/CSS-1h, SS-1/SS-1h and QS-1h/CQS-1h asphaltic emulsion	CRS-1/CRS-2 and QS-1/CQS-1 asphaltic emulsion	Asphalt binder and PMCRS-2/PMCRS-2h asphaltic emulsion
New HMA (between layers)	0.02	0.03	0.02
Concrete pavement and existing asphalt concrete surfacing	0.03	0.04	0.03
Planed Pavement	0.05	0.06	0.04

1. The residual application rate will be verified in accordance with ASTM D2995.

Following the application of tack coat, the surface shall be allowed to cure without being disturbed for period of time necessary to permit setting of the tack coat. Tack coat shall be applied only as far in advance of the placing of the overlying layer as required for that day's operation. Treated surface shall be protected from damage until the succeeding course of pavement is placed.

The Contractor shall apply a tack coat to vertical surfaces with a residual rate that will thoroughly

coat the vertical face without running off.

The Contractor shall notify the Engineer if asphaltic emulsion is diluted with water. The weight ratio of added water to asphaltic emulsion must not exceed 1 to 1.

The Contractor shall measure added water either by weight or volume under section 9-1.02 of the Caltrans Standard Specifications or use water meters from water agencies. If the Contractor measures water by volume, apply a conversion factor to determine the correct weight.

With each dilution, the Contractor shall submit:

1. Weight ratio of water to bituminous material in the original asphaltic emulsion
2. Weight of asphaltic emulsion before diluting
3. Weight of added water
4. Final dilution weight ratio of water to asphaltic emulsion

If authorized, the Contractor may change tack coat rates.

Immediately in advance of placing HMA, the Contractor shall apply additional tack coat to damaged areas or where loose or extraneous material is removed.

23-6.05 Placement

23-6.05.A General

The Engineer will meet daily with the Contractor on days when paving occurs to ensure the Contractor's operations are continuous and non-stop.

The Contractor shall deliver HMA to the site in a thoroughly mixed condition and spread by a self-propelled asphalt paving machine.

HMA shall not be placed when the air temperature is below 50°F unless using an approved WMA technology.

HMA-LG with WMA water injection technology shall be spread at a mix temperature of not less than 260°F, or not less than 250°F if a WMA additive technology is used.

No placement will be allowed when the roadway is moist, damp or when it is raining. For the purpose of this provision, "raining" means any weather condition that causes the roadway to become moist or damp. In the case of sudden precipitation, all paving work must stop immediately, all HMA on site not yet placed and all HMA in transit from the plant will be rejected and no payment will be allowed.

The Contractor may deposit HMA in a windrow and load it in the paver if:

1. Paver is equipped with a hopper that automatically feeds the screed
2. Loading equipment can pick up the windrowed material and deposit it in the paver hopper without damaging base material
3. Activities for depositing, pickup, loading, and paving are continuous

The Contractor shall not use petroleum products such as kerosene or diesel fuel to release HMA from trucks, spreaders, or compactors.

Where the pavement thickness shown is 0.30 foot or greater, the Contractor may place HMA-LG in multiple lifts not less than 0.15 foot each. If placing HMA-LG in multiple lifts:

1. Table in Section 23-3.01.C does not apply
2. Aggregate gradation must comply with the requirements shown in the following table:

Aggregate Gradation Requirements

HMA-LG lift thickness	Gradation
0.15 to less than 0.20 foot	1/2 inch
0.20 foot or greater	3/4 inch

3. A tack coat must be applied before placing a subsequent lift
4. The Engineer will evaluate each HMA-LG lift individually for compliance

If the ambient air temperature is below 60 degrees F, the Contractor shall cover the loads in trucks with tarpaulins. If the time for HMA discharge to truck at the HMA plant until transfer to paver's hopper is 90 minutes or greater and if the ambient air temperature is below 70 degrees F, the Contractor shall cover the loads in trucks with tarpaulins, unless the time from discharging to the truck until transfer to the paver's hopper or the pavement surface is less than 30 minutes. The tarpaulins must completely cover the exposed load until the Contractor transfers the mixture to the paver's hopper or the pavement surface.

The Contractor shall spread HMA-LG with WMA at the ambient air and surface temperatures shown in the following table:

Minimum Ambient Air and Surface Temperatures

Lift thickness (feet)	Ambient air (°F)		Surface (°F)	
	Unmodified asphalt binder	Modified asphalt binder	Unmodified asphalt binder	Modified asphalt binder
<i>HMA-LG produced with WMA water injection technology</i>				
<0.15	55	50	60	55
≥0.15	45	45	50	50
<i>HMA-LG produced with WMA additive technology</i>				
<0.15	45	45	50	45
≥0.15	40	40	40	40

23-6.05.B Longitudinal Joints

Longitudinal joints in the top layer must match lane lines. Alternate the longitudinal joint offsets in the lower layers at least 0.5 foot from each side of the lane line. Other longitudinal joint placement patterns are allowed if authorized.

Vertical longitudinal joints are not allowed at any time between adjacent lanes open to traffic. Daily work shall be planned to not leave any exposed vertical longitudinal edge at the end of the shift.

The Contractor shall place temporary HMA conforms along the transverse edge at each lane's end, and when authorized by the Agency, along the exposed longitudinal edges between adjacent lanes. All temporary conforms shall be constructed at a 50:1 (horizontal:vertical) slope or flatter. Hand rake and compact all temporary HMA conforms. The Contractor may place kraft paper or other authorized release agent under the conform tapers to facilitate the taper removal when paving activities resume.

If placing HMA against the edge of existing pavement, the Contractor shall saw cut or grind the pavement straight and vertical along the joint and remove extraneous material.

23-6.06 Compaction

The Contractor shall start rolling at the lower edge and progress toward the highest part except when compacting layers which exceed 4 inches in compacted thickness. For layers which exceed 4 inches in compacted thickness, the Contractor shall start rolling in the middle of the mat, and advance gradually to both edges. Supported edges (edges along concrete curbs and gutters, or headers) shall be rolled before unsupported edges. If approved, the Contractor may delay rolling of an unsupported edge if the required density is achieved on the remainder of the mat after the completion of finish rolling.

The Contractor shall complete finish rolling activities before the pavement surface temperature is:

1. Below 150 degrees F for HMA with unmodified binder
2. Below 140 degrees F for HMA with modified binder

Rolling must leave the completed surface compacted and smooth without tearing, cracking, or shoving.

If a vibratory roller is used as a finish roller, the vibrator must be turned off.

HMA, after the completion of rolling, shall be compacted to not less than 91 percent and not more than 97 percent of the maximum theoretical density (MTD) as determined in accordance with AASHTO T 209. The density of lifts placed on aggregate base may be between 90 and 97 percent, if approved by the Agency.

The Contractor shall not open new HMA pavement to traffic until its mid depth temperature is below 160 degrees F.

If the surface to be paved is both in sunlight and shade, pavement surface temperatures are taken in the shade.

23-6.07 Smoothness

If an inertial profiler is required, the criteria and tolerances will be provided in the Project Special Provisions.

The top layer of HMA pavement must not vary from the lower edge of a 12-foot straightedge:

1. More than 0.01 foot when the straightedge is laid parallel with the centerline
2. More than 0.02 foot when the straightedge is laid perpendicular to the centerline and extends from edge to edge of a traffic lane
3. More than 0.02 foot when the straightedge is laid within 24 feet of a pavement conform

23-6.08 Quality Control

23-6.08.A HMA Density

The Contractor is responsible for the quality control process necessary to achieve the required density.

23-7 NOT USED

23-8 NOT USED

23-9 ACCEPTANCE

23-9.01 General

Laboratories must be accredited for testing HMA in accordance with ASTM D3666. Technicians must be certified by Caltrans to perform specified tests.

With the exception of bituminous distributor testing, coring, and dispute resolution, materials testing necessary to determine conformance with the requirements of Section 23 will be performed by the Agency and the cost thereof will be borne by the Agency.

HMA will be accepted on a lot basis. A lot is 500 tons or a portion thereof. If the portion is 200 tons or less it may be incorporated into the last 500-ton lot of the day or the first 500-ton lot of the following day and might not be sampled separately.

HMA may be sampled from any of the following locations:

1. Plant
2. Truck
3. Windrow
4. Mat behind the paver

The Engineer acceptance samples must be obtained by the Contractor at the Contractor's expense, and no additional compensation will be paid. The Contractor shall sample in the presence of the Engineer. The Contractor shall split the Engineer acceptance samples into at least 4 parts. The Engineer retains 3 parts and the Contractor keeps 1 part.

To obtain workability of the HMA-LG sample for splitting, the Engineer will reheat each sample of HMA-LG mixture not more than 2 cycles.

The Engineer will condition each at-the-plant sample of HMA mixture when composite aggregate absorption factor is greater than 2.0 percent as indicated by the JMF in compliance with sections 7.1.2, 7.1.3, and 7.1.4 of AASHTO R 30.

For Agency acceptance tests performed under AASHTO T 27, results are considered 1 Agency acceptance test regardless of the number of sieves out of compliance.

The Engineer will accept HMA based on:

1. Authorized JMF
2. Authorized QC plan
3. Asphalt binder compliance
4. Asphalt emulsion compliance
5. Visual inspection
6. Pavement smoothness

The Agency will accept HMA based on compliance with:

1. Aggregate quality requirements shown in the following tables:

HMA- LG Aggregate Quality

Quality Characteristic	Test Method	Requirement	
Aggregate gradation ^a	AASHTO T 27	JMF ± Tolerance	
Percent of crushed particles	AASHTO T 335		
Coarse aggregate (min, %)			
One-fractured face			95
Two-fractured faces			90
Fine aggregate (min, %)			
(Passing No. 4 sieve		70	
And retained on No. 8 sieve.)			
One-fractured face			
Los Angeles Rattler (max, %)	AASHTO T 96		
Loss at 100 Rev.		12	
Loss at 500 Rev.		40	
Sand equivalent (min) ^{b, c}	AASHTO T 176	47	
Flat and elongated particles (max, % by weight at 5:1)	ASTM D4791	10	
Fine aggregate angularity (min, %) ^d	AASHTO T 304, Method A	45	

A. The Engineer determines combined aggregate gradations containing RAP under California Test 384. The Engineer uses the correlation factor from Contractor Hot Mix Data Form and mathematically combines the virgin and corrected RAP aggregate gradations at the correct proportions to obtain the combined gradation.

B. Reported value must be the average of 3 tests from a single sample.

C. Use of a sand reading Indicator is required as shown in AASHTO T 176, Figure 1. Sections 4.7, "Manual Shaker," 7.1.2, "Alternate Method No. 2," and 8.4.3, "Hand Method," do not apply.

Prepare the stock solution as specified in section 4.8.1, "Stock solution with formaldehyde," except omit the addition of formaldehyde.

D. The Engineer waives this specification if the HMA-LG contains 10 percent or less of nonmanufactured sand by weight of total aggregate. Manufactured sand is fine aggregate produced by crushing rock or gravel.

RHMA-G Aggregate Quality

Quality Characteristic	Test Method	Requirement
Aggregate gradation	AASHTO T 27	JMF ± Tolerance
Percent of crushed particles	AASHTO T 335	--
Coarse aggregate (min, %)		
One-fractured face		
Two-fractured faces		
90		
Fine aggregate (min, %)	AASHTO T 335	70
(Passing No. 4 sieve		
And retained on No. 8 sieve.)		
One-fractured face	AASHTO T 96	12
Los Angeles Rattler (max, %)		
Loss at 100 Rev.		
Loss at 500 Rev.	AASHTO T 176	47
Sand equivalent (min) ^{a, b}		
Flat and elongated particles (max, % by weight at 5:1)	ASTM D4791	Report only
Fine aggregate angularity (min, %) ^c	AASHTO T 304, Method A	45

A. Reported value must be the average of 3 tests from a single sample.

B. Use of a sand reading Indicator is required as shown in AASHTO T 176, Figure 1. Sections 4.7, "Manual Shaker," 7.1.2, "Alternate Method No. 2," and 8.4.3, "Hand Method," do not apply.

Prepare the stock solution as specified in section 4.8.1, "Stock solution with formaldehyde," except omit the addition of formaldehyde.

C. The Engineer waives this specification if RHMA-G contains 10 percent or less of nonmanufactured sand by weight of total aggregate. Manufactured sand is fine aggregate produced by crushing rock or gravel.

2. If RAP is used, RAP quality requirements shown in the following table:

Reclaimed Asphalt Pavement Quality

Quality Characteristic	Test Method	Requirement
Uncorrected binder content (% within the average value reported ^a)	AASHTO T 308	± 2.00
Specific gravity (within the average value reported ^b)	AASHTO T 209	± 0.06
^a Average uncorrected binder content of three ignition oven tests performed at JMF verification. Engineer must use the same ignition oven used to determine the average uncorrected binder content at JMF verification.		
^b Average maximum specific gravity reported on page 4 of Contractor Hot Mix Asphalt Design Data form.		

3. In-place HMA quality requirements shown in the following tables:

HMA-LG Acceptance In Place

Quality Characteristic	Test Method	Requirement
Asphalt binder content (%)	AASHTO T 308 Method A	JMF -0.30, +0.50
HMA-LG moisture content (max, %)	AASHTO T 329	1.00
Air voids content @ Ndesign (%) ^{a, b}	AASHTO T 269	4.0 ± 1.5
Voids in mineral aggregate on laboratory-produced HMA-LG (min, %) ^d Gradation: 3/8-inch 1/2-inch 3/4-inch	MS-2 Asphalt Mixture Volumetrics ^c	15.5-18.5 14.5-17.5 13.5-16.5
Voids in mineral aggregate on plant-produced HMA (min, %) ^a Gradation: 3/8-inch 1/2-inch 3/4-inch	MS-2 Asphalt Mixture Volumetrics ^c	14.5-17.5 13.5-16.5 12.5-15.5
Dust proportion ^a	MS-2 Asphalt Mixture Volumetrics	0.6–1.3 ^g
Density of core (% of max theoretical density) ^{e, f}	California Test 375	91.0–97.0

- A. Prepare 3 briquettes. Report the average of 3 tests.
- B. The Engineer determines the bulk specific gravity of each lab-compacted briquette under AASHTO T 275, Method A, and theoretical maximum specific gravity under AASHTO T 209, Method A.
- C. Determine bulk specific gravity under AASHTO T 275, Method A.
- D. The Engineer determines the laboratory-prepared HMA-LG value for only mix design verification.
- E. The Engineer determines percent of theoretical maximum density under California Test 375 except the Engineer uses:
 1. AASHTO T 275, Method A, to determine in-place density of each density core instead of using the nuclear gauge
 2. AASHTO T 209, Method A to determine theoretical maximum density instead of calculating test maximum density
- F. The Engineer determines theoretical maximum density under AASHTO T 209, Method A, for each lot (500 tons or portion thereof).

RHMA-G Acceptance In Place

Quality Characteristic	Test Method	Requirement
Asphalt binder content (%)	AASHTO T 308 Method A	JMF -0.40, +0.50
HMA moisture content (max, %)	AASHTO T 329	1.00
Air voids content @ Ndesign (%) ^{a, b}	AASHTO T 269	4.0 ± 1.5
Voids in mineral aggregate on laboratory-produced HMA ^d (min, %) Gradation: 1/2-inch	MS-2 Asphalt Mixture Volumetrics ^c	18.0–23.0
Voids in mineral aggregate on plant-produced HMA (min, %) ^a Gradation: 1/2-inch	MS-2 Asphalt Mixture Volumetrics ^c	18.0–23.0
Dust proportion ^a	MS-2 Asphalt Mixture Volumetrics	Report only
Density of core (% of max theoretical density) ^{e, f}	California Test 375	91.0–97.0

- A. Prepare 3 briquettes. Report the average of 3 tests.
- B. The Engineer determines the bulk specific gravity of each lab-compacted briquette under AASHTO T 275, Method A, and theoretical maximum specific gravity under AASHTO T 209, Method A.
- C. Determine bulk specific gravity under AASHTO T 275, Method A.
- D. The Engineer determines the laboratory-prepared RHMA-G value for only mix design verification.
- E. The Engineer determines percent of theoretical maximum density under California Test 375 except the Engineer uses:
 - 1. AASHTO T 275, Method A, to determine in-place density of each density core instead of using the nuclear gauge
 - 2. AASHTO T 209, Method A to determine theoretical maximum density instead of calculating test maximum density
- F. The Engineer determines theoretical maximum density under AASHTO T 209, Method A, for each lot (500 tons or portion thereof).

23-9.02 HMA Density

Cores for determining the density of the compacted HMA will be taken on a lot basis. A minimum of 3 random cores shall be taken per lot in the presence of the Engineer. The cores must be taken in accordance with the Special Provisions and as directed by the Engineer. The Contractor shall backfill and compact holes from coring with authorized material.

Core samples for determination of the density of completed pavements must be obtained by the Contractor at the Contractor's expense, and no additional compensation will be paid. The core samples must be 4 inches in diameter. The Contractor may utilize a nuclear density gauge for preliminary testing. Dry ice may be used for cooling the pavement prior to coring. The number and locations of the samples will be as agreed upon in the field by the Engineer and the Contractor. Samples must be neatly cut with a saw, core drill, or other approved equipment. The Contractor must provide the core samples to the Engineer within 2 hours after final compaction.

Actual core locations will be randomly selected per ASTM D3665 (Random Method).

The Engineer will calculate the percent of MTD to the nearest 0.1 percent for each core by dividing the in-place density by the MTD and multiplying by 100 percent. The mean percent of MTD will be used by the Engineer to determine compliance with the specification for each lot.

If the percent of theoretical maximum density does not comply with the specifications, the Engineer must accept the HMA lot and take a payment deduction as shown in the following table:

Reduced Payment Factors for Percent of Maximum Theoretical Density

HMA percent of maximum theoretical density	Reduced payment factor	HMA percent of maximum theoretical density	Reduced payment factor
91.0	0.0000	97.0	0.0000
90.9	0.0125	97.1	0.0125
90.8	0.0250	97.2	0.0250
90.7	0.0375	97.3	0.0375
90.6	0.0500	97.4	0.0500
90.5	0.0625	97.5	0.0625
90.4	0.0750	97.6	0.0750
90.3	0.0875	97.7	0.0875
90.2	0.1000	97.8	0.1000
90.1	0.1125	97.9	0.1125
90.0	0.1250	98.0	0.1250
89.9	0.1375	98.1	0.1375
89.8	0.1500	98.2	0.1500
89.7	0.1625	98.3	0.1625
89.6	0.1750	98.4	0.1750
89.5	0.1875	98.5	0.1875
89.4	0.2000	98.6	0.2000
89.3	0.2125	98.7	0.2125
89.2	0.2250	98.8	0.2250
89.1	0.2375	98.9	0.2375
89.0	0.2500	99.0	0.2500
<89.0	Remove and replace	>99.0	Remove and replace

23-10 RUBBERIZED HOT MIX ASPHALT-GAP GRADED

23-10.01 General

23-10.01.A Summary

Section 23-10 includes specifications for producing and placing rubberized hot mix asphalt-gap graded. The Contractor may produce RHMA-G using a WMA technology.

23-10.02 Submittals

23-10.02.A General

At least 5 business days before use, the Contractor shall submit the permit issued by the local air district for asphalt rubber binder blending equipment. If an air quality permit is not required by the local air district for producing asphalt rubber binder, the Contractor shall submit verification from the local air district that an air quality permit is not required.

At least 10 days before RHMA-G production, the Contractor shall submit the name of an authorized laboratory to perform QC testing for asphalt rubber binder. The authorized laboratory must comply with the Caltrans Independent Assurance Program.

23-10.02.B Job Mix Formula

The Contractor's proposed JMF, shall include the SDS for:

1. Base asphalt binder
2. CRM and asphalt modifier
3. Blended asphalt rubber binder components

The JMF must be based on the superpave HMA mix design as described in MS-2 Asphalt Mix Design Methods by the Asphalt Institute.

23-10.02.C Asphalt Rubber Binder

The Contractor shall submit a proposal for asphalt rubber binder design and profile. The design shall include the asphalt binder, asphalt modifier, and CRM and their proportions.

If the Contractor changes asphalt rubber binder supplier or any component material used in asphalt rubber binder or its percentage, they shall submit a new JMF.

For the asphalt rubber binder used, the Contractor shall submit:

1. Log of production daily.
2. Certificate of compliance with test results for CRM and asphalt modifier with each truckload delivered to the HMA plant. The certificate of compliance for asphalt modifier must represent no more than 5,000 lb.
3. Certified weight slips for the CRM and asphalt modifier furnished.
4. QC test results on viscosity within 2 business days after sampling.
5. QC test results on cone penetration, resilience, and softening point within 3 business days after sampling.

The Contractor shall submit a certificate of compliance for the CRM and asphalt modifier. With the certificate of compliance, the Contractor shall submit test results for CRM and asphalt modifier with each truckload delivered to the HMA plant.

23-10.03 Quality Assurance**23-10.03.A Job Mix Formula Verification**

If the Contractor requests, the Engineer will verify RHMA-G quality requirements within 7 days of receiving all verification samples and after the JMF document submittal has been accepted.

23-10.04 Quality Control**23-10.04.A Asphalt Rubber Binder****23-10.04.A.1 General**

The asphalt rubber binder blending plant must conform to all requirements of Section 39 of the Caltrans Standard Specifications.

Asphalt rubber binder samples shall be taken from the feed line connecting the asphalt rubber binder tank to the HMA plant.

23-10.04.A.2 Asphalt Modifier

The Contractor shall test asphalt modifier under the test methods and frequencies shown in the following table:

Asphalt Modifier for Asphalt Rubber Binder

Quality Characteristic	Test Method	Frequency
Viscosity	ASTM D445	1 per shipment
Flash point	ASTM D92	
Molecular analysis: Asphaltenes Aromatics	ASTM D2007	1 per shipment

23-10.04.A.3 Crumb Rubber Modifier

The Contractor shall sample and test scrap tire crumb rubber and high natural crumb rubber separately. The Contractor shall test CRM under the test methods and frequencies shown in the following table:

Crumb Rubber Modifier for Asphalt Rubber Binder

Quality Characteristic	Test Method	Frequency
Scrap tire crumb rubber gradation	California Test 385	1 per 10,000 lb
High natural crumb rubber gradation	California Test 385	1 per 3,400 lb
Wire in CRM	California Test 385	1 per 10,000 lb
Fabric in CRM	California Test 385	
CRM particle length	--	
CRM specific gravity	California Test 208	
Natural rubber content in high natural crumb rubber	ASTM D297	1 per 3,400 lb

23-10.04.A.4 Asphalt Rubber Binder

The Contractor shall test asphalt rubber binder under the test methods and frequencies shown in the following table:

Quality Characteristic	Test Method	Frequency
Cone penetration	ASTM D217	1 per lot ^a
Resilience	ASTM D5329	
Softening point	ASTM D36/D36M	
Viscosity	ASTM D7741/D7741M	15 minutes before use per lot ^a

A. The lot is defined in the Department's MPQP.

The Contractor shall retain the sample from each lot. The Contractor shall test for cone penetration, resilience, and softening point for the first 3 lots and, if all 3 lots pass, the testing frequency may be reduced to once for every 3 lots.

If QC test results indicate that the asphalt rubber binder does not comply with the specifications, the Contractor shall take corrective action and notify the Engineer.

23-10.04.B Aggregates

The Contractor shall test the quality characteristics of aggregates under the test methods and frequencies shown in section 23-5.04.B.

23-10.04.C Rubberized Hot Mix Asphalt-Gap Graded Production

The Contractor shall test the quality characteristics of RHMA-G under the test methods and frequencies shown in section 23-5.04.F.

23-10.05 Department Acceptance**23-10.05.A General**

The Department accepts RHMA-G based on compliance with:

1. Aggregate quality requirements shown in section 23-9.01 for RHMA-G.
2. In-place RHMA-G quality requirements shown section 23-9.01 for RHMA-G.

23-10.05.B Asphalt Rubber Binder**23-10.05.B.1 General**

The Department does not use asphalt rubber binder design profile for production acceptance.

23-10.05.B.2 Asphalt Modifier

The Department accepts asphalt modifier based on compliance with the requirements shown in the following table:

Asphalt Modifier for Asphalt Rubber Binder

Quality Characteristic	Test Method	Requirement
Viscosity at 100 °C ($\text{m}^2/\text{s} \times 10^{-6}$)	ASTM D445	$X \pm 3^a$
Flash point (min, °C)	ASTM D92	207
Molecular analysis:	ASTM D2007	
Asphaltenes (max, % by mass)		0.1
Aromatics (min, % by mass)		55

A. The symbol X is the asphalt modifier viscosity.

23-10.05.B.3 Crumb Rubber Modifier

CRM used must be on the Authorized Materials List for Crumb Rubber Modifier.

CRM must be a ground or granulated combination of scrap tire crumb rubber and high natural scrap tire crumb rubber, CRM must be 75.0 ± 2.0 percent scrap tire crumb rubber and 25.0 ± 2.0 percent high natural scrap tire crumb rubber by total weight of CRM. Scrap tire crumb rubber and high natural scrap tire crumb rubber must be derived from waste tires described in Pub Res Code § 42703.

The Department accepts CRM, scrap tire crumb rubber, and high natural crumb rubber based on compliance with the requirements shown in the following table:

Crumb Rubber Modifier for Asphalt Rubber Binder

Quality Characteristic	Test Method	Requirement
Scrap tire crumb rubber gradation (% passing No. 8 sieve)	California Test 385	100
High natural crumb rubber gradation (% passing No. 10 sieve)	California Test 385	100
Wire in CRM (max, %)	California Test 385	0.01
Fabric in CRM (max, %)	California Test 385	0.05
CRM particle length (max, in)	--	3/16
CRM specific gravity	California Test 208	1.1–1.2
Natural rubber content in high natural crumb rubber (%)	ASTM D297	40.0–48.0

Scrap tire crumb rubber and high natural crumb rubber are sampled and tested separately.

23-10.05.B.4 Asphalt Rubber Binder

For Department acceptance testing, the Contractor shall take samples of asphalt rubber binder in the Engineer's presence every 5 lots or once a day, whichever is greater. Each sample must be in a 6

qt can with open top and friction lid.

The Department accepts asphalt rubber binder based on compliance with the requirements shown in the following table:

Quality Characteristic	Test Method	Requirement
Cone penetration at 25 °C (0.10 mm)	ASTM D217	25–70
Resilience at 25 °C (min, % rebound)	ASTM D5329	18
Softening point (°C)	ASTM D36/D36M	52–74
Viscosity at 190 °C (centipoises) ^a	ASTM D7741/D7741M	1,500–4,000

A. Prepare sample for viscosity test under California Test 388.

23-10.06 Materials

23-10.06.A Rubberized Hot Mix Asphalt-Gap Graded Mix Design

For RHMA-G, the mix design must comply with the requirements shown in the following table:

RHMA-G Mix Design Requirements

Quality Characteristic	Test Method	Requirement
Air voids content (%)	AASHTO T 269 ^a	N _{design} = 4.0
Gyrations compaction (no. of gyrations)	AASHTO T 312	N _{design} = 50–150 ^b
Voids in mineral aggregate (min, %)	SP-2 Asphalt Mixture Volumetrics ^c	18.0–23.0
Dust proportion	SP-2 Asphalt Mixture Volumetrics	Report only
Hamburg wheel track (min, number of passes at 0.5-inch rut depth) Binder grade: PG 64	California Test 389 ^d	15,000
Hamburg wheel track (min, number of passes at the inflection point) Binder grade: PG 64	California Test 389 ^d	Report only
Moisture susceptibility, dry strength (min, psi)	AASHTO T 283 ^d	100
Moisture susceptibility, wet strength (min, psi)	AASHTO T 283 ^{d, e}	70

-
- A. Calculate the air voids content of each specimen using AASHTO T 275, Method A, to determine bulk specific gravity and AASHTO T 209, Method A, to determine theoretical maximum specific gravity. Under AASHTO T 209, use a digital manometer when performing AASHTO T 209.
- B. Superpave gyratory compactor ram pressure may be increased to a maximum of 825kPa, and specimens may be held at a constant height for a maximum of 90 minutes.
- C. Measure bulk specific gravity using AASHTO T 275, Method A.
- D. Test plant produced RHMA.
- E. Freeze thaw required.

The Contractor shall determine the quantity of asphalt rubber binder to be mixed with the aggregate for RHMA-G as follows:

1. Base the calculations on the average of 3 briquettes produced at each asphalt rubber binder content.
2. Plot asphalt rubber binder content versus average air voids content for each set of 3 specimens and connect adjacent points with a best-fit curve.
3. Calculate voids in mineral aggregate for each specimen, average each set, and plot the average versus asphalt rubber binder content.
4. Calculate the dust proportion and plot versus asphalt rubber binder content.
5. From the curve plotted, select the theoretical asphalt rubber binder content at 4 percent air voids.
6. At the selected asphalt rubber binder content, calculate dust proportion.
7. Record the asphalt rubber binder content in the Contractor Hot Mix Asphalt Design Data Form as the OBC.

The OBC must not fall below 7.5 percent by total weight of the mix.

Laboratory mixing and compaction must comply with superpave HMA mix design as described in MS-2 Asphalt Mix Design Methods by the Asphalt Institute, except the mixing temperature of the aggregate must be from 300 to 325 degrees F. The mixing temperature of the asphalt rubber binder must be from 375 to 425 degrees F. The compaction temperature of the combined mixture must be from 290 to 320 degrees F.

23-10.06.B Asphalt Rubber Binder

23-10.06.B.1 General

Asphalt rubber binder must be a combination of:

- 1.1. Asphalt binder
- 1.2. Asphalt modifier
- 1.3. CRM

The combined asphalt binder and asphalt modifier must be 80.0 ± 2.0 percent by weight of the asphalt rubber binder.

23-10.06.B.2 Asphalt Modifier

Asphalt modifier must be a resinous, high-flash-point, aromatic hydrocarbon and must comply with the requirements shown in the following table:

Asphalt Modifier for Asphalt Rubber Binder

Quality Characteristic	Test Method	Requirement
Viscosity at 100 °C ($\text{m}^2/\text{s} \times 10^{-6}$)	ASTM D445	$X \pm 3^a$
Flash point (min, °C)	ASTM D92	207
Molecular analysis:		
Asphaltenes (max, % by mass)	ASTM D2007	0.1
Aromatics (min, % by mass)		55

A. The symbol X is the proposed asphalt modifier viscosity. X must be between 19 and 36. A change in X requires a new asphalt rubber binder design.

Asphalt modifier must be from 2.0 to 6.0 percent by weight of the asphalt binder in the asphalt rubber binder.

23-10.06.B.3 Crumb Rubber Modifier

CRM must be a ground or granulated combination of scrap tire crumb rubber and high natural scrap tire crumb rubber. CRM must be 75.0 ± 2.0 percent scrap tire crumb rubber and 25.0 ± 2.0 percent high natural scrap tire crumb rubber by total weight of CRM. Scrap tire crumb rubber and high natural scrap tire crumb rubber must be derived from waste tires described in Pub Res Code § 42703.

The CRM must comply with the requirements shown in the following table:

Crumb Rubber Modifier for Asphalt Rubber Binder

Quality Characteristic	Test Method	Requirement
Scrap tire crumb rubber gradation (% passing No. 8 sieve)	California Test 385	100
High natural crumb rubber gradation (% passing No. 10 sieve)	California Test 385	100
Wire in CRM (max, %)	California Test 385	0.01
Fabric in CRM (max, %)	California Test 385	0.05
CRM particle length (max, in) ^a	--	3/16
CRM specific gravity	California Test 208	1.1–1.2
Natural rubber content in high natural crumb rubber (%)	ASTM D297	40.0–48.0
^a Test at mix design and for certificate of compliance.		

CRM must be ground or granulated at ambient temperature. If steel and fiber are cryogenically separated, separation must occur before grinding or granulating. Cryogenically produced CRM particles must be ground or granulated and not pass through the grinder or granulator.

CRM must be dry, free-flowing particles that do not stick together. CRM must not cause foaming when combined with the asphalt binder and asphalt modifier. The Contractor may add calcium carbonate or talc up to 3 percent by weight of CRM.

23-10.06.B.4 Design and Profile

The Contractor shall design the asphalt rubber binder from testing that the Contractor performs for each quality characteristic and for the reaction temperatures expected during production. The profile must include the same component sources for the asphalt rubber binder used. The 24-hour (1,440-minute) interaction period determines the design profile. At a minimum, the Contractor shall mix asphalt rubber binder components, take samples, and perform and record the tests shown in the following table:

Asphalt Rubber Binder Reaction Design Profile

Quality Characteristic	Test Method	Minutes of Reaction ^a							Limit
		45	60	90	120	240	360	1440	
Cone penetration at 25 °C (0.10 mm)	ASTM D217	X ^b	--	--	--	X	--	X	25–70
Resilience at 25 °C (min, % rebound)	ASTM D5329	X	--	--	--	X	--	X	18
Field softening point (°C)	ASTM D36/D36M	X	--	--	--	X	--	X	52–74
Viscosity (centipoises)	ASTM D7741/D7741M	X	X	X	X	X	X	X	1,500–4,000

- A. Six hours (360 minutes) after CRM addition, reduce the oven temperature to 275 °F for 16 hours. After the 16-hour (960 minutes) cool down after CRM addition, reheat the binder to the reaction temperature expected during production for sampling and testing at 24 hours (1,440 minutes).

- B. X denotes required testing.

23-10.06.B.5 Asphalt Rubber Binder Production**23-10.06.B.5.a General**

The Contractor shall deliver scrap tire crumb rubber and high natural crumb rubber in separate bags.

23-10.06.B.5.b Mixing

The Contractor shall proportion and mix asphalt binder, asphalt modifier, and CRM simultaneously or premix the asphalt binder and asphalt modifier before adding CRM. If the Contractor premixes asphalt binder and asphalt modifier, they shall be mixed for at least 20 minutes. When the Contractor adds CRM, the temperature of the asphalt binder and asphalt modifier must be from 375 to 440 degrees F.

After interacting for at least 45 minutes, the asphalt rubber binder must comply with the requirements shown in the following table:

Quality Characteristic	Test Method	Requirement
Cone penetration at 25 °C (0.10 mm)	ASTM D217	25–70
Resilience at 25 °C (min, % rebound)	ASTM D5329	18
Softening point (°C)	ASTM D36/36M	52–74
Viscosity at 190 °C (centipoises) ^a	ASTM D7741/D7741M	1,500–4,000

A. Prepare sample for viscosity test under California Test 388.

The Contractor shall not use the asphalt rubber binder during the first 45 minutes of the reaction period. During this period, the asphalt rubber binder mixture must be between 375 degrees F and the lower of 425 or 25 degrees F below the asphalt binder's flash point shown in the SDS.

If any asphalt rubber binder is not used within 4 hours after the reaction period, heating shall be discontinued. If the asphalt rubber binder drops below 375 degrees F, the Contractor shall reheat before use. If the Contractor adds more scrap tire crumb rubber to the reheated asphalt rubber binder, the binder must undergo a 45-minute reaction period. The added scrap tire crumb rubber must not exceed 10 percent of the total asphalt rubber binder weight.

Reheated and reacted asphalt rubber binder must comply with the viscosity specifications. The Contractor shall not reheat asphalt rubber binder more than twice.

23-10.06.C Aggregates

23-10.06.C.1 General

For RHMA-G, before the addition of asphalt binder, the aggregates must comply with the requirements shown in the following table:

Aggregate Quality

Quality Characteristic	Test Method	Requirement
Percent of crushed particles	AASHTO T 335	-- 90
Coarse aggregate (min, %)		
One-fractured face		
Two-fractured faces		
Fine aggregate (min, %)		
(Passing No. 4 sieve and retained on No. 8 sieve.)	AASHTO T 96	12 40
One-fractured face		
Los Angeles Rattler (max, %)	AASHTO T 176	47
Loss at 100 Rev.		
Loss at 500 Rev.		
Sand equivalent (min) ^a	ASTM D4791	Report only
Flat and elongated particles (max, % by weight at 5:1)	AASHTO T 304, Method A	45
Fine aggregate angularity (min, %) ^b	<p>A. Reported value must be the average of 3 tests from a single sample. The use of a sand reading indicator is required as shown in AASHTO T 176, Figure 1. Sections 4.7, "Manual Shaker," 7.1.2, "Alternate Method No. 2," and 8.4.3, "Hand Method," do not apply. Prepare the stock solution as specified in section 4.8.1, "Stock solution with formaldehyde," except omit the addition of formaldehyde.</p> <p>B. The Engineer waives this specification if the HMA contains 10 percent or less of nonmanufactured sand by weight of total aggregate unless the Contractor's r JMF fails verification. Manufactured sand is fine aggregate produced by crushing rock or gravel.</p>	

23-10.06.C.2 Aggregate Gradations

The aggregate gradations for RHMA-G must comply with the requirements shown in the following table:

Aggregate Gradation Requirements

RHMA-G pavement thickness shown	Gradation
0.10 foot or greater	1/2 inch

For RHMA-G, the aggregate gradations must be within the TV limits for the specified sieve size shown in the following tables:

**Aggregate Gradations for RHMA-G
(Percentage Passing)**

1/2 inch		
Sieve size	Target Value Limit	Allowable Tolerance
3/4"	100	--
1/2"	90–98	TV \pm 6
3/8"	83–87	TV \pm 5
No. 4	28–42	TV \pm 6
No. 8	14–22	TV \pm 5
No. 200	0.0–6.0	TV \pm 2.0

23-10.06.D Rubberized Hot Mix Asphalt-Gap Graded Production

Asphalt rubber binder must be from 375 to 425 degrees F when mixed with aggregate.

23-10.07 Construction

The Contractor shall use a material transfer vehicle when placing RHMA-G. The Contractor shall not use a pneumatic tired roller to compact RHMA-G.

The Contractor shall spread and compact RHMA-G and RHMA-G produced with WMA water injection technology at an ambient air temperature of at least 55 degrees F and a surface temperature of at least 60 degrees F.

The Contractor shall spread and compact RHMA-G produced with WMA additive technology at an ambient air temperature of at least 50 degrees F and a surface temperature of at least 50 degrees F.

If the ambient air temperature is below 70 degrees F, the Contractor shall cover loads in trucks with tarps. The tarps must completely cover the exposed load until the Contractor transfers the mixture to the paver's hopper or to the pavement surface. Tarps are not required if the time from discharge to truck until transfer to the paver's hopper or the pavement surface is less than 30 minutes.

For RHMA-G and RHMA-G produced with WMA water injection technology placed under method compaction, the Contractor shall:

1. Complete the 1st coverage of breakdown compaction before the surface temperature drops below 285 degrees F.
2. Complete breakdown and intermediate compaction before the surface temperature drops below 250 degrees F. Use a static steel-tired roller instead of the pneumatic-tired roller for intermediate compaction.
3. Complete finish compaction before the surface temperature drops below 200 degrees F.

For RHMA-G produced with WMA additive technology placed under method compaction, the Contractor shall:

1. Complete the 1st coverage of breakdown compaction before the surface temperature drops below 260 degrees F
2. Complete breakdown and intermediate compaction before the surface temperature drops below 230 degrees F
3. Complete finish compaction before the surface temperature drops below 180 degrees F.

- | 4. The Contractor may continue static rolling below 140 degrees F to remove roller marks

The Contractor shall spread sand at a rate between 1 and 2 lb/sq yd on new RHMA-G pavement when finish rolling is complete. Sand must be free of clay or organic matter. Sand must comply with section 90-1.02C(3). The Contractor shall keep traffic off the pavement until spreading of the sand is complete.

23-11 MEASUREMENT AND PAYMENT

Measurement and payment for HMA will be as specified in Section 9-1.02, "Measurement", of the State Specifications, and these Specifications.

When acceptance testing is required for HMA placement, full compensation for placement of the test section is included in the price paid per ton for HMA and no additional compensation will be paid.

RHMA-G will be measured by the ton as specified for AC in Section 9-1.02, "Measurement", of the State Specifications.

The unit price paid per ton for RHMA-G includes full compensation for furnishing all labor, materials, tools, equipment, and incidentals, and for doing all work involved in placing RHMA-G complete in place, including furnishing and spreading sand cover if directed by the Agency, as shown on the Plan, as specified in the State Specifications, these Specifications, and the Special Provisions, and as directed by the Agency, except that HMA leveling courses will be paid per ton of HMA-LG, and no additional compensation will be paid.

HMA-LG leveling courses will be measured and paid for by the ton as HMA.

23-12 COMPENSATION ADJUSTMENTS FOR PRICE INDEX FLUCTUATIONS

23-12.01 General

Each lot must be subject to a Pay Factor as specified in Section 23-9.02, "Pay Factors," of the Standard Construction Specifications.

The Agency will adjust payment if the California Statewide Crude Oil Price Index for the month the material is placed is more than five percent (5%) higher or lower than the price index at the time of bid.

The California Statewide Crude Oil Price Index is determined each month on or about the 1st business day of the month by the Department using the average of the posted prices in effect for the previous month as posted by Chevron, ExxonMobil, and ConocoPhillips for the Buena Vista, Huntington Beach, and Midway Sunset fields.

If a company discontinues posting its prices for a field, the Department determines the index from the remaining posted prices. The Department may include additional fields to determine the index.

For the California Statewide Crude Oil Price Index, go to

<http://www.dot.ca.gov/hq/construc/crudeoilindex/>

The Agency includes payment adjustments for price index fluctuations when making adjustments under Section 2.101, Unit Price Bid in these Specifications.

If the Contractor does not complete the work within the contract time, payment adjustments during the overrun period are determined using the California Statewide Crude Oil Price Index in effect for the month in which the overrun period began.

If the price index at the time of placement increases twenty-five percent (25%) or more over the price index at bid opening, the Contractor shall not furnish material containing asphalt until the Agency authorizes the Contractor to proceed with that work. The Agency may decrease Bid item quantities, eliminate Bid items, or terminate the contract.

23-12.02 Asphalt Quantities**HMA:**

The Engineer calculates the quantity of asphalt in Hot Mix Asphalt (HMA) using the following formula:

$$Q_h = HMATT \times X_a$$

where:

Q_h = quantity in tons of asphalt used in HMA

$HMATT$ = HMA, total tons placed

X_a = theoretical asphalt content from the job mix formula, expressed as a percentage of the total weight of HMA

RHMA:

The Engineer calculates the quantity of asphalt in rubberized HMA (RHMA) using the following formula:

$$Q_{rh} = RHMATT \times 0.80 \times X_{arb}$$

where:

Q_{rh} = quantity in tons of asphalt in asphalt rubber binder used in RHMA

$RHMATT$ = RHMA, total tons placed

X_{arb} = theoretical asphalt rubber binder content from the job mix formula, expressed as a percentage of the total weight of rubberized HMA

HMA (with Modified Asphalt Binder):

The Engineer calculates the quantity of asphalt in modified asphalt binder using the following formula:

$$Q_{mh} = MHMATT \times [(100 - X_{am})/100] \times X_{mab}$$

where:

Q_{mh} = quantity in tons of asphalt in modified asphalt binder used in HMA

$MHMATT$ = modified asphalt binder HMA, total tons placed

X_{am} = specified percentage of asphalt modifier

X_{mab} = theoretical modified asphalt binder content from the job mix formula, expressed as a percentage of the total weight of HMA

HMA (with RAP):

The Engineer calculates the quantity of asphalt in HMA containing RAP using the following formulas:

$$Q_{rap} = HMARTT \times X_{aa}$$

where:

$$X_{aa} = X_{ta} - [(X_{rap} \times X_{ra} \times (X_{ta} - 100)) / (100 \times (X_{ra} - 100))]$$

and:

Q_{rap} = quantity in tons of asphalt used in HMA containing RAP

$HMARTT$ = HMA containing RAP, total tons placed

X_{aa} = asphalt content of HMA containing RAP adjusted to exclude the asphalt content in RAP, expressed as a percentage of the total weight of HMA containing RAP

X_{ta} = total theoretical asphalt content in HMA containing RAP from the job mix formula, expressed as a percentage of the total weight of HMA containing RAP

X_{rap} = RAP percentage in HMA containing RAP from the job mix formula, expressed as a

percentage of the total dry weight of aggregate in HMA containing RAP

X_{ra} = average asphalt content of RAP from the job mix formula, expressed as percentage of total weight of RAP

Other:

Other materials containing asphalt not covered above are not subject to payment adjustments.

23-12.03 Payment Adjustments

Payment adjustments for price index fluctuations will be included in Contract Change Orders per section 9-14, "Contract Change Orders," in these Specifications. If material containing asphalt is placed within 2 months during 1 estimate period, the Engineer calculates 2 separate adjustments. Each adjustment is calculated using the price index for the month in which the quantity of material containing asphalt subject to adjustment is placed in the work. The sum of the 2 adjustments is used for increasing or decreasing payment in the progress pay estimate. The Engineer calculates each payment adjustment as follows:

$$PA = Q_t \times A$$

where:

PA = Payment adjustment in dollars for asphalt contained in materials placed in the work for a given month.

Q_t = Sum of all quantities of asphalt-contained materials in pavement structural sections and pavement surface treatments placed ($Q_h + Q_{rh} + Q_{mh} + Q_{rap}$).

A = Adjustment in dollars per ton of asphalt used to produce materials placed in the work rounded to the nearest \$0.01.

$A = [(I_u / I_b) - 1.05] \times I_b \times [1 + (T / 100)]$ for an increase in the crude oil price index exceeding 5 percent

$A = [(I_u / I_b) - 0.95] \times I_b \times [1 + (T / 100)]$ for a decrease in the crude oil price index exceeding 5 percent

I_u = California Statewide Crude Oil Price Index for the month in which the quantity of asphalt subject to adjustment was placed in the work.

I_b = California Statewide Crude Oil Price Index for the month in which the bid opening for the project occurred

T = Sales and use tax rate, expressed as a percent, currently in effect in the tax jurisdiction where the material is placed. If the tax rate information is not submitted timely, the statewide sales and use tax rate is used in the payment adjustment calculations until the tax rate information is submitted.