2024 Bituminous Concrete Mix Design Submittal Policy

(updated April 24, 2024)

1. **Definition of Terms**: The definitions outlined in Subsection 101.02 of the *2018 Standard Specifications for Construction* and the *2024 Standard Specifications for Construction*, the *Quality Assurance Program (QAP)*, the *Materials Sampling Manual (MSM),* and the *Doc Express Contractors User Manual* apply to this policy, in addition to the following:

   Bituminous Concrete Materials Unit – Agency unit responsible for the Quality Assurance of HMA materials. The unit consists of an Engineering group, HMA field inspection group, PG binder laboratory, HMA laboratory and HMA Core laboratory.

   Bituminous Concrete Field Unit Supervisor – Authorized representative of the Agency responsible for overseeing the quality assurance activities associated with the field-testing of HMA materials at HMA production facilities; AOT.HMAField@vermont.gov.

   Bituminous Concrete Materials Engineer – Authorized representative of the Agency responsible for reviewing and approving mix design submittals and letters of intent in accordance with the Contract documents.

   Doc Express – Web based document management program to be used for submitting Project Specific Mix Designs and letters of intent. For more information regarding usage and to create an account, see the information at the following link: https://outside.vermont.gov/agency/vtrans/external/docs/construction/Contracting/DocExpressOverviewforContractors.docx

   Flexibility Index Test (FIT) – Test method under the 2018 specifications completed for Superpave mix designs to analyze cracking susceptibility in accordance with AASHTO T 393. **Modifications to the AASHTO procedure are included in Appendix B of this Policy.**

   Hamburg Wheel Tracker Test (HWTT) – Test method completed for Superpave mix designs in analyze rutting and moisture susceptibility in accordance with AASHTO T 324. **Modifications to the AASHTO procedure are included in Appendix A of this Policy**.

   Indirect Tensile Cracking Test (IDEAL-CT) – Test method under the 2024 specifications completed for Superpave mix designs to analyze cracking susceptibility in accordance with ASTM D8225-19. **Modifications to the ASTM procedure are included in Appendix C of this Policy**.

   HMA Producer – Production facility responsible for the manufacturing of HMA materials

   Maintenance District Project Manager - The duly authorized representative for providing technical expertise in District mix designs within each VTrans Maintenance District.

   Master Mix Design – Mix design submitted for general use and intended for use on multiple projects and/or multiple contracts.

Non – Performance (NP) – Superpave mix design without HWTT and FIT results intended for use in hand-placed applications, temporary paving applications, and QAP Level 4 projects.

Performance (P) – Superpave mix design with HWTT, and either FIT or IDEAL-CT results intended for use on mainline paving applications on QAP Level 1-3 projects.

PG Binder Supplier –Final entity providing the Certificate of Analysis (COA) for PG binder.

VTrans Construction Paving Engineer – The duly authorized representative for providing technical expertise in pavement operations to the Resident Engineer.

VTrans Mix Design Mailbox – Email address to which Master Mix Designs must be submitted; AOT.VTransMixDesigns@vermont.gov.

WMA – Warm mix asphalt; approved technology meant to lower the mixing and placement temperatures of bituminous concrete. Only designs with lowered mixing temperatures will be considered WMA mix designs.

2. **Applicability of Mix Designs**: The contents of this submittal policy apply to the following mix design methods and procedures:
   a) **Marshall Mix Design**

   b) **Superpave Mix Design**

   c) **Paver Placed Surface Treatment Mix Design/Bonded Wearing Course**

   Mix design methods and procedures not covered under this submittal policy will be handled on a project-by-project basis.

3. **Mix Design Contents & Submittal Process:** Submittal packets for each mix design method are available on the Bituminous Concrete Materials Unit website. Each submittal must include the contents outlined below at a minimum. Mix designs must be submitted for each grade of performance-graded binder found in the project plans or within the project contract. Hyperlinks to each mix design workbook are provided in the descriptions below.
   a) **Marshall Mix Design –** Must be submitted for each type of mix and shall be classified as "HMA" or "WMA" on the cover sheet. All mix design submittals will be considered as "MASTER MIX DESIGNS" and shall be indicated this way where appropriate on the cover sheet; the intended projects on which the design will be used, if known, should also be noted where appropriate. Before a design can be approved for use on a specific project/contract, a letter of intent which indicates its intended use shall be submitted as dictated in the *Doc Express Contractors User Manual.*
      i) Design of bituminous concrete mixtures (Cover sheet)
      ii) Marshall test property curves (Sheet 1)
      iii) Marshall design analysis (Sheet 2)
      iv) Particle distribution curve (Sheet 3)
      v) Production Action & Suspension Limits (Sheet 4)
      vi) Effect of Water on Asphalt – Coated Aggregate Using Boiling Water worksheet (Sheet 5) **(required for mix designs containing granite and/or quartzite aggregates on projects advertised with GSP-1809 effective January 26th, 2021)**

b) Superpave Mix Design - Must be submitted for each type of mix and shall be classified as "HMA" or "WMA" on the cover sheet. All mix design submittals will be considered as "MASTER MIX DESIGNS" and shall be indicated this way where appropriate on the cover sheet; the intended projects on which the design will be used, if known, should also be noted where appropriate. Before a design can be approved for use on a specific project/contract, a letter of intent which indicates its intended use shall be submitted as dictated in the *Doc Express Contractor User Manual.*

i) Superpave Bituminous Concrete Mixture Design (Cover sheet)
ii) Superpave test property curve(s) (Sheet 2a)
iii) Superpave mix points design analysis (Sheet 3)
iv) RAP and Aggregate property worksheet. (Sheet 4)
v) Recycled Asphalt Pavement properties Worksheet. (Rap_Test_Sheet). This sheet is required only with designs listing RAP as an aggregate source.
vi) Production Action & Suspension Limits (Sheet 5)
vii) Analysis of specimen gyrated to N_{max} worksheet. (Sheet 6)
viii) Copy of gyratory height printout for the specimen gyrated to N_{max}.
ix) Hamburg Wheel Tracker Test (HWTT) and Indirect Tensile Cracking Test (IDEAL-CT) worksheet (Sheet 7)*
x) Copies of HWTT and IDEAL-CT graphs and reports*
xi) Effect of Water on Asphalt – Coated Aggregate Using Boiling Water worksheet (Sheet 8) **(required for mix designs containing granite and/or quartzite aggregates on projects advertised with GSP-1809 effective January 26th, 2021)**

*Performance testing on Superpave mix designs is required for mainline paving on QAP Level 1-3 projects, and such designs will be designated as **Performance (P).** Those designs without performance testing will be labelled as **Non – Performance (NP)**, and only permissible for use on hand-placed applications, temporary paving, and/or QAP Level 4 projects. Flexibility Index Test (FIT) results, if completed, must be provided in separate files.

c) Bonded Wearing Course Mix Design – Must be submitted for each type of mix. All mix design submittals will be considered as "MASTER MIX DESIGNS" and shall be indicated this way where appropriate on the cover sheet; the intended projects on which the design will be used, if known, should also be noted where appropriate. Before a design can be approved for use on a specific project/contract, a letter of intent which indicates its intended use shall be submitted as dictated in the *Doc Express Contractor User Manual.*

i) Paver Placed/Bonded Wearing Course Bituminous Concrete Mixture Design (cover sheet)
ii) Aggregate property worksheet. (Sheet 2)
iii) Aggregate test results (Sheet 3)
iv) Minimum PG binder content worksheet (Sheet 4)
v) Effect of Water on Asphalt – Coated Aggregate Using Boiling Water worksheet (Sheet 5) **(required for mix designs containing granite and/or quartzite aggregates on projects advertised with GSP-1809 effective January 26th, 2021)**

Note that mix design submittals will not be formally approved for use if any of the following components have not been inspected and/or approved for use by Agency representatives:

i) PG Binder Source(s)
ii) Aggregate Source(s)
iii) Production Facility

4. **Changes to JMF**: Once a mix design is used in production, jurisdiction is transferred to the Bituminous Concrete Field Unit Supervisor (AOT.HMAField@vermont.gov). The contractor may adjust the original JMF design binder content up to ± 0.1% at their discretion. All other requests to change the JMF shall be submitted electronically to the Bituminous Concrete Field Unit Supervisor for review/approval. Supporting data/documentation shall be included that substantiates each request. Approved requests will be applied proactively. The Agency may request a new mix design submittal if it is in the best interest of the project.

5. **Binder Downgrading:** An approved Performance mix design may serve as the basis for a Non-Performance design in which the only difference is the binder being downgraded (i.e., 70-28 to 58-28). The Non-Performance design with identical aggregate structure, gyration level, RAP and Binder percentage and job aim, but a lower binder grade, will not require its own mix design testing, but rather copy the supporting data from the approved Performance design. The intent to utilize this process should be noted in the mix design submission and note the approved performance design number.

   To ensure the reduction in binder grade is not impactful, 3 verification tests, from either plant or lab mix, should accompany the request, to prove the design remains within range for all 3 tests. Verification results should include the items outlined in the section on Trial Drops below and be inputted on the Validation sheets available on the Bituminous Concrete Materials Unit website. The Agency reserves the right to require a full design be conducted if it is determined there is not enough evidence to support approval of a downgraded design.

6. **Trial Drops/Laboratory Checkpoints:** The Agency currently does not require trial drops and/or laboratory "checkpoints" as part of mix design approval, except as described below for mix design carryover requests. Trial drops performed for corrective action during Method Spec production are still required **and are the responsibility of the hot mix producer**.

   Trial drops and laboratory "checkpoints" shall contain at a minimum the following information and the raw data used to calculate all values:

   a. Copy of batch slip or raw test data
   b. JMF
   c. Volumetric properties (air voids, VMA, effective asphalt content, maximum specific gravity, bulk specific gravity, and dust/binder ratio)
   d. Gradation (dry sieve only)
   e. Marshall flow & stability values (for Marshall Mix Design)
   f. Copy of gyratory height printout for specimen gyrated to N_{design} (for Superpave Mix Design)
   g. Date & time sampled, fabricated, and/or tested

   Laboratory "checkpoints" will only be allowed for mix design carryover requests in which weather conditions are not conducive to conducting trial drops.

7. **Carryover of Mix Designs:** Prior to each paving season, contractors must submit a letter and supporting data electronically to the VTrans Mix Design Mailbox (AOT.VTransMixDesigns@vermont.gov) requesting a list of designs approved during the previous season to be carried over for the upcoming construction season. It is the intent that contractors will submit requests during the off-season to allow VTrans appropriate time to review. The Bituminous Concrete Materials Engineer will review and provide a formal response for each request. Approval will be dependent but not limited to each design's past performance and the following factors below:

a. The origin of materials (approved aggregate, recycled materials, approved PG binder, binder grade, and additives) shall be unchanged from the original design. Additionally, no significant changes have taken place that would affect material properties from the previous year's operation, i.e. change in crushing operation or plant operation. If deemed necessary, **the Agency reserves the right to request submittal of production or trial drop data to substantiate the review.**
b. No significant changes to the JMF have taken place. The mix design reviewer will review all requested aim changes to each design and determine if changes are significant enough to warrant a new design, i.e. Gradation – aim change on 4 or more sieves and/or > ± 5% on any one sieve or > ± 0.5% on the #200 sieve. Deviations of the binder content during production beyond ± 0.2% of the original design binder content will be significant enough to require a new design.
c. Designs must exhibit acceptable past quality characteristics both plant and field. A review of production (QC and QA) and field data will be conducted to determine eligibility for carry over. Designs meeting criteria a&b above, have a plant pass/fail ratio above 85% and have exhibited reasonably acceptable field performance will be eligible for carryover. Designs meeting criteria a&b above with a plant pass/fail ratio between 70-85% will be further reviewed on a case-by-case basis. A detailed review of the design's history may need to be performed to make the proper assessment. Designs that have a plant pass/fail ratio less than 70% will not be considered for carry-over unless it is determined that it qualifies as a "limited use" design as explained in part (d) below.
d. Designs with "limited use" within the past 5 years, i.e. less than 15 sample points; **The Agency reserves the right to request additional information to substantiate the review. Designs requested for carryover in which no test results are provided will not be approved without the submission of trial drop or laboratory "checkpoint" data.**
e. District Designs: Because certified contractor test results are used for acceptance of district paving projects that are QAP Level 4, contractors shall submit a summary of each design's QC plant data to aid in the review of the design's past plant performance. To evaluate field performance, the appropriate Maintenance District Project Manager, or designee will be consulted with for the design's eligibility for carry-over.
f. Initial approval of the mix design occurred within the past 5 years, and the mix design has been continuously carried over and produced each year. **Under no circumstances will mix designs be deemed eligible for carryover beyond the fifth year of use.**

In addition to the requirements outlined above, HWT and IDEAL-CT results are required every 2 years to carry over all "Performance" Superpave mix designs. Results must be fabricated in accordance with the guidance provided in Appendices A & C and shall be clearly noted as being Lab-Produced or Plant-Produced.

8. **Letters of Intent**: A letter of intent for each project/contract shall be submitted at a minimum of 5 working days prior to the start of production identifying the approved mix designs intended to be used for that particular project/contract. Letters of intent shall be submitted through Doc Express in accordance with the latest edition of the *Doc Express Contractor User Manual* and, in addition to the project name and project number, include the mix design number, mix type, PG binder grade, and percent amount of RAP if present. The Bituminous Concrete Materials Engineer will review the request and relevant project plans to ensure the mix design is eligible; in addition, the project Resident Engineer and VTrans Construction Paving Engineer will be

consulted with if questions arise. Usage of the mix design on Agency projects will not be authorized without the letter of intent being approved by the Agency and recorded on Doc Express.

Note: If the HMA Producer is a Subcontractor on an Agency project, then the HMA Producer must either a. be assigned “Associate” permission by the Prime Contractor to submit a letter of intent into Doc Express, or b. have the Prime Contractor submit the letter on behalf of the HMA Producer.

Appendix A: Laboratory Testing of Hamburg Wheel Tester (HWT) Samples at VAOT

Specimen Preparation - Lab Produced Mixtures

Lab produced HWT samples shall be fabricated in accordance with the procedures outlined in AASHTO T 324, with the following modifications:

- Upon mixing the constituent materials to ensure all aggregates are coated, test samples shall be conditioned at the appropriate temperature in accordance with AASHTO R 30, subsection 7.1: *Short-Term Mixture Conditioning*.
    - Samples shall be conditioned for 2 hours at a temperature of 135 ± 3°C regardless of whether a warm-mix asphalt (WMA) technology is present or not.
- A Superpave Gyratory Compactor (SGC) shall be used for specimen fabrication. The SGC shall be operated in height mode to achieve specimens 62 ± 1 mm tall. Four specimens shall be fabricated.
- Air void values for the SGC specimens will be calculated in accordance with AASHTO T 269 to two decimal places for the purpose of pairing specimens for testing. The target air void content for each specimen shall be 7.0 ± 0.5 %, and specimens for HWT testing shall be paired by matching up specimens with the closest air voids. For example:
    - Specimen A: P_a = 6.7%
    - Specimen B: P_a = 7.1%
    - Specimen C: P_a = 6.8%
    - Specimen D: P_a = 7.3%

  For the air void contents shown above, specimens A & C would be paired with an average air voids content of 6.8% for one wheel, and specimens B & D would be paired with an average air voids content of 7.2% for the other wheel.

Specimen Preparation - Field Produced Mixtures

Field produced HWT samples shall consist of loose mix obtained via box samples in accordance with AASHTO R 97. Specimens shall be fabricated in accordance with the procedures outlined in AASHTO T 324, with the following modifications:

- Loose mix box samples must be reheated to provide separation of particles specified in AASHTO T 209 (maximum specific gravity) procedure that particles of fines shall be no larger than ¼". Box samples shall be reheated at a temperature below compaction temperature for splitting purposes only. No HWT sample shall remain in the oven for more than 2 hours at compaction temperature. Total sample size and box shape affect the reheating time. Once sufficiently warmed through for separation in accordance with T 209, remove from the oven and proceed with T 209 separation.
- Loose mix samples are required to split down to appropriate size for SGC specimens using the mini stockpile method, with final adjustment to the target mass done manually.
- Prior to compaction in the SGC, the loose mix will be reheated at compaction temperature ± 3 °C and compacted immediately once the mix reaches the target temperature as measured by two separate thermometer probes inserted into the sample. For modified mixes, the compaction temperature tolerance of ± 3 ℃ may be waived at the user's discretion so long as the mix compaction temperature does not exceed 165 ℃. The mixture should be removed from the oven and stirred once while reheating, and the time the mixture is out of the oven for stirring should be as short as possible.

- A Superpave Gyratory Compactor (SGC) shall be used for specimen fabrication. The SGC shall be operated in height mode to achieve specimens 62 ± 1 mm tall. Four specimens shall be fabricated.
- Air void values for the SGC specimens will be calculated in accordance with AASHTO T 269 to two decimal places for the purpose of pairing specimens for testing. The target air void content for each specimen shall be 7.0 ± 0.5 %, and specimens for HWT testing shall be paired by matching up specimens with the closest air voids (see example above).

Test Setup & Procedure

HWT testing shall be performed in accordance with AASHTO T 324 and the equipment manufacturer's instructions, with the following modifications:

- The test temperature for all HWT specimens shall be 45°C.
- Specimens shall be conditioned for 45 minutes after achieving the test temperature. Specimens shall not be submerged for more than 60 minutes prior to test initiation.
- The maximum number of passes shall be set to 20,000 passes (or 10,000 cycles depending on the testing device). The equipment shall also be set such that the test will end once a maximum rut depth of 12.5 mm (0.50 inches) is reached for either pair of specimens.
- Equipment shall be set to record the LVDT displacement at the following sensor locations along the specimen: -114 mm (-4.5 inches), -92 mm (-3.6 inches), -69 mm (-2.7 inches), -46 mm (-1.8 inches), -23 mm (-0.9 inches), 0 mm (0 inches) (middle between two gyratory specimens), +23 mm (+0.9 inches), +46 mm (+1.8 inches), +69 mm (+2.7 inches), +92 mm (+3.6 inches), and +114 mm (+4.5 inches). The data acquisition shall be set to record deformation location at each of the 11 locations at every 2 passes.

Reporting & Calculations

The HWT report of test results must include the following for each set of specimens (each side of the HWT machine):

- HMA production (field or lab)
- Number of passes to failure
- Maximum impression (average rut depth for the 5 middle deformation locations in both wheels))
- Test temperature
- Specimen(s) air voids
- Type and amount of anti-strip or additive (if used)
- Creep slope (in mm/1,000 passes) (if determined from the machine software)
- Strip slope (in mm/1,000 passes) (if determined from the machine software)
- Stripping inflection point (SIP) (if determined from the machine software)

HWT reports for the purpose of mix design approval and verification shall combine the data from the left and right side of the HWT machine to create one deformation curve. All test results will be reported as the average value of both specimens, and the maximum deformation for each side will be determined based on the average rut depth for the five middle deformation locations. The following measures will be reported for the combined deformation curve and represent the final values for the mix design approval and verification sample:

- Number of passes to failure
- Maximum impression (average rut depth for the 5 middle deformation locations in both wheels)
- Creep slope (in mm/1,000 passes) (if determined from the machine software)
- Strip slope (in mm/1,000 passes) (if determined from the machine software)
- Stripping inflection point (SIP) (if determined from the machine software)

The HWT test will be deemed inconclusive if all of the following conditions are met:

- The maximum deformation difference between the 2 sets of specimens (from each side of the HWT machine) exceeds 6 mm (0.25 inches) and,
- One set of specimens is deemed passing and one set of specimens is deemed failing when analyzed individually (by either passes to failure or SIP).

If a sample is deemed inconclusive, a replacement sample shall be obtained immediately. If the initial sample was for mix design approval, a secondary set of material shall be re-tested by the Producer. If the initial sample was a split sample taken during field production operations, the re-test will be performed on another split sample provided that no changes to the mix design have been made.

Stripping Inflection Point (SIP):

The intersection of the creep slope and the stripping slope is found mathematically by setting the equations for both lines equal and solving for the pass number. If any of the following conditions are met, the SIP will be considered invalid and reported as "N/A":

- The ratio between the stripping slope and the creep slope is less than 3.0
- The stripping slope is less than 0.63 mm/1,000 passes.

Appendix B: Laboratory Testing of Flexibility Index Test (FIT) Samples at VAOT

Specimen Preparation - Lab Produced Mixtures

Lab produced FIT samples shall be fabricated in accordance with the procedures outlined in AASHTO T 393, with the following modifications. Note that a minimum of three (3) half-moon specimens are required for a valid FIT result per AASHTO T 393.

- Upon mixing the constituent materials to ensure all aggregates are coated, test samples shall be conditioned at the appropriate temperature in accordance with AASHTO R 30, subsection 7.1: *Short-Term Mixture Conditioning*.
    - Samples shall be conditioned for 2 hours at a temperature of 135 ± 3°C regardless of whether a warm-mix asphalt (WMA) technology is present or not.
- A Superpave Gyratory Compactor (SGC) shall be used for specimen fabrication. The SGC shall be operated in height mode to achieve a specimen 160 ± 1 mm tall. Two (2) cylindrical 50 ± 1 mm thick discs shall be saw cut from the middle of the tall specimen.
    - If the SGC being used is unable to achieve a specimen 160 ± 1 mm tall, then two (2) specimens 115 ± 1 mm tall shall be fabricated. One (1) cylindrical 50 ± 1 mm thick disc shall be saw cut from the middle of each gyrated specimen.
- Air void values for the discs obtained will be calculated in accordance with AASHTO T 269. The target air void content for each specimen shall be 7.0 ± 1.0 %.
- Cut each 50 ± 1 mm thick disc into two (2) identical halves, resulting in four (4) half-moon specimens.
- For cutting the 15 ± 1 mm notch in each half-moon specimen, it is recommended that a tile saw be used.
- Double check the final specimen dimensions to ensure the specimens are within the dimensional tolerances prescribed in AASHTO T 393. If a minimum of three (3) half-moon specimens meeting the requirement of T 393 are not available, the fabrication process must be redone.

Specimen Preparation - Field Produced Mixtures

Field produced FIT samples shall consist of loose mix obtained via box samples in accordance with AASHTO R 97. Specimens shall be fabricated in accordance with the procedures outlined in AASHTO T 393, with the following modifications. Note that a minimum of three (3) half-moon specimens are required for a valid FIT result per AASHTO T 393.

- Loose mix box samples must be reheated to provide separation of particles specified in AASHTO T 209 (maximum specific gravity) procedure that particles of fines shall be no larger than ¼". Box samples shall be reheated at a temperature below compaction temperature for splitting purposes only. No HWT sample shall remain in the oven for more than 2 hours at compaction temperature. Total sample size and box shape affect the reheating time. Once sufficiently warmed through for separation in accordance with T 209, remove from the oven and proceed with T 209 separation.
- Loose mix samples are required to split down to appropriate size for SGC specimens using the mini stockpile method, with final adjustment to the target mass done manually.
- Prior to compaction in the SGC, the loose mix will be reheated at compaction temperature ± 3 °C and compacted immediately once the mix reaches the target temperature as measured by two separate thermometer probes inserted into the sample. For modified mixes, the compaction temperature tolerance of ± 3 ℃ may be waived at the user's discretion so long as the mix compaction temperature does not exceed 165 ℃. The mixture should be removed from the

oven and stirred once while reheating, and the time the mixture is out of the oven for stirring should be as short as possible.

- A Superpave Gyratory Compactor (SGC) shall be used for specimen fabrication. The SGC shall be operated in height mode to achieve a specimen 160 ± 1 mm tall. Two (2) cylindrical 50 ± 1 mm thick discs shall be saw cut from the middle of the tall specimen.
    - If the SGC being used is unable to achieve a specimen 160 ± 1 mm tall, then two (2) specimens 115 ± 1 mm tall shall be fabricated. One (1) cylindrical 50 ± 1 mm thick disc shall be saw cut from the middle of each gyrated specimen.
- Air void values for the discs obtained will be calculated in accordance with AASHTO T 269. The target air void content for each specimen shall be 7.0 ± 1.0 %.
- Cut each 50 ± 1 mm thick disc into two (2) identical halves, resulting in four (4) half-moon specimens.
- For cutting the 15 ± 1 mm notch in each half-moon specimen, it is recommended that a tile saw be used.
- Double check the final specimen dimensions to ensure the specimens are within the dimensional tolerances prescribed in AASHTO T 393. If a minimum of three (3) half-moon specimens meeting the requirement of T 393 are not available, the fabrication process must be redone.

Test Setup & Procedure

FIT testing shall be performed in accordance with AASHTO T 393 and the equipment manufacturer's instructions, with the following modifications:

- The half-moon specimens shall be dried to constant mass, then conditioned in a water bath or an environmental chamber at 25 ± 0.5°C for a minimum of 2 hours. The specimens shall be placed in bags if the water bath method is used, so it is not saturated. If specimens are saturated due to a torn/broken bag, the specimens shall be dried to constant mass and reconditioned accordingly.
- Specimens shall be tested within five (5) minutes of being removed from the conditioning vessel.
- Enter the information for each half-moon specimen per the equipment manufacturer's instructions prior to initiation of the test. If the radius of the half-moon specimens was not measured, 75 mm may be assumed for the purposes of calculating the ligament length.
    - **NOTE:** If using a Troxler/TestQuip I-FIT, I-FIT Plus, or IDEAL-CT Plus test apparatus, be careful not to transpose the notch depth and ligament length measurements when entering the dimensions of each half-moon specimen in the machine software. Transposing these measurements will result in an invalid Flexibility Index (FI) result corresponding to the specimen tested.
- The Flexibility Index (FI) result for each half-moon specimen shall be calculated using the software provided by the equipment manufacturer, the latest version of the Rutgers Asphalt Analysis Tool-Pack (RAAT-Pack) software available from the Rutgers Asphalt Pavement Laboratory's website, or the latest version of the Illinois Center for Transportation (ICT) software available from ICT's website.

Reporting & Calculations

The Flexibility Index (FI) result for each half-moon specimen shall be calculated using the software applications described above. The FIT report of results must also include the following at a minimum:

- HMA production (field or lab)
- Specimen bulk specific gravity
- Specimen air voids

- Specimen thickness
- Specimen notch length
- Specimen ligament length
- Average and Coefficient Of Variation (COV) of post – peak slope
- Average and COV of Fracture Energy
- Average and COV of FI

FIT results will be deemed inconclusive if there are less than three (3) half-moon specimens meeting the dimensional tolerances specified in AASHTO T 393. If a sample is deemed inconclusive, a replacement sample shall be obtained immediately. If the initial sample was for mix design approval, a secondary set of material shall be re-tested by the Producer. If the initial sample was a split sample taken during field production operations, the re-test will be performed on another split sample provided that no changes to the mix design have been made.

Appendix C: Laboratory Testing of Indirect Tensile Cracking Test (aka, IDEAL-CT) Samples at VAOT

Specimen Preparation - Lab Produced Mixtures

Lab produced IDEAL-CT samples shall be fabricated in accordance with the procedures outlined in ASTM D8225-19, with the following modifications. Note that a minimum of three (3) specimens are required for a valid IDEAL-CT result per ASTM D8225-19, and it is recommended that no more than five (5) specimens be fabricated for IDEAL-CT testing.

- Upon mixing the constituent materials to ensure all aggregates are coated, test samples shall be conditioned at the appropriate temperature in accordance with AASHTO R 30, subsection 7.1: *Short-Term Mixture Conditioning*.
    - Samples shall be conditioned for 2 hours at a temperature of 135 ± 3°C regardless of whether a warm-mix asphalt (WMA) technology is present or not.
- A Superpave Gyratory Compactor (SGC) shall be used for specimen fabrication. For all mixes except Type IS, SGC shall be operated in height mode to achieve specimens 62 ± 1 mm tall. For Type IS mixes, the SGC shall be operated in height mode to achieve specimens 95 ± 1 mm tall. A minimum of three specimens shall be fabricated.
- Air void values will be calculated in accordance with AASHTO T 269. The target air void content for each specimen shall be 7.0 ± 0.5 %.

Specimen Preparation - Field Produced Mixtures

Field produced IDEAL-CT samples shall consist of loose mix obtained via box samples in accordance with AASHTO R 97. Specimens shall be fabricated in accordance with the procedures outlined in ASTM D8225-19, with the following modifications. Note that a minimum of three (3) specimens are required for a valid IDEAL-CT result per ASTM D8225-19, and it is recommended that no more than five (5) specimens be fabricated for IDEAL-CT testing.

- Loose mix box samples must be reheated to provide separation of particles specified in AASHTO T 209 (maximum specific gravity) procedure that particles of fines shall be no larger than ¼". Box samples shall be reheated at a temperature below compaction temperature for splitting purposes only. No HWT sample shall remain in the oven for more than 2 hours at compaction temperature. Total sample size and box shape affect the reheating time. Once sufficiently warmed through for separation in accordance with T 209, remove from the oven and proceed with T 209 separation.
- Loose mix samples are required to split down to appropriate size for SGC specimens using the mini stockpile method, with final adjustment to the target mass done manually.
- Prior to compaction in the SGC, the loose mix will be reheated at compaction temperature ± 3 °C and compacted immediately once the mix reaches the target temperature as measured by two separate thermometer probes inserted into the sample. For modified mixes, the compaction temperature tolerance of ± 3 ℃ may be waived at the user's discretion so long as the mix compaction temperature does not exceed 165 ℃. The mixture should be removed from the oven and stirred once while reheating, and the time the mixture is out of the oven for stirring should be as short as possible.
- A Superpave Gyratory Compactor (SGC) shall be used for specimen fabrication. For all mixes except Type IS, the SGC shall be operated in height mode to achieve specimens 62 ± 1 mm tall. For Type IS mixes, the SGC shall be operated in height mode to achieve specimens 95 ± 1 mm tall. A minimum of three specimens shall be fabricated.
- Air void values will be calculated in accordance with AASHTO T 269. The target air void content for each specimen shall be 7.0 ± 0.5 %.

Test Setup & Procedure

IDEAL-CT testing shall be performed in accordance with ASTM D8225-19 and the equipment manufacturer's instructions, with the following modifications:

- The specimens shall be dried to constant mass, then conditioned in a water bath or an environmental chamber at 25 ± 0.5°C for a minimum of 2 hours. The specimens shall be placed in bags if the water bath method is used, so it is not saturated. If specimens are saturated due to a torn/broken bag, the specimens shall be dried to constant mass and reconditioned accordingly.
- Specimens shall be tested within four (4) minutes of being removed from the conditioning vessel.
- Enter the information for each specimen per the equipment manufacturer's instructions prior to initiation of the test.
- The Cracking Tolerance Index (CT_{index}) result for each specimen shall be calculated using the software provided by the equipment manufacturer or the latest version of the Rutgers Asphalt Analysis Tool-Pack (RAAT-Pack) software. The RAAT-Pack software is available on the internet through the Rutgers Asphalt Pavement Laboratory's website.

Reporting & Calculations

The CT_{index} result for each specimen shall be calculated using the software provided by the equipment manufacturer. The report of results must also include the following for each specimen tested:

- HMA production (field or lab) and aging condition
- HMA mix type
- Specimen testing temperature
- Specimen air voids
- Specimen thickness
- Specimen diameter
- Specimen displacement at 75 % of the peak load
- Absolute value of the post-peak slope
- Failure Energy
- Work of failure
- CT_{index}

The coefficient of variation (COV) for the post-peak slope, failure energy, and the CT_{index} must also be included in the test report.

IDEAL-CT results will be deemed inconclusive if <u>any</u> of the following conditions are met:

- There are less than three (3) specimens meeting the dimensional and air void tolerances specified in ASTM D8225-19.
- The CT_{index} COV is greater than or equal to 35.0%.

If a sample is deemed inconclusive, a replacement sample shall be obtained immediately. If the initial sample was for mix design approval, a secondary set of material shall be re-tested by the Producer. If the initial sample was a split sample taken during field production operations, the re-test will be performed on another split sample provided that no changes to the mix design have been made.