**SECTION 490**

**BITUMINUMOUS ASPHALT MIXES**

**490.1 Description.** This work covers the requirements for obtaining an approved job mix formula (JMF) for bituminous asphalt mixtures.

**490.2 Naming Convention.** The nomenclature of bituminous mixture will be as follows. When only the mixture type or aggregate size is shown, such as SP125, the specifications shall apply to all variations of that type or size, such as SP125B, SP125C, SP125CLP, etc. When "x" is indicated, such as SP125xLP, specifications shall apply to all variations of mixture designs. Stone Matrix Asphalt will be generally referred to as SMA and designated by SM or SMR.

|  |
| --- |
| **Sec 401 Nomenclature** |
| **BP** | **Bituminous Pavement** |
| -x | Design Type -1,-2, or -3 |
| NC | With Non-Carbonate Requirements |
| **BB** | **Bituminous Base** |
| **Sec 402 Nomenclature** |
| **SL** | **Surface Leveling** |
| **Sec 403 Nomenclature** |
| **SP** | **Superpave** |
| 048 | 4.75mm (No. 4) nominal aggregate size |
| 095 | 9.5 mm (3/8 inch) nominal aggregate size |
| 125 | 12.5 mm (1/2 inch) nominal aggregate size |
| 190 | 19.0 mm (3/4 inch) nominal aggregate size |
| 250 | 25.0 mm (1 inch) nominal aggregate size |
| x | Design Level: B, C, E or F  |
| LP | Limestone Porphyry |
| NC | With Non-Carbonate Requirements |
| SM | Stone Matrix Asphalt |
| SMR | Stone Matrix Asphalt Limestone/Non-Carbonate |
| **Sec 413 Nomenclature** |
| **UBAWS** | Ultrathin Bonded Wearing Surface |
| Type x | Type A, B, or C |

**490.3 Superpave Design Levels.** The following cumulative equivalent single axle loads (ESALs) shall be used for the specified Superpave mix design. The same size aggregate mix design at a higher design traffic may be substituted at the contractor’s expense for the contract specified mixture design with the approval from the engineer. Substitutions shall be done uniformly and project mixing of various designs for the same work will not be permitted. For example, an SP125B mixture may be substituted for an SP125C mixture, or SP190C for SP190E, etc. Mixture design substitution will be limited to one design level higher than that specified in the contract.

|  |  |
| --- | --- |
| **Design Traffic (ESALs)** | **Design** |
| < 300,000 | F |
| 300,000 to < 3,000,000 | E |
| 3,000,000 to < 30,000,000 | C |
| ≥ 30,000,000 | B |

**490.4 Time Limit.** Approved mix designs may be transferred to other projects with similar specifications for a period of three years from the original approval date provided satisfactory results are obtained during production and placement.

**490.5 Design Methodology.**  Asphalt mixtures shall be designed by the contractor using a method appropriate for the type as follows and as designated below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mixture Type** | **BB, BP, SL** | **SP** | **SMA** | **UBAWS** |
| **Design Method** | AASHTO R 35 or Marshall  | AASHTO R 35 | AASHTO R 46 | MoDOT Requirements |

**490.5.1 Marshall Designs.**  Designs using the Marshall method shall follow Asphalt Institute Publication MS-2, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types. The mixture shall be compacted and tested at a minimum of three asphalt contents separated by a maximum of 0.5 percent in accordance with AASHTO T 245, except as herein noted. The test method shall be modified by short-term aging the specimens in accordance with AASHTO R 30.

**490.6 Material.** The grade of asphalt binder will be specified in the contract. All material shall be in accordance with [Division 1000](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Div1000.xhtml#toc_marker-1), Material Details, and specifically as follows:

|  |  |
| --- | --- |
| **Item** | **Section** |
| SP, UBAWS Course Aggregate | 1002.2 |
| BB, BP, SL Coarse Aggregate | [1004.2](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1004.xhtml#S1004_2) |
| Fine Aggregate | [1002.3](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1002.xhtml#S1002_3) |
| Mineral Filler | [1002.4](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1002.xhtml#S1002_4) |
| Hydrated Lime | [1002.5](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1002.xhtml#S1002_5) |
| Asphalt Binder | [1015](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1015.xhtml#S1015) |

**490.6.1 Wet Bottom Boiler Slag.**  The contractor may furnish wet bottom boiler slag of approved quality in lieu of coarse aggregate. If wet bottom boiler slag is used, the slag shall meet the requirements for applicable coarse aggregate. The Los Angles Abrasion requirements will not apply.

**490.6.2 Reclaimed Asphalt.**Reclaimed Asphalt may be obtained from Reclaimed Asphalt Pavement (RAP) and Reclaimed Asphalt Shingles (RAS). The asphalt binder content of recycled asphalt materials shall be determined in accordance with AASHTO T 164, ASTM D 2172 or other approved method of solvent extraction. RAP and/or RAS correction factor(s) for binder ignition use during production shall be determined by burning a sample in accordance with AASHTO T 308 and subtracting from the binder content determined by extraction.

**490.6.2.1 RAP.** Reclaimed Asphalt Pavement (RAP) may be used in any mixture, except SMA mixtures. All RAP material shall be in accordance with [Sec 1004](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1002.xhtml) for deleterious and other foreign material. The aggregate specific gravity shall be determined by performing AASHTO T 209 in accordance with [Sec 490.9](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec403.xhtml%22%20%5Cl%20%22S403_19_3_1_2) and calculating the Gse  as follows:

 100  −  Pb

RAP Gse =  100 \_   Pb

 GmmGb

|  |  |  |
| --- | --- | --- |
| **Mixture Type** | **BB, BP, and SL** | **SP, UBAWS** |
| **RAP Gsb Calculation** | Gsb= RAP Gsex 0.98 | Gsb= RAP Gse |

**490.6.2.1.1 RAP Duribility**  All RAP material not originating from a MoDOT roadway shall be tested in accordance with AASHTO T 327, *Method of Resistance of Coarse Aggregate Degradation by Abrasion in the Micro-Deval Apparatus*. The Micro-Deval percent loss for the RAP aggregate shall not exceed loss of the combined virgin material by more than five percent.

**490.6.2.1.2 UBAWS RAP**. The RAP used in UBAWS shall have 100 percent passing the 3/8 inch and no less than 70 percent passing the No. 4 sieve.

**490.6.2.2 RAS.** Reclaimed Asphalt Shingles (RAS) may be used in any mixture specified to use PG 64-22. RAS shall be ground to 3/8-inch minus. Waste, manufacturer or new, shingles shall be essential free of deleterious materials. Post-consumer RAS shall not contain more than 1.5 percent wood by weight or more than 3.0 percent total deleterious by weight. Post-consumer RAS shall be certified to contain less than the maximum allowable amount of asbestos as defined by national or local standards. The bulk specific gravity of RAS shall be determined as follows:

|  |  |  |
| --- | --- | --- |
| **Mixture Type** | **BB, BP, and SL** | **SP** |
| **RAS Gsb Calculation** | Gsb= 2.600 |  100  −   PbGsb =  100  \_   Pb Gmm Gb |

**490.6.2.2.1 RAS Gradation.** The gradation of the RAS aggregate may be determined by solvent extraction of the binder or by using the following as a standard gradation:

|  |
| --- |
| **Standard Shingle Gradation** |
| **Sieve Size** | **Percent Passing by Weight** |
| 3/8 in. | 100% |
| No. 4 | 95% |
| No. 8 | 85% |
| No. 16 | 70% |
| No. 30 | 50% |
| No. 50 | 45% |
| No. 100 | 35% |
| No. 200 | 25% |

**490.6.3 Rejuvenators.** Rejuvenators may be used in any asphalt mixture containing reclaimed asphalt.  When a rejuvenator is used for the purpose of softening the virgin binder grade, the requirements for the Extraction Grading of the final mixture option in Sec 490.10 must be satisfied.

**490.6.4 Anti-Strip Agent.**  An anti-strip may be used to improve resistance to stripping. Anti-strip agents shall be from the approved list in accordance with [Sec 1071](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1071.xhtml%22%20%5Cl%20%22S1071).

**490.7 Aggregate Correction Factor.**  When AASHTO T 308 will be used to determine mixture asphalt content during production, an aggregate correction factor in accordance with AASHTO T 308 ANNEX 2 shall be determined. The test method shall be modified by adding the following: If the calibration factor exceeds 1.0 percent, lower the test temperature to 800 ± 8 F and repeat test.

**490.8 Compacted Specimens.** The surface of puck and cores prepared for testing may have the surface texture removed by sawing a minimal amount. Specimens shall be securely held in a jig or other clamping device to eliminate distortion and retain a face parallel to the original surface. Measurements for lift thickness shall be made prior to sawing.

**490.8.1 Bulk Specific Gravity.**  During both the design and production phases for both gyro pucks and pavement cores; the following shall apply. Either AASHTO T 166 or T 331 shall be used to determine bulk specific gravity of compacted specimens. When AASHTO T 166 is used and absorption is above the 2% limit, ASTM D 1188 shall be used. The use of AASHTO T 275 is prohibited.

**490.9 Maximum Theoretical Specific Gravity.** AASHTO T 209 shall be used including the supplemental procedure for mixtures containing porous aggregate when the water absorption of any aggregate fraction is greater than 2.0 percent. Design samples shall be short-term aged in accordance with AASHTO R 30.

**490.10 Composition of Mixtures.**

**490.10.1 Gradation.** The combined aggregate gradation, including filler if needed, shall meet the following gradation for the type of mixture specified in the contract.

|  |
| --- |
| **Percent Passing by Weight** |
| **Sieve** **Size** | **SP250** | **SP190** | **SP125** | **SP095** | **SP048** | **SP125xSM****SP125xSMR** | **SP095xSM****SP095xSMR** | **BB** | **BP-1** | **BP2** | **BP-3** | **SL** |
| 1 1/2 in. | ≤100 | - | - | - | - | - | - | - | - | - | - | - |
| 1 in. | ≥ 90 | ≤100 | ≤100 |
| 3/4 in. | ≤ 90 | ≥ 90 | ≤100 | ≤100 | ≥ 85 | ≤100 | ≤100 | ≤100 |
| 1/2 in. | - | ≤ 90 | ≥ 90 | ≤100 | ≥ 90 | ≤100 | 60-90 | ≥ 85 | ≥ 95 | ≥ 99 |
| 3/8 in. | - | ≤ 90 | ≥ 90 | ≤100 | 50-80 | 70-95 | - | - | - | ≤100 | ≥ 90 |
| No. 4 | - | ≤ 90. | ≥ 90 | 20-35 | 30-50 | 35-65 | 50-70 | 60-90 | ≥ 90 | 60-90 |
| No. 8 | 19-45 | 23-49 | 28-58 | 32-67 | - | 16-24 | 20-30 | 25-50 | 30-55 | 40-70 | - | 40-70 |
| No. 16 | - | - | - | - | 30-60 | - | ≤ 21 | - | - | - | 30-60 | - |
| No. 30 | - | ≤ 18 | 10-35 | 10-30 | 15-35 | - | 15-35 |
| No. 50 | ≤ 15 | - | - | - | - | - |
| No. 100 | - |
| No. 200 | 1-7 | 2-8 | 2-10 | 2-10 | 7-12 | 8.0-11.0 | 8.0-12.0 | 4-12 | 5-12 | 5-12 | 7-12 | 5-12 |

**490.10.2 Reclaimed Asphalt Allowances.** The use of reclaimed asphalt shall be limited as follows. The percent binder replacements shown below are the percent recycle binder contribution to the total asphalt binder.

|  |  |  |
| --- | --- | --- |
| **Mixture** **Type** | **Binder** | **Percent Effective Virgin Binder Replacement** |
| **RAP** | **RAS** | **RAP and RAS combination** |
| **BP** | Contract Grade Virgin Binder | 0 - 20 | 0 -10 | RAP + (2\*RAS) ≤ 20 |
| Virgin Binder Softened One Grade | 21 - 40 | 11 - 20 | 20 < RAP + (2\*RAS) ≤ 40 |
| Blend Chart | 0 - 100 | N/A |
| Extraction Grading of Final Mixture | 0 - 100 |
| **BB** | Contract Grade Virgin Binder | 0 - 30 | 0 -15 | RAP + (2\*RAS) ≤ 30 |
| Virgin Binder Softened One Grade | 31 - 50 | 16 - 25 | 30 < RAP + (2\*RAS) ≤ 50 |
| Blend Chart | 0 - 100 | N/A |
| Extraction Grading of Final Mixture | 0 - 100 |
| **SL** | Contract Grade Virgin Binder | 0 - 30 | 0 - 15 | 0 – 30 total and 0-15 from RAS |
| Virgin Binder Softened One Grade | 31 - 40 | 16 - 20 | 31 – 40 total and 0-20 from RAS |
| Blend Chart | 0 - 100 | N/A |
| Extraction Grading of Final Mixture | N/A |
| **SP** | Contract Grade Virgin Binder | 0 - 30 | 0 - 30 | 0-30 |
| Virgin Binder Softened One Grade | N/A | 31 - 40 | 31-40 |
| Blend Chart | 0 - 100 | N/A |
| Extraction Grading of Final Mixture | N/A |
| **UBAWS** | Contract Grade Virgin Binder | 0 - 20 | N/A |
| Virgin Binder Softened One Grade | N/A |
| Blend Chart | 0 - 20 | N/A |
| Extraction Grading of Final Mixture | 0 - 20 | N/A |

**490.10.2.1 Virgin Binder Softened One Grade.** When the contractor elects to provide a softer grade of virgin binder than specified in the contract the following shall apply. The virgin binder shall have a low temperature grade 6 degrees lower than the binder grade specified in the contract. Lowering the high temperature of the virgin binder is not required; however, if lowered, the virgin binder shall have a high temperature grade no lower than 6 degrees below the binder grade specified in the contract (Ex. Contract grade PG 64-22; virgin binder could be either PG 58-28 or PG 64-28). The Pressure Aging Vessel (PAV) test temperature (AASHTO M 320) shall be tested at 19° C, regardless of the high temperature grade of the selected virgin binder.

**490.10.2.2 Blend Chart.** When the contractor elects to utilize a blend chart to prove the as designed binder grade meets the contract specifications the following shall apply. Testing in accordance with AASHTO M 323 shall be performed on all binder supplying components and the raw data included with the mix design. The calculation which demonstrates that the grade of the combine mixture meets the contract requirements shall be included with the mix design. RAS is not allowable when blend charts are used. No significant alterations to binder providing components during production shall be allowed without a new blend chart evaluation.

**490.10.2.3 Extraction Grading.** When the contractor elects to utilize an extraction process to prove the as designed binder grade meets the contract specifications the following shall apply. Testing in accordance with either AASHTO T 319, or AASHTO T 164 and AASHTO R 59 along with grading in accordance with AASHTO M 320 including raw data shall be included with the mix design which demonstrates that the grade of the combine mixture and rejuvenator, if applicable, meets the contract requirements. No significant alterations to binder providing components during production shall be allowed without a new extraction grading evaluation.

**490.10.3 Moisture Susceptibility.** Moisture susceptibility shall be tested in accordance with AASHTO T 283 with the exception that SMA mixtures test specimens shall have 6±0.5 percent air voids. An approved anti-strip additive may be added to increase retained strength to a passing level. TSR testing shall only be required for BB and BP mixtures when any plasticity index on a individual aggregate fractions with 10 percent or more passing the No. 30 sieve exceeds 3. The TSR shall meet the following requirements.

|  |  |  |  |
| --- | --- | --- | --- |
| **Mix Type** | **BB, BP** | **SL** | **SP, UBAWS** |
| **Min. TSR** | 70% | NA | 80% |

**490.10.4 BB, BP, SL Mixture Characteristics.**

**490.10.4.1** Base, BP-1, BP-2, BP-3, and SL mixtures shall have the following properties, when tested in accordance with AASHTO T 245 or AASHTO T 312.  The number of blows with the compaction hammer shall be 35 or the number of gyrations shall be 35 with the gyratory compactor.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Mix Type** | **Percent****Air Voids** | **AASHTO** **T 245****Stability (lbs)** | **Voids in Mineral Aggregate****(VMA)b** | **VMA filled with Asphalt (VFA)** | **Dust to Effective Binder Ratio** |
| **Virgin Binder Replacement**  |
| **≤ 40%** | **> 40%** |
| BB | 3.5 | 750 | 13.0 (12.0)a | 13.5 (12.5)a | - | - |
| BP-1 | 13.5 | 14.0 | 60 - 80 | 0.8 - 1.6 |
| BP-2 | 14.0 | 14.5 | 0.8 - 1.6 |
| BP-3 | 15.0 | 15.5 | ≥ 75 | 0.9 - 2.0 |
| SL | 14.5 | 15.0 | 0.8 - 1.6 |

 aBituminous base mixtures with a gradation that would require 12.0 percent VMA following Asphalt Institute MS-2 may use the lower VMA shown.

**490.10.4.2** **Non-Carbonate.** When specified in the contract as BP-3NC, BP-3 mixtures containing limestone aggregate shall contain a minimum amount of non-carbonate aggregate as shown in the table below, or the aggregate blend shall have an acid-insoluble residue (A.I.R.), MoDOT Test Method TM 76, meeting the criteria of crushed non-carbonate material. The A.I.R. shall be determined on the minus No. 4 sieve. Non-carbonate aggregate shall have an A.I.R. of at least 85 percent insoluble residue.

|  |  |
| --- | --- |
| **Aggregate** | **Minimum Non-Carbonate by Volume** |
| Limestone | 20% Minus No. 4 |
| Dolomite | No Requirement |

**490.10.5 SP Mixture Characteristics**

**490.10.5.1 Fine Aggregate Angularity.** Fine aggregate angularity (FAA) shall be measured on the fine portion of the blended aggregate. When tested in accordance with AASHTO T 304 Method A, aggregate particles passing the No. 8 sieve shall meet the following criteria for the minimum percent air voids in loosely compacted fine aggregate:

|  |  |
| --- | --- |
| **Design** | **FAA** |
| F | - |
| E | 40 |
| C, B | 45 |

**490.10.5.2 Coarse Aggregate Angularity.** Coarse aggregate angularity (CAA) shall be measured on the coarse portion of the blended aggregate. When tested in accordance with ASTM D 5821, the coarse aggregate shall meet the following percent criteria for the number of fracture faces listed. Crushed limestone, dolomite, steel slag and porphyry will be considered as having 100 percent two fractured faces unless visual observations indicate an undesirable particle shape is being produced.

|  |  |
| --- | --- |
| **Design** | **Fractured Faces** |
| **One** | **Two**  |
| F | 55 | - |
| E | 75 |
| C | 95 | 90 |
| B | 100 | 100 |

**490.10.5.3 Clay Content.** When tested in accordance with AASHTO T 176, blended aggregate particles passing the No. 4 sieve shall meet the following minimum sand equivalent criteria:

|  |  |
| --- | --- |
| **Design** | **Sand Equivalent** |
| F, E | 40 |
| C | 45 |
| B | 50 |

**490.10.5.4 Surface Mixtures.** Design level B surface mixtures, except non-integral shoulders and other non-traffic areas, containing limestone coarse aggregate shall contain a minimum amount of non-carbonate aggregate. The LA abrasion values, AASHTO T 96, of the limestone will determine the type and amount of non-carbonate aggregate required as shown in the table below. The LA abrasion value will be determined from the most recent source approval sample. In lieu of the above requirements, the aggregate blend shall have an acid insoluble residue (AIR), MoDOT Test Method TM 76, meeting the plus No. 4 criteria of crushed non-carbonate material. Non-carbonate aggregate shall have an AIR of at least 85 percent insoluble residue.

|  |  |  |
| --- | --- | --- |
| **Mixture** | **Coarse Aggregate (Plus No. 4)** | **Minimum Non-Carbonate by Volume** |
| SP095 | Dolomite | No Requirement |
| SP125 |
| Limestone, LA ≤  30 | 30% of Plus No. 4 |
| Limestone, LA > 30 | 20% of Minus No. 4 |
| SP095 | All Limestone |

**490.10.5.5 Design Gyrations.** The number (N) of gyrations required for gyratory compaction shall be as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Design** | **Ninitial** | **Ndesign** | **Nmaximum** |
| F | - | 50 | - |
| E | 7 | 75 | 115 |
| C | 8 | 100 | 160 |
| - | 80 | - |
| B | 9 | 125 | 205 |
| SMA | - | 100 | - |

**490.10.5.5 Design Density.** The density, as a percent of theoretical maximum specific gravity, shall be as follows:

|  |  |  |  |
| --- | --- | --- | --- |
| **Design** | **Ninitial** | **Ndesign** | **Nmaximum** |
| F | ≤ 91.5 | 96.0 | ≤ 98,0 |
| E | ≤ 90.5 |
| C | ≤ 89.0 |
| B |
| SMA |

**490.10.5.6 Volumetric Characteristics.** When compacted in accordance with AASHTO T 312, the mixture shall meet the following criteria.

**490.10.5.6.1** **Air Voids (Va).** Design air voids for all mixtures at all traffic levels shall be 4.0%.

**490.10.5.6.2** **Voids in the Mineral Aggregate (VMA).**

|  |  |
| --- | --- |
| **Mixture** | **VMA Minimum**  |
| SP250 | 12.0% |
| SP190 | 13.0% |
| SP125 (except for SMA) | 14.0% |
| SP095 (except for SMA) | 15.0% |
| SP048 | 16.0% |
| SMA | 17.0% |

**490.10.5.6.3 Voids Filled With Asphalt (VFA).**

|  |  |
| --- | --- |
| **Design** | **VFA** |
| F |  70 – 80% |
|  |  |
| E |  65 – 78% |
| B, C |  65 – 75% |
| SP095B | ≤ 76% |
| SMA, SP048F | ≥ 75% |

**490.10.5.6.4 Dust to Binder Ratio.** For all mixtures the ratio of minus No. 200 material to effective asphalt binder (Pbe) shall as follows.

|  |  |
| --- | --- |
| **Design** | **D/B** |
| SP095, SP125, SP190, SP250  | 0.8 – 1.6 |
| SP048 | 0.9 – 2.0 |
| SMA | - |

**490.10.5.7 Porphyry Mixtures.** In addition to the SP mixture requirements, mixtures designated as porphyry (LP) mixtures shall meet the following. At least 50 percent by volume of the aggregate shall be crushed porphyry retained on the following sieves: No. 30 for SP048, No. 16 for SP095 and No. 8 for SP125. Depending on the actual gradation of porphyry aggregate furnished, the amount of crushed porphyry required may vary, however at least 40 percent by weight of crushed porphyry will be required. Steel slag may be substituted for porphyry in LP mixtures, except at least 45 percent by weight of crushed porphyry and/or slag will be required. The engineer may approve the use of other hard, durable aggregate in addition to porphyry and steel slag.

**490.10.5.8 Stone Matrix Asphalt Mixtures.** In addition to the SP mixture requirements, SMA mixtures shall meet the following. Coarse aggregate shall consist of crushed limestone and either porphyry or steel slag in accordance with the quality requirements of [Sec 1002](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec1002.xhtml%22%20%5Cl%20%22S1002), except as follows. The Los Angeles (LA) abrasion, when tested in accordance with AASHTO T 96, shall not exceed 40 percent based on initial ledge approval and source approval. The percent absorption, when tested in accordance with AASHTO T 85, shall not exceed 3.5 percent based on the individual fractions. The amount of flat and elongated particles, measured on material retained on a No. 4 sieve, of the blended aggregate shall not exceed 20 percent based on a 3:1 ratio or 5 percent based on a 5:1 ratio.

**490.10.5.8.1 Voids in Coarse Aggregate.** The percent VCAMIX of SMA mixtures shall be less than or equal to the VCADRC as determined using AASHTO T 19 using the following equations:

 VCADRC = 100 x (GCAγW - γs) / GCAγW

 VCAMIX = 100 - (Pbp x GMB / GCA)

 Pbp = Ps x PAbp

Where:   GCA =        bulk specific gravity of the combined coarse aggregate (AASHTO T 85)

 γS =        unit weight of coarse aggregate in the dry-rodded condition (DRC) (lb/ft3) (AASHTO T 19)

 γW     =        unit weight of water (62.34 lb/ft3)

 Pbp=        percent aggregate by total mixture weight retained on No. 4 sieve\*

 PAbp   =        percent aggregate by total aggregate weight retained on No. 4 sieve\*

 \*Use No. 8 sieve for SP095xSM

**490.10.5.8.2 Filler Restriction.** Rigden void content determined in accordance with MoDOT Test Method TM-73 shall be no greater than 50 percent.

**490.10.5.8.3 Draindown.** AASHTO T 305, Draindown Test, shall be performed on all SMA mixtures prior to job mix approval. The mixture shall be stabilized in such a way that the draindown of the asphalt binder shall not exceed 0.3 percent by weight of mixture.

**490.10.5.8.4 Fibers.** A fiber additive shall be used as a stabilizer in SMA mixtures. Fibers shall be uniformly distributed by the end of the plant mixing process. The dosage rate for fibers shall be no less than 0.3 percent by weight of the total mixture for cellulose and no less than 0.4 percent by weight for mineral fibers.

**490.10.5.8.5 Minimum Stone Matrix Asphalt Binder.** The percent asphalt binder for SMA mixtures shall not be less than 6.0 percent unless otherwise allowed by the engineer.

**490.10.5.8.6 Durability.** SMA mixtures shall meet the requirements of a Sec 490.10.5.12 for Porphyry mixtures. When an SMR mixture is designated, in lieu of the porphyry requirement, the mixture shall contain aggregate blends with at least 30 percent non-carbonate material as defined in [Sec 490.10.5.4](#S403_3_5).

**490.10.6 UBAWS Mixture Characteristics.**

**490.10.6.1 Coarse Aggregate.** Coarse aggregate may consist of crushed gravel, limestone, dolomite, porphyry, steel slag, flint chat, or blends of two or more of these aggregates will be acceptable. When coarse aggregate for these mixes are from more than one source or of more than one type of material, the coarse aggregate shall be proportioned and blended to provide a uniform mixture. Coarse aggregate shall be material predominantly retained above the No. 4 sieve and shall be in accordance with the following requirements:

|  |
| --- |
| **Coarse Aggregate** |
| **Requirements on Individual Ledge Basis** | **Method** | **Min.** | **Max.** |
| Micro-Deval, % loss | AASHTO T 327 | - | 18 |
| Los Angeles Abrasion Value, % Loss | AASHTO T 96 | 35 |
| Soundness, % Loss, Sodium Sulfate | AASHTO T 104 | 12 |
| **Requirements on the Course Portion of the Blended Aggregate** | **Method** | **Min.** | **Max.** |
| Flat & Elongated Ratio, % @ 3:1 | ASTM D 4791 | - | 25 |
| % Crushed, single faces | ASTM D 5821 | 95 | - |
| % Crushed, two faces | ASTM D 5821 | 85 |

**490.10.6.2 Fine Aggregate.** Fine aggregate portion of the blended aggregate shall be material predominantly passing the No. 4 sieve and shall be in accordance with the following requirements:

|  |  |  |  |
| --- | --- | --- | --- |
| **Tests** | **Method** | **Min** | **Max** |
| Sand Equivalent | AASHTO T 176 | 45 | - |
| Methylene Blue | AASHTO T 330 | - | 10 |
| Uncompacted Void Content | AASHTO T 304 | 40 | - |

**490.10.6.3** **Gradation.** Prior to mixing with asphalt binder, the combined aggregate gradation, including filler if needed, shall meet the following gradation for the type of mixture specified in the contract.

|  |
| --- |
| **Composition by Weight Percentages** |
|  | **Type A** | **Type B** | **Type C** |
| **Sieves** | **% Passing** | **% Passing** | **% Passing** |
| 3/4 in. | - | 100 | 100 |
| 1/2 in. | 97 - 100 | 85 – 100 |
| 3/8 in. | 100 | 75 – 100 | 50 – 80 |
| No. 4 | 40 – 55 | 25 – 41 | 25 – 41 |
| No. 8 | 22 – 32 | 17 – 27 | 17 – 27 |
| No. 16 | 15 – 25 | ≤ 23 | ≤ 23 |
| No. 30 | ≤ 18 | ≤ 18 | ≤ 18 |
| No. 50 | ≤ 13  | ≤ 13 | ≤ 13 |
| No. 100 | ≤ 10  | ≤ 10 | ≤ 10 |
| No. 200 | 4.0 – 6.0 | 4.0 – 6.0 | 4.0 – 6.0 |

**490.10.6.4 Non-Carbonate Aggregate Requirement.** Mixtures containing limestone coarse aggregate shall contain a minimum amount of non-carbonate aggregate as shown in the table below, or the aggregate blend shall have an acid-insoluble residue (A.I.R.), MoDOT Test Method TM 76, meeting the plus No. 4 sieve criteria of crushed non-carbonate material. Non-carbonate aggregate shall have an A.I.R. of at least 85 percent insoluble residue.

|  |  |
| --- | --- |
| **Coarse Aggregate (+ No. 4)** | **Minimum Non-Carbonate by Volume** |
| Limestone | 30% Plus No. 4 |
| Dolomite | No Requirement |

**490.10.6.5 Asphalt Binder.** The asphalt binder shall be PG76-22 in accordance with Sec 1015, including all subsections pertaining to UBAWS.

**490.10.6.6 Binder Content.** The amount of asphalt binder in the mixture shall meet the following limits for the type of mixture specified in the contract.

|  |  |  |  |
| --- | --- | --- | --- |
| **UBAWS** | **Type A** | **Type B** | **Type C** |
| **Asphalt Content** | 5.3 – 5.8 % | 5.1 – 5.6 % | 4.9 – 5.6 % |

**490.10.6.7 Film Thickness.** The film thickness shall be a minimum 10.0 microns when calculated using the effective asphalt content in conjunction with the surface area for the aggregate in the Job Mix Formula. The surface area factors can be found in Table 6.1 of the Asphalt Institute MS-2, *Mix Design Methods for Asphalt Concrete and Other Hot Mix Types*, Sixth Edition.

**490.10.6.8 Drain Down.** Drain down from the loose mixture shall not exceed 0.10 percent when tested in accordance with AASHTO T 305.

**490.20 Approval Process.**

**490.20.1** Mix designs may be approved by the engineer either through a full verification process or a 7-day review process. The engineer has the right to perform a full verification on any mixture submitted.

**490.20.2 Job Mix Formula Modification.** The JMF approved for each mixture shall be in effect until modified in writing by the engineer. When unsatisfactory results occur or should a source of material be changed, a new JMF may be required.

**490.20.3**  **7-Day Review.**  Laboratories that participate and achieve a score of 3 or greater in the AASHTO proficiency sample program for T 11, T 27, T 84, T 85, T 166, T 176, T 209, T 304, T 308 and T 245 or T 312 will have the option of submitting mix designs for 7-day review. The mix design shall be submitted to Construction and Materials for approval at least seven days prior to mixture production. Samples of components will not be required unless for nuclear density or ignition oven correction factor purposes.

**490.20.4**  **Full Verification.**  When a full verification is required representative samples of each ingredient for the mixture shall be submitted with the mix design. The mix design and ingredients shall be submitted to Construction and Materials for approval at least thirty days prior to production. Aggregate fractions submitted shall be in the same proportions as the proposed job mix formula with a minimum of 150 pounds required for any individual fraction. The amount of each ingredient submitted shall be as follows for each mix design to be verified:

|  |  |  |
| --- | --- | --- |
| **Ingredient** | **Marshall Design** | **Superpave or SMA Design** |
| Aggregate, RAP, and/or RAS | 300 Pounds | 750 Pounds |
| Hydrated Lime, Mineral Fillerand/or Baghouse Fines | 20 Pounds | 20 Pounds |
| Asphalt Binder | 10 Gallon | 10 Gallons |
| Antistrip, Warm Mix Additives, and/or Rejuvenating Agents. | 1 Gallon | 1 Gallon |

**490.20.5 Required Information.** The mix design shall include a detailed description of the mix design process and raw data from the design process including the following information when applicable:

(a) All possible sources intended for use, and grade and specific gravity of asphalt binder.

(b) Source, type (formation, etc.), ledge number(s) if applicable, gradation, and percent chert of each aggregate fraction.

(c) For BB, BP, and SL mixtures, plasticity index of each aggregate fraction which has 10 percent or more passing the No. 30 sieve.

(d) Bulk and apparent specific gravities and absorption of each aggregate fraction in accordance with AASHTO T 85 for coarse aggregate and AASHTO T 84 for fine aggregate, including all raw data, or in accordance with MoDOT TM 81.

(e) Specific gravity of hydrated lime, mineral filler or baghouse fines, if used, in accordance with AASHTO T 100.

(f)  Percentage of each aggregate component.

(g) Combined gradation of the job mix.

(h) Percent of asphalt binder, by weight, based on the total mixture.

(i) Bulk specific gravity (Gmb) by AASHTO T 166, Method A of a laboratory compacted mixture.

(j) Percent air voids (Va) of the laboratory compacted specimen.

(k) Voids in the mineral aggregate (VMA) and voids in the mineral aggregate filled with asphalt binder (VFA).

(l) Theoretical maximum specific gravity (Gmm) in accordance with [Sec 490.9](http://sharepoint/systemdelivery/CM/FieldOffice/Shared%20Documents/Text/Sec403.xhtml%22%20%5Cl%20%22S403_19_3).

(m) Mixing temperature and molding temperature as well as the gyratory sample weight to produce a 115 mm minimum height specimen.

(n) Bulk specific gravity (Gsb) of the combined aggregate.

(o) Percent deleterious content of the combine aggregate.

(p) Reclaimed asphalt binder contribution worksheet as well as any extraction or blend calculations needed to prove contract compliance.

(q) The tensile strength ratio as determined by AASHTO T 283 including all raw data.

(r) The film thickness for UBAWS mixtures.

(s) Number of gyrations at Ninitial, Ndesign, and Nmaximum.

(t) Dust proportion ratio (-200/Pbe).

(u) Percent of Gmm at Ninitial and Nmaximum.

(v) Blended aggregate properties for clay content, angularity, and thin and elongated particles.

(w) Voids in coarse aggregate (VCA) for both the mixture and dry-rodded condition for SMA mixtures.

(x) Draindown for SMA and UBAWS mixtures.

(y) Baghouse fines added for design. Provide the combine gradation with and without the baghouse percentage.

 (y-i) Batch and continuous mix plants – Indicate which aggregate fraction to add baghouse percentage during production.

 (y-ii) Drum mix plants – Provide cold feed settings with and without baghouse percentage.

(z) Ignition oven correction factor(s) and test temperatures used when testing of the combined aggregate, RAP, or RAS gradations.