

**23-1 GENERAL**

**23-1.01 Summary**

This section is applicable to all HMA placement under 2,500 tons unless otherwise stated in the project plans and specifications.

Do not use this Section 23 and use Section 39, “Asphalt Concrete” of the State Standard Specifications for the production and placement of the following:

1. HMA to be used in miscellaneous areas and dikes
2. HMA to be placed on the State Highway System
3. The following Types of HMA:
  - a. Type A HMA for quantities more than 2,500 tons
  - b. RHMA-G
  - c. OGFC
  - d. Bonded Wearing Course (BWC)
4. Other asphalt concrete

**23-1.02 Abbreviations**

Abbreviations used in Section 23 are those listed in 1-1.06 of the Caltrans Standard 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**

**23-1.04.A Job Mix Formula**

Submit your proposed JMF to be used. The JMF must be submitted on the Caltrans Contractor Job Mix Formula Proposal form for each type of HMA to be used, along with:

1. Mix design documentation on a Caltrans Contractor Hot Mix Asphalt Design Data form dated within 12 months of the submittal for the JMF verification.
2. 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. SDS for:
  - 3.1 Asphalt binder
  - 3.2 Supplemental fine aggregate except fines from dust collectors
  - 3.3 Antistrip additives

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

If you cannot submit a City (or Caltrans)-verified JMF on a Caltrans Hot Mix Asphalt Verification form dated within 12 months before HMA production, the Engineer verifies the JMF in accordance with Section 23-1.05.D.

Submit a new JMF if you change 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 your Contractor Hot Mix Asphalt Design Data form
7. Average maximum specific gravity in a new processed RAP stockpile by more than  $\pm 0.060$  from the average maximum specific gravity value reported on page 4 of your Contractor Hot Mix Asphalt Design Data form
8. Any material in the JMF, except lime supplier and source

Allow the Engineer 5 business days from a complete JMF submittal for document review of the aggregate qualities, mix design, and JMF. The Engineer notifies you if the proposed JMF submittal is accepted.

If your JMF fails verification testing, submit an adjusted JMF based on your testing. 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.

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## SECTION 23 – ASPHALT CONCRETE

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You 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.

### **23-1.04.B Job Mix Formula Renewal**

The Engineer verifies the JMF for renewal from samples taken from the plant to be used. You 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.

### **23-1.04.C Job Mix Formula Modification**

The Engineer verifies the JMF modification.

For an authorized JMF, submit a modified JMF if you change any of the following:

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

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

Submit your modified JMF request at least 15 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 Engineer verifies each modified JMF within 10 days of receiving all verification samples.

### **23-1.04.D Quality Control Plan**

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

1. Controlling quality characteristics.
2. Taking 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.

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## SECTION 23 – ASPHALT CONCRETE

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

1. Aggregates.
2. Asphalt binder.
3. Additives.
4. Production.
5. Paving.

The QC plan must include aggregate QC sampling and testing during lime treatment. Allow 10 business days for review of the QC plan.

If you change QC procedures, personnel, or sample testing locations, submit a QC plan supplement before implementing the proposed change. Allow 3 business days for review of the QC plan supplement.

### **23-1.04.E Liquid Antistrip Treatment**

Refer to Section 39-2.01 A(3)(f) of the State Standard Specifications.

### **23-1.04.F Lime Treatment**

Refer to Section 39-2.01 A(3)(g) of the State Standard Specifications.

### **23-1.04.G Warm Mix Technology**

Refer to Section 39-2.01 A(3)(h) of the State Standard Specifications.

## **23-1.05 Quality Assurance**

### **23-1.05.A Laboratories**

Laboratories testing aggregate and HMA qualities used to prepare the mix design and JMF must be qualified under the AASHTO re:source program and the Caltrans Independent Assurance Program.

### **23-1.05.B Hot Mix Asphalt Plants**

Before production, the HMA plant must have a current qualification under the Caltrans' Material Plant Quality Program.

### **23-1.05.C Test Methods**

Wherever reference is made to the following test methods, the year of publication for these test methods is as shown in the following table:

| <b>Test method</b> | <b>Year of publication</b> |
|--------------------|----------------------------|
| AASHTO M 17        | 2011 (2015)                |
| AASHTO M 323       | 2013                       |
| AASHTO R 30        | 2019                       |
| AASHTO R 59        | 2011 (2015)                |
| AASHTO T 27        | 2020                       |
| AASHTO T 49        | 2014                       |
| AASHTO T 59        | 2013                       |

**SECTION 23 – ASPHALT CONCRETE**

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|------------------------|------------------------|
| AASHTO T 96            | 2002 (2010)            |
| AASHTO T 164           | 2014                   |
| AASHTO T 176           | 2008                   |
| AASHTO T 209           | 2020                   |
| AASHTO T 269           | 2014                   |
| AASHTO T 275           | 2007 (2012)            |
| AASHTO T 304           | 2011                   |
| AASHTO T 305           | 2014                   |
| AASHTO T 308           | 2010                   |
| AASHTO T 312           | 2014                   |
| AASHTO T 313           | 2012 (2016)            |
| AASHTO T 315           | 2012 (2016)            |
| AASHTO T 329           | 2013                   |
| AASHTO T 335           | 2009                   |
| ASTM D36/D36M          | 2014 <sup>ε1</sup>     |
| ASTM D92               | 2012b                  |
| ASTM D217              | 2010                   |
| ASTM D297              | 2013                   |
| ASTM D445              | 2014                   |
| ASTM D1856             | 2009 (Reapproved 2015) |
| ASTM D2007             | 2011                   |
| ASTM D2074             | 2007 (Reapproved 2013) |
| ASTM D2995             | 1999 (Reapproved 2009) |
| ASTM D4791             | 2010                   |
| ASTM D5329             | 2009                   |
| ASTM D7741/D7741M      | 2011 <sup>ε1</sup>     |
| Asphalt Institute MS-2 | 7th edition (2015)     |
| California Test 389    | 2020                   |

Take samples in accordance with California Test 125:

<https://dot.ca.gov/-/media/dot-media/programs/engineering/documents/californiatestmethods-ctm/ctm-125-a11y.pdf>

**23-1.05.D Job Mix Formula Verification**

The Engineer verifies the JMF from samples taken from HMA produced by the plant to be used.

The production set point at the plant must be within  $\pm 0.2$  from the asphalt binder percentage TV shown in your Contractor Job Mix Formula Proposal form. Notify the Engineer at least 2 business days before sampling materials. Samples may be taken from a different

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## SECTION 23 – ASPHALT CONCRETE

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project including a non-Agency project if you make arrangements for the Engineer to be present during sampling.

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

1. Aggregates. Coarse, fine, and supplemental fine aggregates must be taken from the combined cold-feed belt or the hot bins. If lime treatment is required, samples must be taken from individual stockpiles before lime treatment. 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.
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 used or 100 pounds from the belt.
4. Plant-produced HMA. The HMA samples must be at least 250 pounds.

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

After acceptance of the JMF submittal, the Engineer verifies each proposed JMF within 20 days of receiving all verification samples.

For JMF verification, the Engineer tests 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 Engineer uses an average of 3 briquettes. The Engineer tests plant-produced material.

If the Engineer verifies the JMF, the Engineer furnishes you a Hot Mix Asphalt Verification form.

If the Engineer's test results on plant-produced samples do not show compliance with the specifications, the Engineer notifies you. Submit a JMF adjusted after verification failure based on your testing unless the Engineer authorizes reverification without adjustments. 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  $\pm 0.20$  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 You may adjust the JMF only once due to a failed verification test.

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## SECTION 23 – ASPHALT CONCRETE

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For each HMA type and aggregate size specified, the Engineer verifies up to 2 proposed JMF submittals including a JMF adjusted after verification failure. Do not resubmit any of the 2 proposed submittals including a JMF adjusted after verification failure that failed verification on any other *Agency* projects. If you submit more than 2 JMFs for each type of HMA and aggregate size, the Engineer deducts \$3,000 from payments for each verification exceeding this limit. This deduction does not apply to verifications initiated by the Engineer or if a JMF expires while HMA production is stopped longer than 30 days.

A verified JMF is valid for 24 months.

### **23-1.05.E Job Mix Formula Authorization**

You may start HMA production if:

1. Engineer's review of the JMF shows compliance with the specifications
2. The JMF has been verified within 24 months before HMA production
3. Engineer authorizes the verified JMF
4. The Contractor QC plan has been reviewed and approved.

### **23-1.05.F Job Mix Formula Renewal**

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

1. Aggregates. Coarse, fine, and supplemental fine aggregates must be taken from the combined cold-feed belt or the hot bins. If lime treatment is required, samples must be taken from individual stockpiles before lime treatment. 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*.

Notify the Engineer at least 2 business days before sampling materials. For aggregate, RAP, and HMA, split samples into at least 4 parts. Submit 3 parts and use 1 part for your testing.

Allow the Engineer 5 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 or upon request, the Engineer may perform aggregate quality tests for verification of JMF renewal.

The Engineer verifies the JMF for renewal in accordance with Section 23-1.04.B except:

1. Engineer keeps the samples until you provide test results for your part on a Contractor Job Mix Formula Renewal form.

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## SECTION 23 – ASPHALT CONCRETE

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2. The Engineer 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 Engineer verifies each proposed JMF within 20 days of receiving the verification renewal samples and the complete Contractor Job Mix Formula Renewal form.
4. You may not adjust the JMF due to a failed verification.

The Engineer furnishes you an HMA Verification form. The HMA Verification form is valid for 24 months.

### **23-1.05.F Job Mix Formula Modification**

The Engineer verifies the modified JMF after the modified JMF HMA is placed and verification samples are taken within the first 750 tons. The Engineer tests verification samples for compliance with:

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

The Engineer may test for moisture susceptibility for compliance with the mix design specifications.

If the modified JMF is verified, the ITP revises your Hot Mix Asphalt Verification form to include the new asphalt binder source, new liquid antistriper producer, or new liquid antistriper dosage. Your revised form will have the same expiration date as the original form.

If a modified JMF is not verified, stop production and any HMA placed using the modified JMF is rejected.

### **23-1.06 Quality Control**

#### **23-1.06.A General**

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

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

Condition each at-the-plant sample of HMA mixture for testing under AASHTO 283 in compliance with sections 7.1.2, 7.1.3, and 7.1.4 of AASHTO R 30. 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.

Prepare 3 briquettes for air voids content and voids in mineral aggregate determination. Report the average of 3 tests.

## SECTION 23 – ASPHALT CONCRETE

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:

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.

Do not resume production and placement until the Engineer authorizes your corrective action proposal.

### **23-1.06.B Aggregates**

#### **23-1.06.B(1) General**

Test the quality characteristics of aggregates under the test methods and frequencies shown in the following table:

| <b>Aggregate Testing Frequencies</b>   |                          |   |
|--|--------------------------|---|
| <b>Quality characteristic</b>          | <b>Test method</b>       | <b>Minimum testing frequency</b>                        |
| Gradation <sup>a</sup>                 | AASHTO T 27              | 1 per 750 tons and any remaining part                   |
| Sand equivalent <sup>b, c</sup>        | AASHTO T 176             |   |
| Moisture content <sup>d</sup>          | 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 <sup>e</sup> | AASHTO T 304<br>Method A |   |

<sup>a</sup>If RAP is used, test the combined aggregate gradation under California Test 384.

<sup>b</sup>Reported value must be the average of 3 tests from a single sample.

<sup>c</sup>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.

<sup>d</sup>Test at continuous mixing plants only. If RAP is used, test the RAP moisture content at continuous mixing plant and batch mixing plant.

<sup>e</sup>Waived if 10% or less non-manufactured sand.

For lime treated aggregate, test aggregate before treatment and test for gradation and moisture content during HMA production

**23-1.06.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. Do not wash the coarse aggregate. Wash the fine aggregate only. Use a mechanical sieve shaker. Aggregate shaking time must not exceed 10 minutes for each coarse and fine aggregate portion.

Choose a TV within the TV limits shown in the tables titled "Aggregate Gradations."

Gradations are based on nominal maximum aggregate size.

**23-1.06.B(3) Lime Treatments**

Refer to Section 39-2.01A(4)(h)(iii)(B) of the State Standard Specifications

**23-1.06.C Reclaimed Asphalt Pavement**

During RAP production sample RAP at a minimum frequency of 1 sample per 1,000 tons with a minimum of 6 samples per stockpile and test for the following:

1. Binder content under AASHTO T308 and T164
2. Aggregate gradation under California Test 384

Sample and test processed RAP at a minimum frequency of 1 sample per 1,000 tons with a minimum of 6 samples per fractionated stockpile. If the fractionated stockpile has not been augmented, the 3 RAP samples taken and tested for mix design can be part of this minimum sample requirement. If a processed RAP stockpile is augmented, sample and test processed RAP quality characteristics at a minimum frequency of 1 sample per 500 tons of augmented RAP.

When tested under AASHTO T 308, the uncorrected binder content of the combined RAP sample must be within  $\pm 2.00$  percent of the average uncorrected asphalt binder content reported on page 4 of your Contractor Hot Mix Asphalt Design Data form. If a new processed RAP stockpile is required, the average uncorrected binder content of the new processed RAP stockpile tested under AASHTO T 308 must be within  $\pm 2.00$  percent of the average uncorrected binder content reported on page 4 of your Contractor Hot Mix Asphalt Design Data form. You must use the same ignition oven used to determine the uncorrected asphalt binder content reported on page 4 of your Contractor Hot Mix Asphalt Design Data form.

The combined RAP sample when tested under AASHTO T 209 must be within  $\pm 0.06$  of the average maximum specific gravity reported on page 4 of your Caltrans Contractor Hot Mix Asphalt Design Data form.

During HMA production, 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

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## SECTION 23 – ASPHALT CONCRETE

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Submit QC test results for RAP gradation with the combined aggregate gradation within 2 business days of taking RAP samples during HMA production.

### **23-1.06.D Liquid Antistrip Treatment**

Refer to Section 39-2.01A(4)(h)(iv) of the State Standard Specifications

### **23-1.06.E Hot Asphalt Mixtures**

Test the quality characteristics of HMA under the test methods and frequencies shown in the following table:

**HMA Production Testing Frequencies**

| <b>Quality characteristic</b> | <b>Test method</b>               | <b>Minimum testing frequency</b>                                |
|-------------------------------|----------------------------------|---|
| Asphalt binder content        | AASHTO T 308, Method A           | 1 per 750 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 |   |

If ordered, submit QC test results within 3 business days of a request.

If a tapered notched wedge is used, submit compaction test result values within 24 hours of testing.

### **23-1.07 Dispute Resolution**

You and the Engineer must work together to avoid potential conflicts and to resolve disputes regarding test result discrepancies. You and the Engineer may request witness testing and sharing of test data worksheets. Notify the Engineer within 5 business days of receiving a test result if you dispute the test result.

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 Caltrans Independent Assurance Program. 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 you or your HMA producer.

The Agency is responsible for securing 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 you and the Engineer as representing the disputed HMA for evaluation.

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## SECTION 23 – ASPHALT CONCRETE

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The results of the tests performed by the independent third party shall prevail. The Agency pays half of the independent third party's testing cost. The Engineer deducts half of the independent third party's testing costs from payments.

### **23-2 MIX FORMULA AND DESIGN**

#### **23-2.01 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.

The HMA mix design must comply with AASHTO R 35 except:

1. Notes 3 and 10 do not apply.

#### **23-2.02 Requirements**

##### **23-2.02.A General**

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

**SECTION 23 – ASPHALT CONCRETE**

| <b>Quality Characteristic</b>   |  | <b>Test Method</b>                        | <b>Requirement</b>                               |
|---|--|---|--|
| Air voids content (%)   |  | AASHTO T 269 <sup>a</sup>                 | Ninitial > 8.0<br>Ndesign = 4.0<br>Nmax > 2.0    |
| Gyrations compaction (no. of gyrations)   |  | AASHTO T 312                              | Ninitial = 7<br>Ndesign = 65.0<br>Nmax = 115     |
| Voids in mineral aggregate (min, %) <sup>b</sup><br><br>Gradation:<br>No. 4<br>3/8-inch<br>1/2-inch<br>3/4-inch                     |  | MS-2<br>Asphalt<br>Mixture<br>Volumetrics | 16.0–19.5<br>15.0–18.0<br>14.0–17.0<br>13.0–16.0 |
| Dust proportion   |  | MS-2<br>Asphalt<br>Mixture<br>Volumetrics | 0.6–1.3  |
| Hamburg wheel track (min number of passes at 0.5-inch rut depth)<br><br>Binder grade:<br>PG 58<br>PG 64<br>PG 70<br>PG 76 or higher |  | California<br>Test<br>389 <sup>c</sup>    | 10,000<br>15,000<br>20,000<br>25,000             |

<sup>a</sup>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 and pycnometer when performing AASHTO T 209.

<sup>b</sup>Measure bulk specific gravity using AASHTO T 275, Method A.

<sup>c</sup>Test plant-produced HMA.

**23-2.02. B Reclaimed Asphalt Pavement**

For HMA mixtures using RAP, the maximum allowed binder replacement is 25.0 percent. 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.

## SECTION 23 – ASPHALT CONCRETE

For RAP substitution greater than 15 percent and not exceeding 25 percent use one of the following criteria:

- The grade of the virgin binder must be the specified grade of asphalt binder for HMA with the upper and lower temperature classification reduced by 6 degrees C.
- The grade of the virgin binder as identified using a blending chart.

Hamburg wheel track requirements are based on the grade of asphalt binder specified for HMA.

### **23-2.02.C Hot Mix Asphalt Treatments**

Refer to Section 39-2.01 B(2)(b) of the State Standard Specifications

### **23-2.02.D Warm Mix Asphalt Technology**

Refer to Section 39-2.01 B(2)(c) of the State Standard Specifications.

## **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 and lime treatment (if required), the aggregates must comply with the requirements shown in the following table:

| Quality Characteristic  | Test Method            | Requirement |
|---|------------------------|-------------|
| Percent of crushed particles: Coarse aggregate (min, %)                                       | AASHTO T 335           | 85          |
| One-fractured face  |                        | 80          |
| Two-fractured faces   |                        |             |
| Fine aggregate (min, %) (Passing No. 4 sieve and retained on No. 8 sieve.) One-fractured face |                        | 70          |
| Los Angeles Rattler (max, %)  | AASHTO T 96            |             |
| Loss at 100 Rev.  |                        | 12          |
| Loss at 500 Rev.  |                        | 40          |
| Sand equivalent (min) <sup>a</sup>  | AASHTO T 176           | 47          |
| Flat and elongated particles (max, % by weight at 5:1)  | ASTM D4791             | 10          |
| Fine aggregate angularity (min, %) <sup>b</sup>   | AASHTO T 304, Method A | 45          |

**SECTION 23 – ASPHALT CONCRETE**

<sup>a</sup>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.

<sup>b</sup>The Engineer waives this specification if the Type A HMA contains 10 percent or less of non-manufactured sand by weight of total aggregate, except if your JMF fails verification.

**23-3.01.C Gradations**

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

**Aggregate Gradation Requirements**

| HMA pavement thickness shown      | Gradation |
|-----------------------------------|-----------|
| 0.10 foot to less than 0.125 foot | 3/8 inch  |
| 0.125 to less than 0.20 foot      | 1/2 inch  |
| 0.20 foot and 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**

**3/4 inch**

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

**1/2 inch**

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

**SECTION 23 - ASPHALT CONCRETE**

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**3/8 inch**

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

**23-3.01.D Aggregate Lime Treatments**

Refer to Section 39-2.01 B(4)(c) of the State Standard Specifications.

**23-3.02 Reclaimed Asphalt Pavement**

Provide enough space at your plant for complying with all RAP handling requirements. Provide a clean, graded base, well drained area for stockpiles.

If RAP is from multiple sources, 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, 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**

| <b>Size</b>                         | <b>Test method</b>                  | <b>Requirement</b> |
|-------------------------------------|-------------------------------------|--------------------|
| Coarse (% passing the 1-inch sieve) | California Test<br>202 <sup>a</sup> | 100                |
| Fine (% passing the 3/8-inch sieve) | California Test<br>202 <sup>a</sup> | 98-100             |

<sup>A</sup> Maximum mechanical shaking time is 10 minutes.

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

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## SECTION 23 – ASPHALT CONCRETE

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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 must be PG 64-10.

### **23-3.04 Liquid Antistrip Treatment**

Refer to Section 39-2.01B(5) of the State Standard Specifications.

### **23-3.05 Tack Coat**

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

## **23-4 PRODUCTION**

### **23-4.01 General**

Do not start HMA production before authorization of the JMF.

Weighing and metering devices used for the production of HMA modified with additives must comply with the Caltrans Material Plant Quality Program (MPQP):

<https://dot.ca.gov/programs/construction/material-plant-quality-program>

or

Comply with California Test 109 as certified by a State of California Department of Food and Agriculture, Division of Measurement Standards, Registered Service Agency. A listing of registered service agencies is available at the following:

<https://www.cdfa.ca.gov/dms/programs/rsa/rsalistings/rsaListings.html>

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.

Calibrate the loss-in-weight meter 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.

Proportion aggregate by hot or cold-feed control.

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## SECTION 23 – ASPHALT CONCRETE

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Asphalt binder temperature must be from 275 to 375 degrees F when mixed with aggregate.

Mix HMA ingredients into a homogeneous mixture of coated aggregates. HMA must be produced at the temperatures shown in the following table:

| <b>HMA Production Temperatures</b> |                         |
|------------------------------------|-------------------------|
| <b>HMA compaction</b>              | <b>Temperature (°F)</b> |
| HMA                                |                         |
| Density based                      | ≤ 325                   |
| HMA with WMA technology            |                         |
| Density based                      | 240–325                 |

If you stop production for longer than 30 days, a production start-up evaluation is required.

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

During production, you 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  $\pm 5$  of RAP percentage shown in your Contractor Job Mix Formula Proposal form without exceeding 15 percent. For RAP substitution of greater than 15 percent, RAP must be within  $\pm 5$  of RAP percentage shown in your Contractor Job Mix Formula Proposal form without exceeding 25 percent.

### **23-4.02 Liquid Antistrip**

Refer to Section 39-2.01B(8)(b) of the State Standard Specifications

### **23-4.03 Warm Mix Asphalt Technology**

Refer to Section 39-2.01B(8)(c) of the State Standard Specifications

### **23-4.04 Production Start-up Evaluation**

You and the Engineer evaluate HMA production and placement at production start-up if the tonnage of HMA is 1,000 or greater.

Within the first 750 tons produced on the 1st day of HMA production, in the Engineer's presence, and from the same production run, take samples of:

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

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## SECTION 23 – ASPHALT CONCRETE

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Sample aggregates from the combined cold-feed belt or hot bin. Take RAP samples from the RAP system.

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

You and the Engineer must test the samples and report test results, except for AASHTO T324. If you proceed with paving before receipt of the test results, the Engineer may consider the HMA placed to be represented by these test results.

AASHTO T324 is not required.

If production stops for more than 60 days, perform a production start-up evaluation. If production stops for more than 30 days but less 60 days, perform a reduced production start-up evaluation. Reduced production start-up evaluation is production start-up evaluation without California Test 389.

If production start-up evaluation fails, do not begin production.

The test strip construction, cores, and correlation of the nuclear gauge specified in Section 23-6.8.1 shall be performed concurrently with production start-up evaluation.

### **23-5 CONSTRUCTION**

#### **23-5.01 General**

If a WMA technology is used, a technical representative for the WMA technology must attend the preconstruction meeting.

Do 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, 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, do 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, pave each through lane's top layer before paving a tapering lane's top layer. Simultaneous to paving a through lane's top layer, you may pave an adjoining area's top layer, including shoulders. Do not operate spreading equipment on any area's top layer until completing final compaction.

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

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

If a driveway or a road connection is shown, 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.

### **23-5.02 Equipment**

#### **23-5.02.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

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 you can eliminate them by rolling.

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

#### **23-5.02.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:

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## SECTION 23 – ASPHALT CONCRETE

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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

### **23-5.03 Surface Preparation**

Prepare subgrade to receive HMA under the sections for the material involved. Subgrade must be free of loose and extraneous material.

Before placing HMA, 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.

### **23-5.04 Tack Coat**

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.

Close areas receiving tack coat to traffic. Do not allow the tracking of tack coat onto pavement surfaces beyond the job site.

If you use 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, apply a tack coat in one application at the minimum residual rate shown in the table. If water was used, do 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

**SECTION 23 – ASPHALT CONCRETE**

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 <sup>1</sup> (gallons/square yard)    |  |   |
|---|--|--|---|
|   | CSS-1/CSS-1h, SS-1/SS-1h and QS-1h/CQS-1h asphaltic emulsion | CRS-1/CRS-2, RS-1/RS-2 and QS-1/CQS-1 asphaltic emulsion | Asphalt binder and PMRS-2/PMCRS-2 and PMRS-2h/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  |
| Cold Milled/Micro-Milled/Cold Planed Pavement             | 0.05   | 0.06   | 0.04  |

<sup>1</sup>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.

Apply a tack coat to vertical surfaces with a residual rate that will thoroughly coat the vertical face without running off.

Notify the Engineer if you dilute asphaltic emulsion with water. The weight ratio of added water to asphaltic emulsion must not exceed 1 to 1.

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 you measure water by volume, apply a conversion factor to determine the correct weight.

With each dilution, 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, you may:

1. Change tack coat rates

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**SECTION 23 – ASPHALT CONCRETE**

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2. Omit tack coat between layers of new HMA during the same work shift if:
  - 2.1 No dust, dirt, or extraneous material is present
  - 2.2 Surface is at least 140 degrees F

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

**23-5.05 Placement**

**23-5.05.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.

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 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.

You 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

Do 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, you may place HMA in multiple lifts not less than 0.15 foot each. If placing HMA in multiple lifts:

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

**Aggregate Gradation Requirements**

| HMA lift thickness               | Gradation |
|----------------------------------|-----------|
| 0.15 to less than 0.20 foot      | 1/2 inch  |
| 0.20 foot to less than 0.25 foot | 3/4 inch  |

**SECTION 23 – ASPHALT CONCRETE**

|                      |          |
|----------------------|----------|
| 0.25 foot or greater | 3/4 inch |
|----------------------|----------|

3. Apply a tack coat before placing a subsequent lift
4. The Engineer evaluates each HMA lift individually for compliance

If the ambient air temperature is below 60 degrees F, 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, 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 you transfer the mixture to the paver's hopper or the pavement surface.

Spread HMA with WMA at the ambient air and surface temperatures shown in the following table:

**Minimum Ambient Air and Surface Temperatures**

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

**23-5.05.B Pre-overlay Preparation**

Existing asphalt concrete roadways to be overlaid with asphalt concrete shall be prepared as follows:

A leveling course may be required. Leveling courses shall be Type "A" HMA with three-eighths inch (3/8") inch maximum aggregate gradation. A leveling course shall be required for all locations for which the difference in elevation between the existing pavement surface and the finished pavement surface, as indicated on the Plans, exceeds the thickness of the overlay designated for the associated areas of roadway by more than 0.04 feet. The total thickness for asphalt concrete leveling course varies. At locations where the leveling course thickness exceeds three inches (3"), the leveling course shall be placed in lifts not exceeding three inches (3"). For projects with pavement reinforcing fabric, leveling course material shall be placed at least one day prior to the placement of the fabric.

The Contractor is responsible for removing all vegetation from the edge of pavement and sweeping and washing the pavement, if required, in advance of the overlay operation.

The Contractor shall remove and dispose of all pavement markers, temporary Type "B" Detector Handhole protection devices, and temporary traffic stripe (tape), if any, prior to the

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## SECTION 23 – ASPHALT CONCRETE

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overlay. In addition, the Contractor shall remove and dispose of existing traffic bars as required by the City.

All thermoplastic limit lines, crosswalks, and legends existing on the road surface shall be scarified prior to placing the overlay. Scarification shall be performed by grinding such that approximately twenty percent (20%) of the underlying pavement is exposed. All material resulting from the grinding operation shall be removed immediately from the right-of-way and shall become the property of the Contractor and properly disposed of.

Striping removal shall occur no sooner than one calendar day prior to the scheduled date for the placement of asphalt concrete overlay. If the stripe removal is performed on a day other than the day of the pavement overlay, the Contractor shall supply and install temporary pavement markings. Temporary pavement markings shall be flush mounted reflectorized tape squares, 4" x 4" #M "Staymark" with backing liners, detour grade, #6350 yellow and #6351 white, or approved equal. Right turn barrier lines, edge lines, and shoulder lane lines shall not be delineated with temporary pavement markings. The spacing of the temporary pavement markings shall be as follows:

| Line Type                                | Color  | Spacing  |
|--|--------|----------|
| Centerline (straight roadway portions)   | Yellow | 48' O.C. |
| Centerline (tapered or curving portions) | Yellow | 24' O.C. |
| Stop Lines                               | White  | 6' O.C.  |
| Channelizing Line                        | White  | 24' O.C. |

The Contractor shall be responsible for the removal of the temporary pavement markings prior to the placement of the overlay.

All manhole and other utility covers encountered in the area to be overlaid with asphalt concrete shall be carefully referenced out by the Contractor and the locations of the cover painted on the surface immediately after paving.

The Contractor is responsible for furnishing and placing an asphalt emulsion tack coat in advance of the overlay as provided in Sections 37, 39, and 94 of the State Specifications.

### **23-5.05.C 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.

A vertical longitudinal joint of more than 0.15 foot is not allowed at any time between adjacent lanes open to traffic.

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## SECTION 23 – ASPHALT CONCRETE

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For an HMA thickness of 0.15 foot or less, the distance between the ends of the adjacent surfaced lanes at the end of each day's work must not be greater than can be completed in the following day of normal paving.

For an HMA thickness greater than 0.15 foot, you must place HMA on adjacent traveled way lanes or shoulder such that at the end of each work shift the distance between the ends of HMA layers on adjacent lanes is from 5 to 10 feet. Place additional HMA along the transverse edge at each lane's end and along the exposed longitudinal edges between adjacent lanes. Hand rake and compact the additional HMA- LG to form temporary conforms. You 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, saw cut or grind the pavement straight and vertical along the joint and remove extraneous material.

### **23-5.06    *Compaction***

Start rolling at the lower edge and progress toward the highest part except when compacting layers which exceed 4 inches (4") in compacted thickness. For layers which exceed 4 inches (4") in compacted thickness, start rolling in the middle of the mat, and advance gradually to both edges. Roll supported edges (edges along concrete curbs and gutters, or headers) before unsupported edges. If approved, you 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.

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, turn the vibrator off.

HMA, after the completion of rolling, shall be compacted to not less than 92 percent and not more than 97 percent of the maximum theoretical density (MTD) as determined in accordance with California Test 309, AASHTO T 209, AASHTO T 209 or ASTM D2041.

Do 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.

### **23-5.07    *Smoothness***

The HMA pavement top layer must not vary from the lower edge of a twelve foot (12') long straightedge:

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## SECTION 23 – ASPHALT CONCRETE

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1. More than 0.01 foot when the straight edge 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 twenty-four (24') of a pavement conform

### **23-5.08 HMA Density**

#### **23-5.08.A Test Strip**

The Contractor shall demonstrate that their equipment and operation can achieve the required density on a test strip not less than 200 feet long and 12 feet wide in accordance with California Test 375. The Contractor is responsible for the quality control process necessary to achieve the required density. The test strip construction shall be on the same day as production verification testing and may be part of the production paving. However, any paving placed prior to the known calibration of the nuclear density testing device will be placed at risk by the contractor.

#### **23-5.08.B In-Place Density**

The Engineer determines the percent of theoretical maximum density by determining the in-place density by nuclear gauge and dividing by the theoretical maximum density.

The Engineer will determine the field density by a nuclear gauge calibrated from cores taken from the test strip in accordance with California Test 375. Nuclear gauge asphalt testing devices will be re-correlated whenever there is a change in lift thickness of one half inch ( $\frac{1}{2}$ " ) inch or greater, underlying material, materials source, or mix design.

## **23-6 ACCEPTANCE**

### **23-6.01 General**

The Engineer takes HMA samples from any of the following locations:

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

You must assist in collecting Engineer acceptance samples. Sample in the presence of the Engineer. Split the Engineer acceptance samples into at least 4 parts. Engineer retains 3 parts and you keep 1 part.

To obtain workability of the HMA sample for splitting, the Engineer reheats each sample of HMA mixture not more than 2 cycles. Each reheat cycle is performed by placing the loose mixture in a mechanical forced-draft oven for 2 hours or less after the sample reaches 140 degrees F.

The Engineer conditions 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.

## SECTION 23 – ASPHALT CONCRETE

No single aggregate or HMA test result may represent more than 750 tons or one day's production, whichever is less.

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 accepts 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 accepts HMA based on compliance with:

1. Aggregate quality requirements shown in the following table:

**Aggregate Quality**

| Quality Characteristic   | Test Method            | Requirement   |
|--|------------------------|---|
| Aggregate gradation <sup>a</sup>   | AASHTO T 27            | JMF ± Tolerance   |
| Percent of crushed particles Coarse aggregate (min, %)<br>One-fractured face Two-fractured faces Fine aggregate (min, %)<br>(Passing No. 4 sieve and retained on No. 8 sieve.)<br>One-fractured face | AASHTO T 335           | As specified for each Level in Section 23-3.1.2<br><br>70 |
| Los Angeles Rattler (max, %)<br>Loss at 100 Rev.<br>Loss at 500 Rev.   | AASHTO T 96            | 12<br>40  |
| Sand equivalent (min.) <sup>b, c</sup>   | AASHTO T 176           | 47  |
| Flat and elongated particles (max, % by weight at 5:1)   | ASTM D4791             | 10  |
| Fine aggregate angularity (min, %) <sup>d</sup>  | AASHTO T 304, Method A | 45  |

<sup>a</sup>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.

<sup>b</sup>Reported value must be the average of 3 tests from a single sample.

<sup>c</sup>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

**SECTION 23 – ASPHALT CONCRETE**

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.

<sup>d</sup>The Engineer waives this specification if HMA contains 10 percent or less of non-manufactured sand by weight of total aggregate.

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 <sup>a</sup> ) | AASHTO T 308 | ± 2.00      |
| Specific gravity (within the average value reported <sup>b</sup> )             | AASHTO T 209 | ± 0.06      |

<sup>a</sup>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.

<sup>b</sup>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 table:

**HMA Acceptance In Place**

| Quality Characteristic   | Test Method                               | Requirement                                     |
|--|---|---|
| Asphalt binder content (%)   | AASHTO T 308<br>Method A                  | JMF +/-0.45                                     |
| HMA moisture content (max, %)  | AASHTO T 329                              | 1.00  |
| Air voids content at Ndesign (%) <sup>a, b</sup>   | AASHTO T 269                              | 3.5 ± 1.5: Level 1<br>4.0 ± 1.5: Levels 2 & 3   |
| Voids in mineral aggregate on laboratory- produced HMA (min, %) <sup>d</sup><br>Gradation:<br>No. 4<br>3/8-inch<br>1/2-inch<br>3/4-inch<br>1-inch<br>with NMAS = 1-inch with NMAS = 3/4-inch | MS-2<br>Asphalt<br>Mixture<br>Volumetrics | As specified for each Level in Section 23-4.2.1 |

**SECTION 23 – ASPHALT CONCRETE**

| <b>Quality Characteristic</b>   | <b>Test Method</b>                               | <b>Requirement</b>                              |
|---|--|---|
| Voids in mineral aggregate on plant-produced HMA (min, %) <sup>a</sup><br>Gradation:<br>No. 4<br>3/8-inch<br>1/2-inch<br>3/4-inch<br>1-inch<br>with NMAS = 1-inch<br>with NMAS = 3/4-inch | MS-2 Asphalt Mixture<br>Volumetrics <sup>c</sup> | As specified for each Level in Section 23-4.2.1 |
| Dust proportion   | MS-2 Asphalt Mixture<br>Volumetrics              | 0.6–1.3 <sup>g</sup>                            |
| Density (% of max theoretical density) <sup>e, f</sup>  | California Test 375                              | 92.0–97.0                                       |

<sup>a</sup>Prepare 3 briquettes. Report the average of 3 tests.

<sup>b</sup>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.

<sup>c</sup>Determine bulk specific gravity under AASHTO T 275, Method A.

<sup>d</sup>The Engineer determines the laboratory-prepared HMA value for only mix design verification.

<sup>e</sup>The Engineer determines percent of theoretical maximum density under California Test 375 except the Engineer uses:

1. AASHTO T 275 to determine in-place density of each density core
2. AASHTO T 209, Method A to determine theoretical maximum density instead of calculating test maximum density

<sup>f</sup>The Engineer determines theoretical maximum density under AASHTO T 209, Method A, at the frequency specified in California Test 375, part 5, section D.

<sup>g</sup>For lime-treated aggregates, the dust proportion requirement is 0.6–1.5.

**23-6.02 HMA Density**

The project will be divided into lots of 500 tons. If one day's production is less than 500 tons that day's production will be a lot. If one day's production is one lot plus an additional amount, the additional work will be included in the last lot of 500 tons. The Engineer will sample and test each lot prior to acceptance. Testing of lots will be at the Engineer's discretion. If the Engineer does not test the lot it will be accepted.

The Engineer will calculate the percent of MTD to the nearest 0.1 percent for each calibrated nuclear gauge density reading or 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.

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**SECTION 23 – ASPHALT CONCRETE**

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If the percent of theoretical maximum density does not comply with the specifications, the Engineer must accept the HMA 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 |
|--|------------------------|--|------------------------|
| 92.0                                       | 0.0000                 | 97.0                                       | 0.0000                 |
| 91.9                                       | 0.0125                 | 97.1                                       | 0.0125                 |
| 91.8                                       | 0.0250                 | 97.2                                       | 0.0250                 |
| 91.7                                       | 0.0375                 | 97.3                                       | 0.0375                 |
| 91.6                                       | 0.0500                 | 97.4                                       | 0.0500                 |
| 91.5                                       | 0.0625                 | 97.5                                       | 0.0625                 |
| 91.4                                       | 0.0750                 | 97.6                                       | 0.0750                 |
| 91.3                                       | 0.0875                 | 97.7                                       | 0.0875                 |
| 91.2                                       | 0.1000                 | 97.8                                       | 0.1000                 |
| 91.1                                       | 0.1125                 | 97.9                                       | 0.1125                 |
| 91.0                                       | 0.1250                 | 98.0                                       | 0.1250                 |
| 90.9                                       | 0.1375                 | 98.1                                       | 0.1375                 |
| 90.8                                       | 0.1500                 | 98.2                                       | 0.1500                 |
| 90.7                                       | 0.1625                 | 98.3                                       | 0.1625                 |
| 90.6                                       | 0.1750                 | 98.4                                       | 0.1750                 |
| 90.5                                       | 0.1875                 | 98.5                                       | 0.1875                 |
| 90.4                                       | 0.2000                 | 98.6                                       | 0.2000                 |
| 90.3                                       | 0.2125                 | 98.7                                       | 0.2125                 |
| 90.2                                       | 0.2250                 | 98.8                                       | 0.2250                 |
| 90.1                                       | 0.2375                 | 98.9                                       | 0.2375                 |
| 90.0                                       | 0.2500                 | 99.0                                       | 0.2500                 |
| <90.0                                      | Remove and replace     | >99.0                                      | Remove and replace     |

**23-7 MEASUREMENT AND PAYMENT****23-7.01 Measurement**

The payment quantity for HMA of the Level shown on the Bid Item List is measured based on the combined mixture weight. If recorded batch weights are printed automatically, the bid item for HMA is measured by using the printed batch weights, provided:

1. Total aggregate and supplemental fine aggregate weight per batch is printed. If supplemental fine aggregate is weighed cumulatively with the aggregate, the total aggregate batch weight must include the supplemental fine aggregate weight.
2. Total virgin asphalt binder weight per batch is printed.
3. Each truckload's zero tolerance weight is printed before weighing the first batch and after weighing the last batch.

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## SECTION 23 – ASPHALT CONCRETE

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4. Time, date, mix number, load number and truck identification is correlated with a load slip.
5. Copy of the recorded batch weights is certified by a licensed weigh master and submitted.

### **23-7.02 Payment**

Payment for tack coat is included in the payment for HMA.

The City does not adjust the unit price for an increase or decrease in the tack coat quantity, nor does the City pay Oil Price Index fluctuations for HMA placed under this section.

Payment for HMA placed in the test strip is included in the payment for HMA.