LEVEL 2

HMA Mix Design Specialist

CERTIFICATION/TRAINING PROGRAM MANUAL



Partners in Quality

Texas Department of Transportation

HMAC Training & Certification

TXAPA Texas Asphalt Pavement Association



The Hot Mix Asphalt Center exists to certify, train, and equip specialists with the knowledge and skills needed to inspect, test, and design construction materials. Through education and support that continue beyond certification, the HMAC seeks to help people realize their potential to contribute to the future of Texas' infrastructure.

To execute our mission, we constantly aim to:

EDUCATE

Through hands-on learning, training, and testing, our instructors ensure specialists not only have a thorough understanding of the subject, but will be able to apply what they've learned in a real-world setting. We believe our role as an educational resource doesn't stop at the door – it continues throughout a specialist's career.

INNOVATE

From installing the latest, cutting-edge equipment in our labs to streamlining processes and developing new educational tools, we strive to continuously set a higher bar for ourselves and those around us.

EMPOWER

We believe in the potential of every specialist who comes through the center and do all we can to help them be successful before, during, and after certification. Our mantra is that what you do matters. If you put in the work to be the best you can be, we'll be here to cheer you on and support you along the way.

SERVE

Service is at the core of everything we do. Whether it be for individuals, companies, TxDOT, or the traveling public, the goal is for every certification to result in improved quality of asphalt pavements across the state of Texas.

Level 2 HMA Mix Design Specialist

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HMAC CERTIFIED SPECIALIST & APPLICANTS FOR CERTIFICATION: RIGHTS AND RESPONSIBILITIES

This agreement (the "Agreement") affirms that, _____, the below Applicant for Certification or the current Certified Specialist (collectively, the "Specialist") seeks to meet or has successfully met the requirements for certification by the Texas Asphalt Pavement Association ("TXAPA"), a/k/a the Hot Mix Asphalt Center (HMAC) as a certified technician. In that connection, the Specialist agrees as follows:

RIGHTS AND RESPONSIBILITIES - HMAC certification includes the exclusive right to perform certified sampling, testing and reporting on Texas Department of Transportation (TxDOT) projects involving Hot Mix Asphalt (HMA) and Soils & Base (SB) in accordance with TxDOT specifications and test procedures (as may be amended by TxDOT from time to time) for the level of certification issued. Specialists are required to perform and report test results with the accuracy and precision required of a certificated HMA or SB Specialist. It is important that the Specialist fully understands the significance of performing these duties in accordance with the certification level received by the Specialist.

Each Specialist is responsible for performing their own independent sampling, testing and reporting in accordance with TxDOT specifications, test procedures and standard operating procedures. These duties must be performed in a diligent and professional manner to produce TxDOT projects of the highest possible quality.

CONTACT INFORMATION - It is the Specialist's responsibility to provide the HMAC with current contact information by logging into www.txhmac.org, Communications from the HMAC will primarily be sent electronically to the most recent contact information provided by the Specialist.

ANNUAL PROFICIENCY - Once certified, Specialists are required to complete annual proficiency testing and the reporting of results to the HMAC. The testing and reporting must be timely and independently performed by the Specialist and, where applicable, in conformance with the requirements of the Specialist's certifications. TxDOT will ship the annual proficiency samples to the Specialist's address of record. (If this address is not current, the Specialist may not timely receive a proficiency sample and his/her certification may be danger of lapsing.)

Failure to submit proficiency test results or to respond to low rating(s) by the appointed deadlines may result in a change of certification status from active to inactive. Specialists whose certifications are inactivated because their annual proficiency testing/reporting is not current or whose certifications have been revoked or inactivated are prohibited from performing the duties associated with all certifications held by that Specialist.

RECERTIFICATION - Certification(s) are valid for three (3) years from the date originally issued, after which the Specialist must be recertified by again passing the requirements for certification. Specialists may seek recertification up to one year prior to the expiration of their certificate(s).

Failure to timely obtain recertification will cause all dependent certifications held by a Specialist to be inactivated. It is the Specialist's responsibility to maintain an active certification(s). (The HMAC will not provide reminders of pending expiration dates.)

ALLEGATIONS OF MISCONDUCT - Allegations of misconduct should be submitted to the HMAC, P.O. Box 1468, Buda, TX 78610 and must include the name, address and signature of the individual asserting the allegations as well as a brief description of the allegations.

If the allegations are properly submitted and appear to have merit, the HMAC Steering Committee (the "Committee") the individual asserting misfeasance and the person so accused will be asked to meet in person (but at separate dates/times) with members of the Committee. At the conclusion of the meeting(s), the Committee will issue its determination.

Misconduct generally consists of (i) neglect, (ii) abuse and/or (iii) breach of trust which are generally defined as:

1. Neglect: unintentional deviation(s) from specifications or testing procedures;

2. Abuse: careless or deliberate deviation from specifications or testing procedures; and

3. Breach of Trust: violation of the trust placed in Certified Specialists including, but not limited to, acts such as:

    a. Falsification of or deliberate omission from material records or information; or

    b. Awareness of improprieties in sampling, testing and/or production by others and the failure to timely report those improprieties to the appropriate project supervision.

The Committee may issue written reprimands (private or public) and/or revoke or inactivate a certification (if the Specialist has made a false representation or misstatement to the Committee or to the public or has engaged in misconduct) or take such other actions as the Committee, in its sole discretion, determines to be appropriate with respect to the Specialist's certification(s).

Specialists who do not achieve recertification or whose certification is revoked or inactivated by the Committee may appeal to a separate appeals committee comprised of industry members (the "Appeal Committee"). The exhaustion of this right of appeal to the Appeal Committee is a prerequisite to the exclusive remedy of administrative review by final and binding arbitration in Hays County, Texas, as administered by the American Arbitration Association by a single-member panel. Any and all other claims related in any way to this Agreement are exclusively subject to final and binding arbitration in Hays County, Texas as administered by the American Arbitration Association by a single-member panel.

In consideration for the HMAC certification/recertification process, Specialist hereby waives any and all claims of whatsoever kind or character related, directly or indirectly, to this Agreement, against the TXAPA, HMAC (including, but not limited to, the Committee and the Appeal Committee and their members), that s/he may have (including claims for attorney's fees) and further agrees to save, indemnify and hold TXAPA, the HMAC (including, but not limited to, the Committee and the Appeal Committee and their members) harmless from any claim, action or cause of action arising as a result of, or relating to this Agreement including, but not limited to, Specialist's certification, or any refusal, reprimand, revocation and/or suspension of certification or recertification of Specialist.

ACKNOWLEGED & AGREED:

SPECIALIST:

_____ _____

SIGNATURE **DATE**

_____

PRINTED NAME

INTRODUCTION
WEBSITES

WWW.TXHMAC.ORG

- TOOLS

WWW.TEXASASPHALT.ORG

- RESOURCES

WWW.APEXTX.ORG

- Knowledge EXchange



LEVEL 2 RESOURCES

HMAC Website

TXAPA Website

Asphalt Definitions and terms

TXDOT Materials

TXAPA
Texas Asphalt Pavement Association

TXAPA Definitions and Terminology

Pertaining to Asphalt Pavement Production and Construction (*ASTM Definitions)

AGGREGATE : A hard inert granular material of mineral composition such as sand, gravel, slag, or crushed stone, used in pavement applications either by itself or for mixing with asphalt mixing in graduated fragments.

COARSE AGGREGATE : Aggregate retained on the 2.36mm (No. 8) sieve.

COARSE-GRADED AGGREGATE : One having a continuous grading in sizes of particles from coarse through fine with a predominance of coarse sizes.

DENSE-GRADED AGGREGATE : An aggregate that has a particle size distribution such that when it is compacted, the resulting voids between the aggregate particles, expressed as a percentage of the total space occupied by the material, are relatively small.

FINE AGGREGATE : That passing the 2.36mm (No. 8) sieve.

FINE-GRADED AGGREGATE : One having a continuous grading in sizes of particles from coarse through fine with a predominance of fine sizes.

OPEN-GRADED AGGREGATE : One containing little or no mineral filler in which void spaces in the compacted aggregate are relatively large.

WELL-GRADED AGGREGATE : Aggregate graded from the maximum size down to filler with the object of obtaining an asphalt mix with a controlled void content and high stability.

AIR VOIDS : Empty spaces (air pockets) in a compacted mix surrounded by asphalt coated particles, expressed as a percentage by volume of total compacted mix.

APPARENT SPECIFIC GRAVITY, (Gsa) : The ratio of the mass in air of a unit volume of an impermeable material at a stated temperature to the mass in air of equal density of an equal volume of gas-free distilled water at a stated temperature.

ASPHALT* : A dark brown to black cementitious material in which the predominating constituents are bitumens which occur in nature or are obtained in petroleum processing. Asphalt is a constituent in varying proportions of most crude proportions.

ASPHALT BINDER : A term utilized in the Superpave Mix Design System to classify the grade of asphalt cement used in an asphalt mix based on expected performance under specific environmental conditions (high and low temperatures) and anticipated traffic loading. It can be either modified or unmodified asphalt cement as long as it complies with AASHTO M 320, Specification for Performance Graded Asphalt Binder.

ASPHALT CEMENTS* : A fluxed or unfluxed asphalt specially prepared as to quality and consistency for direct use in the manufacture of asphalt pavements.

ASPHALT LEVELING COURSE : A course of hot mix asphalt (usually a relatively fine graded asphalt aggregate mixture) of variable thickness used to eliminate irregularities in the contour of an existing surface prior to placing the subsequent course.

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AUTOMATIC DRYER CONTROL* : A system that automatically maintains the temperature of aggregates discharged from the dryer within a preset range.

AUTOMATIC PROPORTIONING CONTROL* : A system in which proportions of the aggregate and asphalt fractions are controlled by means of gates or valves which are opened and closed by means of self-acting mechanical or electronic machinery without any intermediate manual control. The system includes preset timing devices to control the desired periods of dry and wet mixing cycles.

ASPHALT RUBBER: AR : Used to modify liquid asphalt to increase performance and durability.

BALANCED MIX DESIGN: BMD : Asphalt mix design using performance tests on specimens that address multiple modes of distress include rutting and cracking. TXDOT is currently looking at the Hamburg Wheel Test and Overlay Test.

BASE COURSE : The layer of material immediately beneath the surface or intermediate course. It may be composed of crushed stone, crushed slag, crushed or uncrushed gravel and sand, or hot mix asphalt, typically with larger size aggregate.

BATCH PLANT* : A manufacturing facility for producing asphalt paving mixtures that proportions the aggregate constituents into the mix by weighed batches and adds asphalt binder by weight. The aggregates are first fractionated through a screening deck into hot bins from which they are proportioned into a weigh hopper. The batch of aggregates are emptied into a pugmill where the asphalt binder is weighed in and mixed to form the completed asphalt mixture.

BENDING BEAM RHEOMETER: Known as BBR : Provides a measure of low temperature stiffness and relaxation properties of asphalt binders – Indicates an asphalt binder's ability to resist low temperature cracking.

BITUMEN* : A class of black or dark-colored (solid, semisolid, or viscous) cementitious substances, natural or manufactured, composed principally of high molecular weight hydrocarbons, of which asphalts, tars, pitches, and asphaltites are typical.

BLEEDING (FLUSHING) : Is the upward movement of asphalt in an asphalt pavement resulting in the formation of a film of asphalt on the surface. The most common cause is too much asphalt in one or more of the pavement courses, resulting from too rich a plant mix, an improperly constructed seal coat, too heavy a prime or tack coat, or solvent carrying asphalt to the surface. Bleeding or flushing usually occurs in hot weather.

BULK SPECIFIC GRAVITY, Gsb : the ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass in air of equal density of an equal volume of gas-free distilled water at a stated temperature.

COAL TAR* : A dark brown to black cementitious material produced by the destructive distillation of bituminous coal.

COLD FEED BINS : Bins that store the necessary aggregate sizes and feed them to the dryer drum of the asphalt plant in substantially the same proportions as are required by the Job Mix Formula for the mix being produced.

COLD MIX (Cold Patch) : A mixture of emulsified asphalt and aggregate; produced in a central plant (plant mix) or mixed at the road site (mixed-in-place).

COMPACTION : The act of compressing a given volume of material into a smaller volume. Insufficient compaction of the asphalt pavement courses may result in rutting on the pavement surface and/or early oxidation due to the intrusion of air and water. Compaction is usually accomplished by rolling.

CONSENSUS PROPERTIES : Aggregate characteristics that are critical to well performing hot mix asphalt, regardless of the aggregate source, and whose limiting values are set by the Superpave specification. There are four aggregate consensus properties: 1) coarse aggregate angularity, 2) fine aggregate angularity, 3) flat and elongated particles, and 4) clay content.

CONSISTENCY : Describes the degree of fluidity or plasticity of asphalt binder at any particular temperature. The consistency of asphalt binder varies with temperature; therefore, it is necessary to use a common or standard temperature when comparing the consistency of one asphalt binder with another. The standard test temperature is 140°F (60°C).

CONTINUOUS MIX PLANT : A manufacturing facility for producing asphalt paving mixtures that proportions those aggregate and asphalt constituents into the mix by a continuous volumetric proportioning system without definite batch intervals.

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CORRUGATIONS (WASHBOARDING AND SHOVING) : Types of pavement distortion. Corrugation is a form of plastic movement typified by ripples across the asphalt pavement surface. Shoving is a form of plastic movement resulting in localized bulging of the pavement surface. These distortions usually occur at points where traffic starts and stops, on hills where vehicles brake on the downgrade, on sharp curves, or where vehicles hit a bump and bounce up and down. They occur in asphalt layers that lack stability. Lack of stability may be caused by a mixture that is too rich in asphalt, has too high a proportion of fine aggregate, has coarse or fine aggregate that is too round or too smooth, or has asphalt cement that is too soft. It may also be due to excessive moisture, contamination due to oil spillage, or lack of aeration when placing mixes using liquid asphalt.

CRACKS : Breaks in the surface of an asphalt pavement. The common types are:

ALLIGATOR CRACKS : Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken-wire, caused by excessive deflection of the surface over unstable subgrade or lower courses of the pavement.

EDGE JOINT CRACKS : The separation of the joint between the pavement and the shoulder, commonly caused by alternate wetting and drying beneath the shoulder surface. Other causes are shoulder settlement, mix shrinkage, and trucks straddling the joint.

LONGITUDINAL JOINT CRACKS : Longitudinal separations along the seam between two paving lanes caused by a weak seam between adjoining spreads in the courses of the pavement.

REFLECTION CRACKS : Cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath. They are caused by vertical or horizontal movements in the pavement beneath the overlay, brought on by expansion and contraction with temperature or moisture changes.

SHRINKAGE CRACKS : Interconnected cracks forming a series of large blocks usually with sharp corners or angles. Frequently they are caused by volume change in either the asphalt mix or in the base or subgrade.

SLIPPAGE CRACKS : Crescent-shaped cracks that are open in the direction of the thrust of wheels on the pavement surface. These result when there is a lack of good bond between the surface layer and the course beneath.

CRUSHER-RUN* **:** The total unscreened product of a stone crusher.

CUTBACK ASPHALT : Asphalt cement which has been liquefied by blending with a petroleum solvent (also called a diluent). Upon exposure to atmospheric conditions the diluent evaporates, leaving the asphalt cement to perform its function.

DENSITY : The degree of solidity (compaction) that can be achieved in a given mixture, which will be limited only by the total elimination of voids (zero air voids) between particles in the mass. Density is expressed as a percentage of the maximum specific gravity of the mix.

DRUM MIX PLANT : A manufacturing facility for producing asphalt paving mixtures that continuously proportions the aggregate constituents into the mix through its cold feed system, dries the aggregate, and adds a proportional amount of asphalt binder through a metering system into the same drum. The aggregates are fed from calibrated cold feeds into the dryer drum mixer where the aggregates are dried and then asphalt sprayed in and mixed to form the completed asphalt mixture. Variations of this type of plant use several types of drum modifications, separate (and smaller) mixing drums, and coating units (coater) to accomplish the mixing process.

DISTORTION : Pavement distortion is any change of the pavement surface from its original shape.

DRYER : The component of the asphalt plant that dries and heats the aggregates to the specified temperatures. Dryers are large cylindrical drums through which the aggregates pass. An open flame is used to dry and heat the aggregates.

DUCTILITY : The ability of a substance to be drawn out or stretched thin. While ductility is considered an important characteristic of asphalt binder in many applications, the presence or absence of ductility is usually considered more significant than the actual degree of ductility.

DURABILITY : The property of an asphalt paving mixture that describes its ability to resist disintegration by weathering and traffic. Included under weathering are changes in the characteristics of the asphalt, such as oxidation and volatilization, and changes in the pavement and aggregate due to the action of water, including freezing and thawing.

DYNAMIC SHEAR RHEOMETER : Known as DSR – High Temperature rheological properties of asphalt binders. Used to predict the end-use performance of asphalt materials.

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EFFECTIVE ASPHALT CONTENT, Pbe : The total asphalt content of a mix minus the portion of asphalt absorbed into the aggregate particles.

EFFECTIVE SPECIFIC GRAVITY, Gse : The ratio of the mass in air of a unit volume of a permeable material (excluding voids permeable to asphalt) at a stated temperature to the mass in air of equal density of an equal volume of gas-free distilled water at a stated temperature.

EMULSIFIED ASPHALT : An emulsion of asphalt cement and water that contains a small amount of an emulsifying agent, a heterogeneous system containing two normally immiscible phases (asphalt and water) in which the water forms the continuous phase of the emulsion, and minute globules of asphalt form the discontinuous phase. Emulsified asphalt may be of either the anionic (electro-negatively charged asphalt globules), or cationic (electro-positively charged asphalt globule types), depending upon the emulsifying agent. Upon exposure to atmospheric conditions the water evaporates, leaving the asphalt cement to perform its intended function.

FATIGUE RESISTANCE : The ability of asphalt pavement to withstand repeated flexing or slight bending caused by the passage of wheel loads. As a rule, the higher the asphalt binder content, the greater the fatigue resistance.

FLEXIBILITY : The ability of an asphalt pavement structure to conform to settlement of the foundation. Generally, flexibility of the asphalt paving mixture is enhanced by high asphalt content.

FULL-DEPTH ASPHALT PAVEMENT : The term FULL-DEPTH (registered by The Asphalt Institute with the U.S. Patent Office) certifies that the pavement is one in which asphalt mixtures are employed for all courses above the subgrade or improved subgrade. A Full-Depth asphalt pavement is laid directly on the prepared subgrade.

HAMBURG : Laboratory wheel-tracking test. Used to determine mix performance in regards to rutting, fatigue, moisture susceptibility and stripping predictions.

HIMA : Highly Modified Asphalt – Used to enhance durability in asphalt pavement applications.

HOT BINS : Bins in a batch plant that store the heated and separated aggregates prior to their final proportioning into the mixer.

HOT MIX ASPHALT (ASPHALT CONCRETE) : A high quality, thoroughly controlled uniform mixture of asphalt binder and well-graded aggregate fractions, thoroughly compacted into a uniform dense mass. The asphalt mixture is normally produced through an asphalt plant, then placed by a paving machine and compacted by asphalt rollers.

IDEAL CRACK TEST : Known as Ideal CT is a test method to determine indirect tensile strengths of bituminous mixtures and is a candidate for a performance cracking test.

IMPERMEABILITY : The resistance an asphalt pavement has to the passage of air and water into or through the pavement.

IRI (INTERNATIONAL ROUGHNESS INDEX) : Used throughout the world as a standard to quantify road surface roughness.

LIFT : A layer or course of paving material applied to a base or a previous layer.

MANUAL PROPORTIONING CONTROL* : A control system in which proportions of the aggregate and asphalt fractions are controlled by means of gates or valves which are opened and closed by manual means. The system may or may not include power assist devices in the actuation of gate and valve opening and closing.

MAXIMUM SPECIFIC GRAVITY Gmm : Maximum specific gravity of uncompacted bituminous paving mixtures.

MESH* : The square opening of a sieve.

MINERAL DUST : The portion of the fine aggregate passing the 0.075mm (No. 200) sieve.

MINERAL FILLER : A finely divided mineral product at least 70 percent of which will pass a 0.075mm (No. 200) sieve. Pulverized limestone is the most commonly manufactured filler, although other stone dust, hydrated lime, Portland cement, and certain natural deposits of finely divided mineral matter are also used.

OPEN-GRADED ASPHALT FRICTION COURSE : A pavement surface course that consists of a high-void, asphalt plant mix that permits rapid drainage of rainwater through the course and out the shoulder. The mixture is characterized by a large percentage of one-sized coarse aggregate. This course prevents tire hydroplaning and provides a skid-resistant pavement surface.

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OVERLAY TEST : Test method determines the susceptibility of bituminous mixtures to fatigue or reflective cracking. Results are values in Critical Fracture Energy and Crack Resistance Index.

PAVEMENT STRUCTURE : A pavement structure with all its courses of asphalt-aggregate mixtures, or a combination of asphalt courses and untreated aggregate courses placed above the subgrade or improved subgrade.

PENETRATION* : The consistency of a bituminous material expressed as the distance in tenths of a millimeter (0.1 mm) that a standard needle vertically penetrates a sample of the material under specified conditions of loading, time, and temperature.

PERFORMANCE GRADED (PG) : Asphalt binder grade designations used in Superpave; based on the binders mechanical performance at critical temperatures and aging conditions. This system directly correlates laboratory testing to field performance through engineering principles.

PERMANENT DEFORMATION : Deformation that stays even after the removal of the applied force.

PLANT SCREENS : Screens located in a batch plant between the dryer and hot bins which separate the heated aggregates into the proper hot bin sizes.

POISE : A centimeter-gram-second unit of absolute viscosity, equal to the viscosity of a fluid in which a stress of one dyne per square centimeter is required to maintain a difference of velocity of one centimeter per second between two parallel planes in the fluid that lie in the direction of flow and are separated by a distance of one centimeter.

POLYMER MODIFIED ASPHALT BINDER : A conventional asphalt cement to which a styrene block copolymer or styrene butadiene rubber (SBR) latex or neoprene latex has been added to improve performance.

POLYMER MODIFIED ASPHALT: (PMA) : Liquid asphalt modified to increase performance and durability.

QUARTERLY : Occurring once within each quarter of the calendar year; specifically, once during Jan.- Mar., once during Apr.- Jun., once during Jul.-Sep., and once during Oct.- Dec.

RAVELING : The progressive separation of aggregate particles in a pavement from the surface downward or from the edges inward. Raveling is caused by lack of compaction, construction of a thin lift during cold weather, dirty or disintegrating aggregate, too little asphalt in the mix, or overheating of the asphalt mix.

RECYCLED ASPHALT SHINGLES – RAS : Utilized in bituminous mixtures to increase stiffness.

RECYCLED ENGINE OIL BOTTOM – REOB : used to soften hard pen asphalt. No longer being utilized in Texas.

RUTTING : Grooves that develop in the wheel tracks of a pavement. Rutting may result from consolidation or lateral movement under traffic in one or more of the underlying courses, or by displacement in the asphalt surface layer itself. They may develop under traffic in new asphalt pavements that had too little compaction during construction or from plastic movement in a mix that does not have enough stability to support traffic.

SAND ASPHALT : A mixture of sand (natural and/or manufactured) and asphalt cement. It may be prepared with or without special control of aggregate grading and may or may not contain mineral filler. Either mixed-in-place or plant mix construction may be employed. Sand asphalt is used in construction of both base and surface courses.

SEGREGATION : In the asphalt mat -Mechanical Segregation – Thermal Segregation -both can cause poor performance of the finished product.

SIEVE* : In laboratory work an apparatus in which the openings are square for separating sizes of material.

SKID RESISTANCE : The ability of an asphalt paving surface, particularly when wet, to offer resistance to slipping or skidding. The factors for obtaining a high skid resistance are generally the same as those for obtaining high stability. Proper asphalt content and aggregate with a rough surface texture are the greatest contributors. The aggregate must not only have a rough surface texture, but also resist polishing.

SOLUBILITY : A measure of the purity of an asphalt binder. The ability of the portion of the asphalt binder that is soluble to be dissolved in a specified solvent. Inert matter, such as salts, free carbon, or non-organic contaminants are insoluble.

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SPECIFIC GRAVITY : The ratio of the density of a substance to the density of water.

STABILITY : The ability of asphalt paving mixture to resist deformation from imposed loads. Stability is dependent upon both internal friction and cohesion.

STOKE : A unit of kinematic viscosity, equal to the viscosity of a fluid in poises divided by the density of the fluid in grams per cubic centimeter.

SUBBASE : The course in the asphalt pavement structure immediately below the base course is called the subbase course. If the subgrade soil is of adequate quality, it may serve as the subbase.

SUBGRADE : The soil prepared to support a structure or a pavement system. It is the foundation of the pavement structure. The subgrade soil sometimes is called "basement soil" or "foundation soil."

STABILIZED SUBGRADE : Subgrade that has been improved as a working platform by: (1) the incorporation of granular materials or stabilizers such as asphalt, lime, or portland cement into the subgrade soil; or (2) any course or courses of select or improved material placed on the subgrade soil below the pavement structure.

STONE MATRIX ASPHALT– SMA : Typically used as a surface mix using liquid polymer modifiers, fibers & mineral filler. Known as the Cadillac of mixes.

SUPERPAVE™ : Short for "Superior Performing Asphalt Pavement" – a performance-based system for selecting and specifying asphalt binders and for developing an asphalt mix design. SUPERPAVE is a product of the Strategic Highway Research Program (SHRP) established by Congress in 1987 to improve the performance and durability of U.S. roads.

SUPERPAVE GYRATORY COMPACTOR (SGC) : A device used during Superpave mix design or field testing activities for compacting samples of hot mix asphalt into specimens used for volumetric analysis. Continuous densification of the specimen is measured during the compaction process.

SUPERPAVE MIX DESIGN : A mix design system that integrates the selection of materials (asphalt, aggregate) and volumetric proportioning with the project's climate and design traffic.

VISCOSITY : Is a measure of the resistance to flow. It is one method of measuring the consistency of asphalt.

ABSOLUTE VISCOSITY : A method of measuring viscosity using the poise as the basic measurement unit. This method utilizes a partial vacuum to induce flow in the viscometer.

KINEMATIC VISCOSITY : A method of measuring viscosity using the stoke as the basic measurement unit.

VOIDS : Empty spaces (air pockets) in a compacted mix surrounded by asphalt coated particles.

VOIDS IN TOTAL MIX (VTM : Total empty spaces (air pockets) in a compacted mix expressed as a percentage of the total solid volume.

VOIDS in the MINERAL AGGREGATE (VMA) : the volume of void space (air pockets) between the aggregate particles of a compacted mix that includes both the VTM and the effective asphalt content, expressed as a percentage of the total volume of the compacted mix.

VOIDS FILLED WITH ASPHALT (VFA) : The percentage of the voids in the mineral aggregate structure that are filled with asphalt, not including the adsorbed asphalt. It is expressed as a ratio of (VMA – VTM) to VMA.

WARM MIX ASPHALT (WMA) : Asphalt Mixture produced between 215 degrees and 270 degrees.

WET MIXING PERIOD : The interval of time between the beginning of application of asphalt binder and the opening of the mixer gate in a batch plant.

WORKABILITY : The ease with which paving mixtures may be placed and compacted.

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RAP Stockpile Management Best Practices

TxDOT, Materials and Test Division

March 4, 2026

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Introduction

Reclaimed Asphalt Pavement (RAP) is critical for conserving natural resources, and when properly managed and incorporated into hot-mix asphalt (HMA), it supports sustainability without sacrificing pavement performance.

Effective management of RAP stockpiles is critical to reduce variability in HMA and ensure consistent pavement performance. Variability in RAP stockpiles, such as aggregate gradation and asphalt content (AC), can compromise mix quality and limit the percentage of RAP usage in HMA.

This document outlines some best practices that producers can use to minimize variability through improved stockpile handling and processing. Producers are encouraged to modify their Quality Control Plan to address the proper handling and processing of RAP.

Eliminate Contamination

Contamination is a primary source of RAP variability. To maintain RAP quality:

- Prevent inclusion of deleterious materials such as concrete, wood, steel, vegetation, and road debris.
- Avoid placing RAP on untreated ground to prevent soil contamination.
- Keep stockpiles free of geosynthetics, markers, and construction trash.
- RAP with decantation greater than 5% and a plasticity index greater than 8 is prohibited.

Separate Stockpiles by Source

Maintaining separate RAP stockpiles improves consistency:

- Avoid mixing RAP from various sources unless thoroughly blended.

- Separate RAP with Surface Aggregate Classification (SAC) A or lightweight aggregates.
- Separate large quantities of RAP from single projects when feasible.
- Keep Contractor-owned and Department-owned RAP stockpiles separate.
- Test incoming millings before adding them to unprocessed or usable RAP when feasible.
- Avoid blending uncoated plant waste with millings.

Blend Before Processing

Uniformity in processed RAP depends on thorough blending:

- Use front-end loaders to dig from various angles.
- Avoid sequential excavation as it does not adequately mix materials.
- Blending prior to processing ensures more homogeneous processed RAP.

Process and Fractionate RAP

Processing should be consistent and controlled:

- Fractionated RAP must have 95% passing the ½-inch sieve, unless overwise approved.
- Run processing plants at consistent speeds.
- Monitor screens for wear and experiment with screen types.
- Avoid over-crushing, as it creates excessive fines and dust that affect mix performance.

Store Processed RAP Properly

Moisture retention affects mix quality and cost:

- Use stackers with low discharge points to reduce segregation.

- Prefer tall, conical stockpiles over horizontal ones, and control height to limit segregation.
- Store RAP on paved or other suitable sloped surfaces to prevent contamination and aid drainage.
- Covered storage (e.g., open-sided roofs) can reduce moisture without trapping humidity.

Ownership

- Contractors may use Contractor-owned RAP, including HMA plant waste, unless restricted by project plans.
- If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP.
- RAP generated during contract work may be used if permitted; contractors are responsible for testing all RAP for suitability.
- The Department does not guarantee the quality of its RAP unless specified in the plans.

Testing and Quality Control

Maintain quality through regular testing:

- Collect samples while processing or from the processed stockpile. Sample from the active or working face of the RAP stockpile.
- Test RAP at the minimum frequency of **one test per 1,500 tons of RAP used in surface mixtures**.
    - Run asphalt content and aggregate gradation on each sample.
- Use control charts to monitor trends and adjust processing. Make the RAP control charts available to the Engineer when requested.

Loading and Plant Use

Ensure consistent feed into the plant:

- Create a surge pile from processed RAP to stabilize feed.
- Calibrate and maintain feed systems and weigh hoppers regularly.

Production Operations and End of Project

- Submit a new mix design when the AC of the RAP stockpile varies from the value used in the mix design **and** the new recycled binder ratio exceeds the allowable percentage in the specification.
- Remove unused Contractor's RAP from the project site upon completion of the project.
- For Department-owned RAP that must be returned, ensure unused RAP is delivered to designated stockpile locations.

Conclusion

Applying these best practices helps reduce RAP variability and enhances HMA performance. While not eliminating all variability, these guidelines provide a strong foundation for consistent, high-quality RAP use in pavement construction.

REFERENCES:

TxDOT 2024 Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges

Zhou, F. RAP Stockpile Management and Processing in Texas: State of the Practice and Proposed Guidelines, Texas Transportation Institute, Technical Report: 0-6092-1

Best Practices and Tying it All Together

BEST PRACTICES AND TYING IT ALL TOGETHER

SPECIFICATIONS

Know your project specification.

- General Notes
- Special Provision
- Special Specification
- Item Number

TxDOT Specifications

Standard TxDOT Specifications for construction and maintenance of highways, streets, and bridges.

View TxDOT Specifications and Provisions



BEST PRACTICES AND TYING IT ALL TOGETHER

PLANT LIMITATIONS

Know the limitations of your plant.

- Number of cold feed bins.
- Bin %'s from your combined gradation may be too low or too high.
- Additives that can be used.

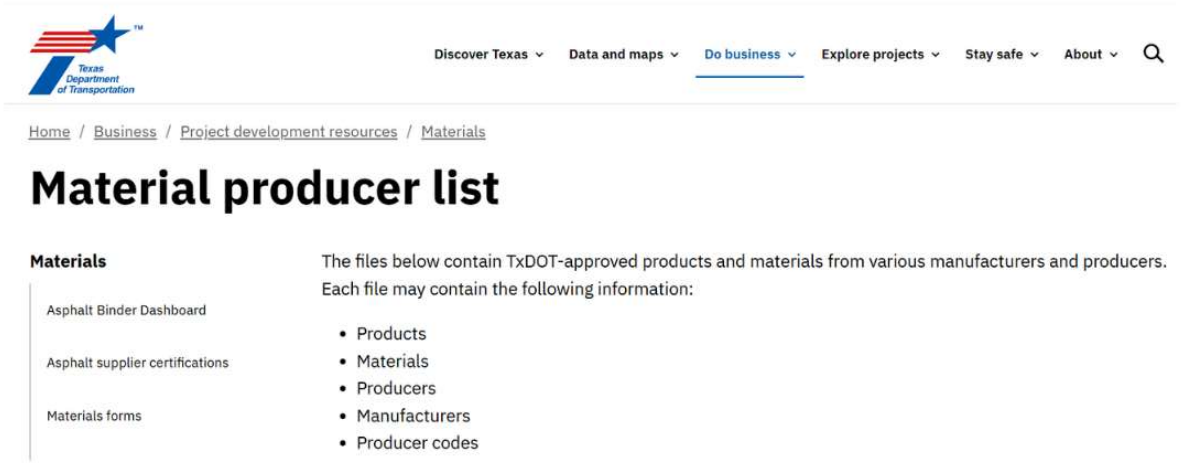


BEST PRACTICES AND TYING IT ALL TOGETHER

MATERIALS

Are the materials you want to use preapproved by TxDOT.

- Material Producer List (MPL)
  - *Bituminous Rated Source Quality Catalog*



BEST PRACTICES AND TYING IT ALL TOGETHER

GRADATION

- Do not design at the specification limits.
- Dense-graded and Superpave mixtures designed too coarse may be prone to segregation and hard to compact in the field to achieve density.
- Sieving aggregate below the No. 8 sieve to the #200 sieve will be more accurate for gradation and correction factors.

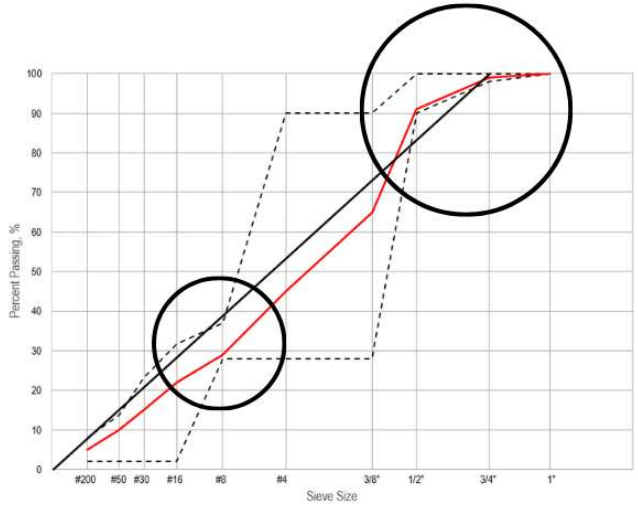


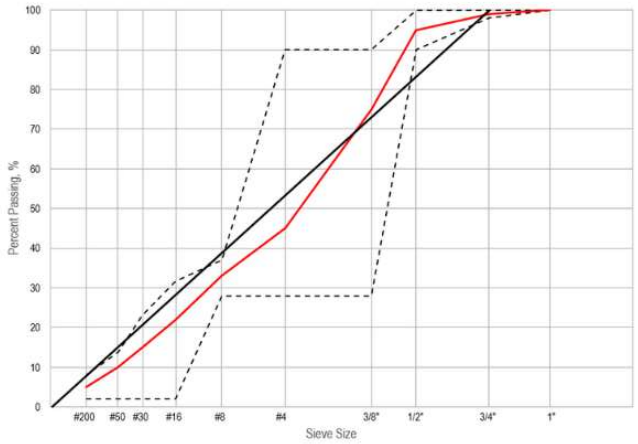
BEST PRACTICES AND TYING IT ALL TOGETHER

GRADATION

Power 45 Curve, Gradation Chart.

- Use the gradation curve as a tool, you can see when you're too close to the specification limits.
- You can see if you're gradation is too coarse or too fine and may need to open it up or bring it closer to the maximum density line.
- Can use it to see how to adjust the curve to meet density and VMA.
- Easier to visualize than looking at numbers.





BEST PRACTICES AND TYING IT ALL TOGETHER

TRENDS IN TEST RESULTS

- G_a results should increase as the asphalt content increases.
- G_r results should decrease as the asphalt content increases.
- G_e results for each asphalt content should be close to the average G_e.

GROUP 2							
Asphalt Content (%)	Binder Ratio (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)
5.0	0.0	2.242	2.425	2.611	2.423	92.5	18.4
5.5	0.0	+ 2.269	- 2.408	2.611	2.406	94.3	17.8
6.0	0.0	2.280	2.386	2.605	2.389	95.4	17.9
6.5	0.0	2.293	2.373	2.610	2.373	96.6	17.8

Effective Specific Gravity:	2.609
Optimum Asphalt Content :	**6.2**
Binder Ratio @ OAC:	0.0
VMA @ Optimum AC:	17.8

BEST PRACTICES AND TYING IT ALL TOGETHER

TEST MORE SAMPLES

- Mix and test two G_r samples at each asphalt content to average or verify which will provide the closest G_e to the average G_e.
    - G_e should be similar for each asphalt content.
- Mix and mold samples at the optimum asphalt content to verify volumetric properties.
    - *Rice Gravity, G_r*
    - *Effective Specific Gravity, G_e*
    - *Theoretical Maximum Specific Gravity, G_t*
    - *Bulk Specific Gravity, G_a*
    - *Density, how close to the target density +/- 0.5%.*

BEST PRACTICES AND TYING IT ALL TOGETHER

EVALUATE TEST RESULTS

- Will the optimum asphalt content change if the G_e at 5.5% was closer to the average G_e?
- Mix another Gr sample at 5.5% asphalt and retest.

GROUP 1							
Asphalt Content (%)	Binder Ratio (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)
4.5	0.0	2.230	2.438	2.606	2.432	91.7	18.0
5.0	0.0	2.284	2.418	2.603	2.415	94.6	16.5
5.5	0.0	2.297	2.375	2.570	2.398	95.8	16.5
6.0	0.0	2.285	2.385	2.604	2.381	96.0	17.3
6.5	0.0	2.315	2.374	2.611	2.365	97.9	16.7

Effective Specific Gravity:	2.599
Optimum Asphalt Content :	**6.0**
Binder Ratio @ OAC:	0.0
VMA @ Optimum AC:	17.3

Average G_e

BEST PRACTICES AND TYING IT ALL TOGETHER

EVALUATE TEST RESULTS

- New Gr result follows trend better.
- There isn't a significant change in the optimum asphalt, but it is more accurate.
  - *OAC increased to 6.1% from 6.0%.*
  - *VMA increased to 17.5% from 17.3%.*

GROUP 1							
Asphalt Content (%)	Binder Ratio (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)
4.5	0.0	2.230	2.438	2.606	2.438	91.5	18.3
5.0	0.0	2.284	2.418	2.603	2.421	94.4	16.7
5.5	0.0	2.297	2.404	2.606	2.404	95.6	16.7
6.0	0.0	2.285	2.385	2.604	2.387	95.7	17.6
6.5	0.0	2.315	2.374	2.611	2.370	97.7	16.9

Effective Specific Gravity:	2.606
Optimum Asphalt Content :	**6.1**
Binder Ratio @ OAC:	0.0
VMA @ Optimum AC:	17.5

+ 0.1%

+ 0.3%

BEST PRACTICES AND TYING IT ALL TOGETHER

EVALUATE TEST RESULTS

- Difference in Ga between two laboratory-molded specimens should be within 0.020, such as the allowable difference between Contractor and Engineer test results.
- It may be reasonable to expect a tighter tolerance within the same lab using the same equipment.
- When it is not, may want to consider using the Ga result that gives you the expected optimum asphalt content and VMA.
- May want to consider mixing and compacting another sample to verify which Ga is more accurate.

BEST PRACTICES AND TYING IT ALL TOGETHER

VERIFY CORRECTION FACTORS

- Asphalt content and gradation results will be accurate.
- Accuracy is important for acceptance and production.
- Differences outside of operation tolerances between the Contractor and Engineer may suspend production and lose bonus.
- VMA results will not be accurate.
- Verify more often than usual when using dolomite or trap rock aggregate.
- Accuracy will reduce or stop referee testing.

BEST PRACTICES AND TYING IT ALL TOGETHER

TROUBLESHOOTING

When to adjust the number of gyrations?

- Need more asphalt to meet density, VMA, or minimum asphalt content requirement.
- Using aggregate with high absorption.
- There may be a locking point with coarser gradations, such as SMA and TOM and may need to lower number of gyrations.

Insert USB flash drive and download compaction files.

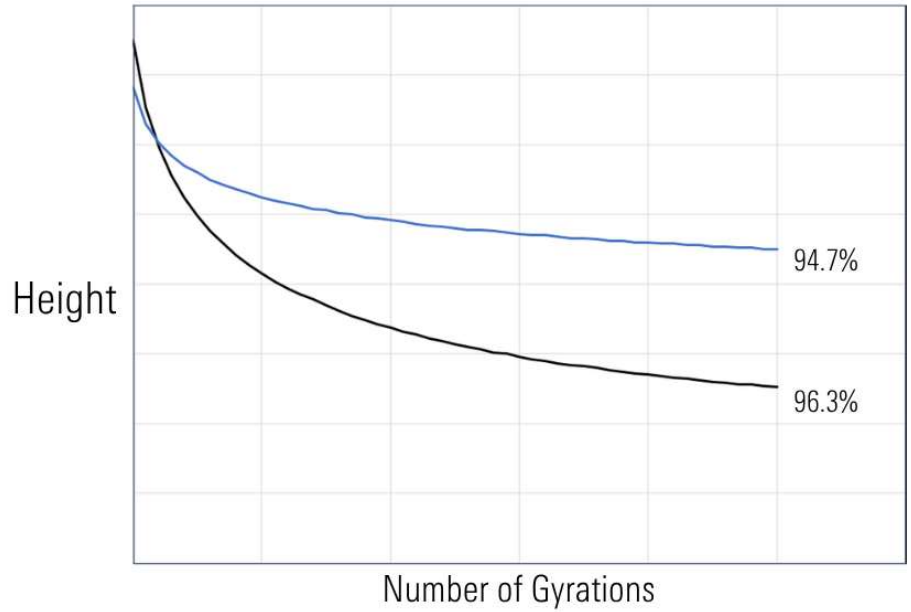


BEST PRACTICES AND TYING IT ALL TOGETHER

TROUBLESHOOTING

What is locking point?

- Locking point is generally with coarser gradations, such as SMA and TOM when trying to compact to a target lab density with a coarse gradation.
- Density of molded sample may be too low.
- May fracture aggregate and lead to high density.



TROUBLESHOOTING

Design fails minimum VMA, what do you look for so production doesn't fail?

- Open up gradation to get more asphalt in the mix.
- Add more intermediate aggregate as coarser aggregate may be more prone to breakdown.
- Lower field sand %.
- Use cleaner screenings, more passing No. 200 may close up the mix.

TROUBLESHOOTING

Why is Design VMA higher than Production (Plant-Produced) VMA?

- Specifications have different requirements for design and plant-produced VMA.
- The plant-produced VMA is 0.5% lower than the design VMA requirements.
- Gradation during production may break down producing a finer mix with lower density.
- It may be difficult to meet the higher VMA during plant production.
- Design above the minimum requirement +0.5%.

TROUBLESHOOTING

What to do when Hamburg test results fail?

- Is the failing result from stripping or rutting or both?
  - *If it's from stripping.*
    - Water bath is not clear, cloudy looking from fines stripping from the mix.
    - Add anti-stripping or add more of it using a higher %.
    - Adding more liquid antistrip generally makes the asphalt binder softer and may be more prone to rutting.

TROUBLESHOOTING

What to do when Hamburg test results fail?

- Is the failing result from stripping or rutting or both?
  - *If it's from rutting.*
    - Make the gradation coarser which will give more stone-on-stone contact, but depending on aggregate source, softer aggregates may crush.
    - Increase fines, passing No. 200 sieve.
    - Higher PG binder will increase stiffness, may not be practical or cost effective.

TROUBLESHOOTING

What to do when Hamburg test results fail?

- If it's both from stripping and rutting.
  - *Recommend using lime.*
  - *If lime is not an option, add liquid anti-strip or more of it and adjust gradation.*

BEST PRACTICES AND TYING IT ALL TOGETHER

TROUBLESHOOTING

Hamburg passes but overlay test fails?

- May need to change asphalt binder source.
- May need to add more asphalt, overlay test is sensitive to asphalt content.
- Try to avoid absorptive aggregates and sources with high soundness values.
- When blending use aggregate sources with close soundness values between SAC A and B sources.

BEST PRACTICES AND TYING IT ALL TOGETHER

TROUBLESHOOTING

- When designing mixes with higher asphalt contents, make sure to break down the Rice gravity samples for consistent and accurate results.
- Sample and test aggregate stockpiles to confirm washed gradations.
- Confirm aggregate properties.
    - *Decant, need clean aggregate to stick to asphalt.*
    - *Specific gravity and micro-deval will detect change in mineralogy*
    - *Flat and elongated, as some sources may be prone to break down during production such as sandstone.*


Quality design, testing, and
inspection will give us durable and
long-lasting asphalt pavements.

Test Procedure for

DESIGN OF BITUMINOUS MIXTURES

TxDOT Designation: Tex-204-F

Effective Date: August 2016

1. SCOPE

1.1 Use the methods in this procedure to determine the proper proportions of approved aggregates, mineral filler, asphalt binder, additives, and recycled materials that, when combined, will produce a mixture that satisfies the specification requirements.

1.1.1 Refer to Part I for the mixture design method of Dense-Graded mixtures. See the example in Part I for a typical mixture design by weight. See Part II for a typical dense-graded design example by volume.

1.1.2 Refer to Part IV for the mixture design method of Superpave mixtures.

1.1.3 Refer to Part V for the mixture design method of Permeable Friction Course (PFC) mixtures.

1.1.4 Refer to Part VI for the mixture design method of Stone Matrix Asphalt (SMA) mixtures.

1.1.5 Refer to Part VIII for the mixture design method of Thin Bonded Wearing Course mixtures.

1.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

Table 1—Nomenclatures and Definitions

Nomenclatures		Definitions
Conventional	**Superpave**	
G_a	G_{mb}	Bulk specific gravity of the compacted mixture
G_t	$G_{max\text{-}theo}$	Calculated theoretical maximum specific gravity of the mixture at the specified asphalt content
A_s	P_b	% by weight of asphalt binder in the mixture
A_g	P_s	% by weight of the aggregate in the mixture
G_e	G_{se}	Effective specific gravity of the combined aggregates
G_s	G_b	Specific gravity of the asphalt binder determined at 77°F (25°C)
G_r	G_{mm}	Theoretical maximum specific gravity

Nomenclatures		Definitions
Conventional	**Superpave**	
G_{rc}	G_{mm}	Theoretical maximum specific gravity corrected for water absorption during test
SA	SA	Surface area in m^2/kg of combined aggregate gradation
F_T	F_T	Film thickness in microns of asphalt binder in mixture
% Density	% G_{mm}	Percentage of the ratio of the G_a to the G_t of the mixture
-	% Air Voids	% of air voids in the compacted mix
VMA	VMA	Voids in mineral aggregates
% Total CL_A	-	Total percentage retained of Class A aggregate on the 4.75 mm (#4) sieve
% CL_A	-	% retained of Class A aggregate on the 4.75 mm (#4) sieve
% CL_B	-	% retained of Class B aggregate on the 4.75 mm (#4) sieve
VCA_{CA}	-	Voids in coarse aggregate (coarse aggregate fraction only)
G_{CA}	-	Bulk specific gravity of the coarse aggregate blend (retained on the 2.36 mm (#8) sieve)
γ_s	-	Unit weight of the coarse aggregate blend fraction in the dry-rodded condition
γ_w	-	Unit weight of water 1000 kg/m^3 (62.4 pcf)
P_{CA}	-	% coarse aggregate in the total mix
VCA_{CA}	-	Voids in the coarse aggregate in the dry-rodded condition
VCA_{Mix}	-	Voids in coarse aggregate for the compacted mixture

1.3 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. REPORT FORMAT

2.1 HMACP Mixture Design: Combined Gradation (2014) is an automated template containing the following worksheets:

- Instructions
- Combined Gradation
- Material Properties (Matl Properties)
- Aggregate Classification
- Weigh Up Sheet (Weigh Up)
- Weigh Up Sheet for Blank Samples (Blank Weigh Up)
- Bulk Gravity

- Film Thickness
- Summary Sheet (Summary)
- Grad Chart.

Note 1—The title in parentheses is the abbreviated title given on the tabs of the workbook.

2.2 Use the Sieve Analysis of Non-Surface Treatment Aggregates template to calculate the washed sieve analysis.

3. APPARATUS

Note 2—Each part of this test method incorporates the use of other test procedures. Each referenced procedure has its own list of apparatus in addition to those listed here.

3.1 *Drying oven*, capable of attaining the temperatures specified in the procedure.

3.2 *Balance*, Class G2 in accordance with Tex-901-K.

PART I—MIX DESIGN FOR DENSE-GRADED HOT-MIX ASPHALT MIXTURES BY WEIGHT

4. SCOPE

4.1 Use this method to determine the proper proportions by weight of approved materials to produce a dense-graded mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the Texas gyratory compactor (TGC) and the Superpave gyratory compactor (SGC).

4.2 Use this method to determine the proper proportions by weight of approved materials to produce Thin Overlay Mixtures (TOM) that will satisfy the specification requirements. This mix design procedure incorporates the use of the TGC and the SGC.

5. PROCEDURE

5.1 *Selecting Aggregates:*

5.1.1 Select the aggregate per specification requirements.

Note 3—Use the Hot Mix Asphalt Concrete (HMAC) Rated Source Soundness Magnesium (RSSM) listed in the Bituminous Rated Source Quality Catalog (BRSQC) for approved stockpile sources from the Aggregate Quality Monitoring Program (AQMP) to determine compliance with soundness specifications.

Note 4—Enter any available aggregate testing results in the Material Properties worksheet and ensure all aggregate quality requirements are met.

5.1.2 Obtain representative samples consisting of a minimum of 50 lb. of each aggregate in accordance with Tex-221-F.

5.1.3 Dry the aggregate to constant weight at a temperature between 100 and 375°F (38 and 191°C).

5.1.4 When the aggregate stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet.

Note 5—Use the construction stockpile washed gradation when it is available.

5.1.5 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 6—If the specific gravity values are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

Note 7—Proceed to Part II of this test procedure if the aggregate stockpile bulk specific gravities vary by 0.300 or more.

Note 8—Do not determine the specific gravity for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values were determined.

5.2 *Selecting Asphalt Binder, Mineral Filler, and Additives:*

5.2.1 Select the asphalt binder per specification requirements.

5.2.2 When applicable, select mineral filler and additives per specification requirements.

5.2.3 Obtain a representative sample of the asphalt binder, mineral filler, and additives. Take asphalt samples in accordance with Tex-500-C. Ensure that you collect enough material for Section 5.2.4.

5.2.4 Confirm the asphalt binder, mineral filler, and additives meet applicable specifications.

Note 9—When using warm mix asphalt (WMA) additives in the mixture design, verify that the additive appears on the Department's Material Producer List (MPL).

5.3 *Selecting Recycled Materials (when applicable):*

5.3.1 Select reclaimed asphalt pavement (RAP) and recycled asphalt shingles (RAS) per specification requirements.

Note 10—Use RAS from shingle sources listed on the Department's MPL.

5.3.2 Obtain representative samples of recycled materials consisting of a minimum of 50 lb. of each material in accordance with Tex-221-F.

5.3.3 Dry RAS per manufacturer's recommendations.

5.3.4 Dry RAP to constant weight at a maximum temperature of 140°F (60°C).

5.3.5 When the recycled material gradation is unknown, extract the asphalt from RAP and RAS samples in accordance with Tex-236-F. Obtain the washed gradation of the burned sample in accordance with Tex-200-F, Part II. Enter the gradations on the Combined Gradation worksheet.

Note 11—Use the recycled material stockpile gradation when it is available.

Note 12—Do not determine the specific gravity for recycled materials.

5.3.6 Determine the asphalt content of the RAP and RAS materials from the average of a minimum of 4 samples (recycled material only) in accordance with Tex-236-F.

5.4 *Selecting the Combined Gradation:*

5.4.1 Enter the anticipated optimum asphalt content (OAC) in the Combined Gradation worksheet based on the mixture type and proposed materials.

5.4.2 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed materials so that the blended combination will fall within the required gradation limits for the specified mixture type. Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors for the bin percentages. Follow these instructions when applicable.

- Enter mineral filler or hydrated lime as an aggregate bin. The combined gradation should include the mineral filler and hydrated lime.
  - When using binder substitution, do not use more than 1% hydrated lime unless otherwise shown on the plans or allowed by the Engineer.
  - Enter RAP and RAS gradation and asphalt content in the "Recycled Materials" bin section. Enter their bin percentages by total mixture. (The worksheet calculates the bin percentages by total aggregate.)
  - Do not exceed the maximum percentage of recycled materials allowable per the specification.

5.4.3 When applicable, the worksheet calculates the ratio of the recycled asphalt binder to total binder. Adjust the recycled material and aggregate bins when the ratio exceeds the specification.

Note 13—After making adjustments to the bin percentages, ensure that the total bin is 100.0%.

5.4.4 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

5.4.5 Evaluate the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification or general note requirement.

Note 14—Consider the coarse aggregate from RAP and RAS as Class B aggregate.

5.5 *Preparing Laboratory-Mixed Samples:*

5.5.1 Separate the material larger than the No. 8 sieve into individual sieve sizes for each stockpile as required by the specification.

Note 15—Do not separate RAP or RAS larger than the No. 8 sieve into individual sieve sizes if the gradations are uniformly graded.

5.5.2 Separate the material passing the No. 8 sieve from each stockpile only when high gradation accuracy is needed.

5.5.2.1 Do not separate the material passing the No. 8 sieve from each stockpile if it meets the following conditions.

- The RAP, RAS, and aggregate passing the No. 8 sieve stockpile gradations are uniformly graded.
- The gradation of the material passing the No. 8 sieve is not prone to segregation.

5.5.3 Calculate the weights of the individual aggregates required to produce batches of mix for a minimum of 5 different asphalt contents using the Weigh Up worksheet.

Note 16—When using recycled materials and changing the asphalt content in the Combined Gradation worksheet, adjust a virgin aggregate bin percentage to ensure that the total bin is 100.0%.

Note 17—Batches of mix for a minimum of 3 different asphalt contents may be produced when using materials from a previous mix design.

Note 18—For designs with the TGC, a batch size of 5000 g is adequate to produce 3 laboratory-molded specimens and 1 sample for the Theoretical Maximum Rice Specific Gravity (G_r) when using a large mechanical mixer. If hand mixing, the batch size must be the amount needed for 1 molded specimen or 1 G_r sample.

Note 19—For designs with the SGC, a batch size of 11,500 g is adequate to produce 2 laboratory-molded specimens and 1 sample for the Theoretical Maximum Rice Specific Gravity (G_r) when using a large mechanical mixer. If using a small mechanical mixer, the batch size must be the amount needed for 1 molded specimen or 1 G_r sample.

5.5.4 Vary the asphalt contents in 0.5% increments around the anticipated optimum asphalt content (OAC). Enter the asphalt percentages in the asphalt content column of the Summary worksheet.

5.5.5 Produce a trial sample mixture in the laboratory to verify the height of a compacted specimen. Select the asphalt content closest to the expected OAC using previous mix design experience. Add any recycled materials and additives, such as RAP, RAS, or lime, before mixing the final bituminous mixture. Pre-blend asphalt additives such as liquid anti-stripping or WMA additives into the asphalt binder before laboratory mixing, similar to additive addition at the mixing plant.

5.5.6 Prepare a laboratory mix in accordance with Tex-205-F.

5.5.7 When using the TGC, mold 3 specimens in accordance with Tex-206-F.

Note 20—Use 1000 g of material per molded specimen for this trial mixture.

5.5.7.1 Determine the amount of material necessary to obtain a standard specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) Use the height adjustment formula in Tex-206-F, Part I, to determine the amount of material needed at this asphalt content.

5.5.8 When using the SGC, mold 2 specimens at the design number of gyrations (N_{design}) in accordance with Tex-241-F. Determine the N_{design} as shown on the plans or specification.

Note 21—Use 4500–4700 g of material per molded specimen for this trial mixture. Do not scalp out material larger than the 19.0-mm (3/4-in.) sieve size.

5.5.8.1 Determine the amount of material necessary to obtain a standard specimen height of 115 ± 5 mm (4.5 ± 0.2 in.)

5.5.9 Approximate the total weights for the compacted specimens containing other percentages of asphalt. Use the corrected weight of the trial specimen as a base value.

Note 22—When using the TGC, increasing the asphalt content by 0.5% increases the weight of the mix for molding the specimen by approximately 2.5 g. Decreasing the asphalt content by 0.5% decreases the weight of the mix for molding the specimen by approximately 2.5 g.

Note 23—When using the SGC, increasing the asphalt content by 0.5% increases the weight of the mix for molding the specimen by approximately 10 g. Decreasing the asphalt content by 0.5% decreases the weight of the mix for molding the specimen by 10 g.

5.5.10 Determine the G_r in accordance with Tex-227-F for the mixture produced at each asphalt content. Of these 3 mixtures, 2 should have asphalt contents above the optimum, and 1 mixture should have asphalt content below the optimum. Treat the mix used to perform this test the same as the mix used for molding. For mixtures designed on the TGC, remove the aggregate retained on the 19.0-mm (3/4-in.) sieve from the G_r sample before molding. Oven-cure the mixtures at the selected compaction temperature for 2 hr. Enter the G_r in the Summary worksheet.

5.5.11 Determine the G_a of the molded specimens in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

5.5.12 Use the Mix Design template to calculate the following:

- the average G_e of the blend, in accordance with Section 19.2,
- the G_t for each asphalt content in accordance with Section 19.3, and
- the percent density of the molded specimens for each asphalt content, in accordance with Section 19.4.

5.6 *Determining the OAC:*

5.6.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.

- Asphalt content versus VMA, G_a, and G_r—determine the VMA, G_a, and G_r at the OAC.

5.6.2 If the density or VMA is not within the allowable range, redesign by assuming another combination of aggregates or obtaining different materials.

5.7 *Evaluating the Mixture at the OAC:*

5.7.1 When required by the specification, determine the indirect tensile strength in accordance with Tex-226-F.

5.7.2 Determine the rut depth and number of passes in accordance with Tex-242-F.

5.7.3 When required by the specification or requested by the Engineer, determine the number of cycles to failure in accordance with Tex-248-F and percent loss in accordance with Tex-245-F.

5.7.4 If the indirect tensile strength from Section 5.7.1 or the number of passes from Section 5.7.2 is not within specifications, redesign by adding an anti-stripping agent, adjusting the N_{design}, assuming another combination of aggregates, obtaining different materials, or using a different PG grade.

Note 24—The Engineer must approve any changes made to the N_{design} that results in a value different from what is shown on the plans or is allowed in the specification.

5.7.5 Report all data in the Mix Design Template.

6. MIX DESIGN EXAMPLE BY WEIGHT

6.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement where material weight is the primary consideration.

6.2 Use the following processed materials to design a dense-graded hot-mix asphalt mix by weight:

- aggregate A—a limestone dolomite Type D rock with a surface aggregate classification of class A;
- aggregate B—a limestone dolomite Type F rock with a surface aggregate classification of class B;
- limestone dolomite manufactured sand;
- hydrated lime;
- fractionated RAP;
- recycled asphalt shingles (RAS);
- warm mix additive treated as WMA;
- specified binder: PG 70-22; and
- substitute binder: PG 64-22.

6.2.1 Combine the six bins and asphalt in proportions that meet the requirements for a Type D hot-mix asphalt mixture under the applicable specification.

6.3 *Selecting Materials:*

6.3.1 Verify that all the materials comply with the project specifications.

6.3.2 Obtain the average washed sieve analysis of each of the proposed materials as shown in Figure 1 using the Sieve Analysis of Non-Surface Treatment Aggregates template. The example shown in Figure 1 shows the gradation of the crushed limestone dolomite aggregate used in this sample mix design.

6.3.3 Consider all factors relating to the production of the available materials and desired mixture properties. Assume that the best combination of the aggregates for this mix design example will consist of 23% by weight of aggregate A, 35.4% by weight of aggregate B, 34% by weight of manufactured sand, 1% by weight of hydrated lime, 5.5% by total weight of mix of fractionated RAP, and 1.2% by weight of total mix of RAS.

6.3.4 Use the Combined Gradation worksheet to calculate the combined blend gradation in percent passing of each sieve size. Figure 2 shows an example of a completed worksheet. Use the bin percentages selected in Section 6.3.3. This worksheet also shows the individual and cumulative percent retained of the combined blend.

6.3.5 Use the Aggregate Classification worksheet to check the proposed bin percentages for compliance when blending Class A and B aggregates. At least 50% by weight of material retained on the 4.75 mm (No. 4) sieve from the Class A aggregate source is required, as shown in Figure 4.

6.4 *Preparing Laboratory-Mixed Samples:*

6.4.1 Calculate individual or cumulative aggregate weights with an asphalt weight. Figure 5 is an example weigh-up worksheet that shows the aggregate and asphalt weights for a 5000-g sample at 6% asphalt. A mixture size of 5000 g is adequate to produce 3 molds and 1 sample for G_r, when using a large mechanical mixer. If hand mixing, the mixture size must be the amount needed for one molded specimen or one G_r.

6.4.2 The asphalt contents for these test mixes are 4.0, 5.0, 6.0, 7.0, and 8.0% by weight for this mix design example. Therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 96.0, 95.0, 94.0, 93.0, and 92.0%. For this example, the total aggregate weight for a 5000-g batch at 6.0% asphalt will be 4700 g, and the weight of the asphalt will be 300 g.

6.4.3 Mix one batch using weights calculated in Section 6.4.1 in accordance with Tex-205-F. Use previous mix design experience or select the mixture at the midpoint of the design asphalt contents, which is 6.0% for this example.

Note 25—Select the batch expected to be closest to the OAC.

6.4.4 Determine the weight of mixture required to produce a specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) by molding 3 samples of 1000 g each in accordance with Tex-206-F. Measure the height of the specimen. Divide 51 mm (2 in.) by the molded height and

multiply by 1000 g to give the corrected weight to produce one 51-mm (2-in.) specimen. Refer to the height adjustment formula in Tex-206-F.

6.4.5 Subtract 5 g from the weight at each asphalt content above the trial specimen. Add 5 g to the weight at each asphalt content below the trial specimen. For this example, a 1000-g sample with 6.0% asphalt produced a molded specimen with a height of 53.8 mm (2.12 in.) Therefore, the amount of mixture required to produce a 51-mm (2-in.) molded specimen would be (51 mm/53.8 mm) × 1000 g or (2 in./2.11 in.) × 1000 g = 948 g. The mix weights for molding specimens with the different asphalt contents for this example are:

- asphalt content 4% = 938 g
- asphalt content 5% = 943 g
- asphalt content 6% = 948 g
- asphalt content 7% = 953 g
- asphalt content 8% = 958 g.

6.4.6 Weigh the materials for each of the batches containing 4.0, 5.0, 6.0, 7.0, and 8.0% asphalt content. Mix and mold the test specimens in accordance with Tex-205-F and Tex-206-F.

6.4.7 Determine the G_r of the mixtures at 5.0, 6.0, and 7.0% asphalt content in accordance with Tex-227-F. Treat the mix used to perform this test the same as the samples for molding. Remove aggregates retained on the 19.0-mm (3/4-in.) sieve from the G_r sample. Cure the G_r sample at the compaction temperature specified for the PG binder (PG 70-22 for this example) for 2 hr. in a manner similar to curing the hot-mix asphalt before molding. Enter G_r values in the worksheet as shown in Figure 6.

6.4.8 Determine the G_a of each of the molded specimens in accordance with Tex-207-F. Calculate the average of the 3 molds and enter the result in the Summary worksheet.

6.4.9 Use the Mix Design template to calculate the following, as shown in Figure 6:

- G_e for the blend at each of the 3 asphalt contents tested for G_r,
- the G_t,
- the percent density of the molded specimens, and
- the VMA of the molded specimens.

6.5 *Determining the OAC:*

6.5.1 Use Figure 6 to determine which asphalt content meets the target density. In this example, the OAC is 6.0%.

6.6 *Evaluating the Mixture at the OAC:*

6.6.1 Determine the indirect tensile strength of 4 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-226-F. Enter the average strength as shown in Figure 6.

6.6.2 Determine the rut depth and number of passes on 2 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-242-F. Enter the results as shown in Figure 6.

SIEVE ANALYSIS OF NON-SURFACE TREATMENT AGGREGATES
Tex-200-F

Refresh Workbook File Version: 10/15/15 13:26:06

SAMPLE ID:		SAMPLED DATE:	
TEST NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		GRADE:	D-Rock Limestone Dolom
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:	

SIEVE ANALYSIS
Tex-200-F: Part I

Original Dry Weight, (g):	2,000.0
Dry Weight After Washing, (g):	1,975.0

Sieve Size	Individual Weight Retained, (g)	Cumulative Weight Retained, (g)	Cumulative Percent Retained, (%)	Cumulative Percent Passing, (%)	Limits as Percent: Lower Limit of Grading (%)	Limits as Percent: Upper Limit of Grading (%)	Within Grading Limits
3/4"	0.0	0.0	0.0	100.0			
1/2"	20.0	20.0	1.0	99.0			
3/8"	572.0	592.0	29.6	70.4			
No. 4	1,345.0	1,937.0	96.9	3.1			
No. 8	30.0	1,967.0	98.4	1.6			
No. 16	3.0	1,970.0	98.5	1.5			
No. 30	0.0	1,970.0	98.5	1.5			
No. 50	0.0	1,970.0	98.5	1.5			
No. 200	0.0	1,970.0	98.5	1.5			

-No. 200	5.0		
	0.0	Sieving Loss, (g) from 'Dry Weight After Washing' weight	
	25.0	Washing Loss, (g)	
Total -No. 200	30.0	2,000.0	100.0
Total Weight:	2,000.0		

Figure 1—Sieve Analysis of Fine and Coarse Aggregates

HMACP MIXTURE DESIGN : COMBINED GRADATION

Refresh Workbook — File Version: 10/12/15 10:00:39

SAMPLE ID:		SAMPLE DATE:			
LOT NUMBER:		LETTING DATE:			
SAMPLE STATUS:		CONTROLLING CSJ:			
COUNTY:		SPEC YEAR:	2014		
SAMPLED BY:		SPEC ITEM:			
SAMPLE LOCATION:		SPECIAL PROVISION:			
MATERIAL CODE:		MIX TYPE:	344-SP-D	WMA Additive in Design?	Yes
MATERIAL NAME:				Target Discharge Temp., °F:	250
PRODUCER:				WMA TECHNOLOGY:	
AREA ENGINEER:		PROJECT MANAGER:		WMA RATE: / UNITS:	
COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:	CONTRACTOR DESIGN # :

Maximum Allowable, %	
Frac RAP:	20.0
Unfrac RAF	10.0
RAS:	5.0
RB Ratio:	30.0

Recycled Binder, %	
Bin No.8 :	0.3
Bin No.9 :	0.2
Bin No.10 :	0.0
Total	*0.500*

Use this value in the QC/QA template.)

Ratio of Recycled to Total Binder, %
(based on binder percent (%) entered below in this worksheet)
8.3

	AGGREGATE BIN FRACTIONS							"RECYCLED MATERIALS"			
Aggregate	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10	
Source:	nestone_Dolom	nestone_Dolom	nestone_Dolom					Fractionated RAP	RAS		Material Type
Pit:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		Material Source
Number:	TxDOT	TxDOT	TxDOT								RAS Type
Producer:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT		RAP/RAS Producer
Sample ID:	D-Rock	F-Rock	Manufactured Sand								Sample ID

															Recycled Asphalt Binder (%)						Combined Gradation									
Hydrated Lime?:							Yes								5.5	% of Tot. Mix	1.2	% of Tot. Mix		% of Tot. Mix	Total Bin	Lower & Upper Specification Limits			Restricted Zone			Individual % Retained	Cumulative % Retained	Sieve Size
Individual Bin (%):	23.0	Percent	35.4	Percent	34.0	Percent	1.0	Percent		Percent		Percent		Percent	5.6	% of Aggreg	1.0	% of Aggreg		% of Aggreg	100.0%									
Sieve Size:	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum.% Passing	Wtd Cum. %	Cum. % Passing	Lower	Upper	Within Spec's	Lower	Upper	Within Spec's			
3/4"	100.0	23.0	100.0	35.4	100.0	34.0	100.0	1.0							100.0	5.6	100.0	1.0			100.0	100.0	100.0	Yes				0.0	0.0	3/4"
1/2"	99.0	22.8	100.0	35.4	100.0	34.0	100.0	1.0							100.0	5.6	100.0	1.0			99.8	98.0	100.0	Yes				0.2	0.2	1/2"
3/8"	70.4	16.2	99.9	35.4	100.0	34.0	100.0	1.0							100.0	5.6	100.0	1.0			93.2	90.0	100.0	Yes				6.6	6.8	3/8"
No. 4	3.1	0.7	75.2	26.6	99.6	33.9	100.0	1.0							98.6	5.5	100.0	1.0			68.7	32.0	90.0	Yes				24.4	31.3	No. 4
No. 8	1.6	0.4	15.3	5.4	86.6	29.4	100.0	1.0							85.5	4.8	100.0	1.0			42.0	32.0	67.0	Yes	47.2	47.2	Yes	26.7	58.0	No. 8
No. 16	1.5	0.3	5.2	1.8	55.8	19.0	100.0	1.0							70.2	3.9	99.8	1.0			27.1	2.0	67.0	Yes	31.6	37.6	Yes	14.9	72.9	No. 16
No. 30	1.5	0.3	2.8	1.0	35.7	12.1	100.0	1.0							51.2	2.9	99.2	1.0			18.3	2.0	67.0	Yes	23.5	27.5	Yes	8.8	81.7	No. 30
No. 50	1.5	0.3	2.3	0.8	20.8	7.1	100.0	1.0							14.5	0.8	97.6	1.0			11.0	2.0	67.0	Yes	18.7	18.7	Yes	7.3	89.0	No. 50
No. 200	1.5	0.3	1.9	0.7	7.3	2.5	100.0	1.0							1.0	0.1	62.8	0.6			5.2	2.0	10.0	Yes				5.8	94.8	No. 200

(Bold Italic) Not within specifications *(Bold Italic)* Not within specificaitons- Restricted Zone *(Italic)* Not cumulative

Lift Thickness, in:		Binder Substitution?	Yes	Binder Originally Specified:	PG 70-22	Substitute Binder:	PG 64-22
Asphalt Source:		Binder Percent, (%):	6.0	Asphalt Spec. Grav.:	1.029		
Antistripping Agent:		Percent, (%):					

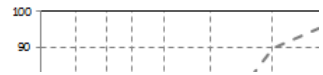


Figure 2—Combined Gradation

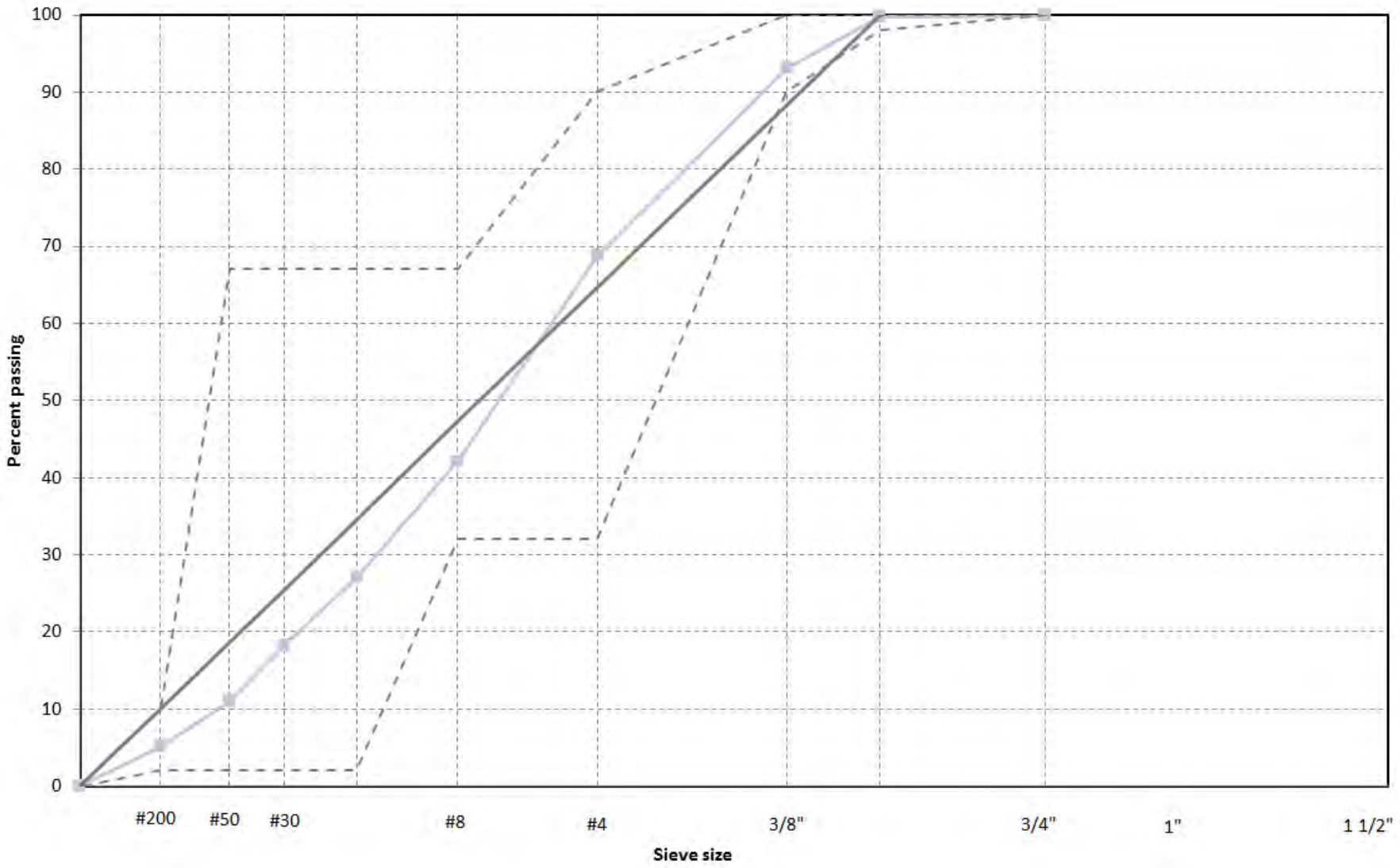


Figure 3—Power 0.45 Curve

HMACP MIXTURE DESIGN : Aggregate Classification

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :

Aggregate Classification

		Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10
Individual Bin (%):		Bin No.1 = 23 %	Bin No.2 = 35.4 %	Bin No.3 = 34 %	Bin No.4 = 1 %				Bin No.8 = 5.6 %	Bin No.9 = 1 %	
Aggregate Source:		Limestone_Dolomite	Limestone_Dolomite	Limestone_Dolomite					Fractionated RAP	RAS	
Aggregate Number:		TxDOT	TxDOT	TxDOT							
Class (A) Rock (Y/N):		Yes									
Sieve Size:		Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %	Individual Ret., %
Passing	Retained										
-	3/4"	0.0	0.0	0.0	0.0				0.0	0.0	
3/4"	1/2"	0.2	0.0	0.0	0.0				0.0	0.0	
1/2"	3/8"	6.6	0.0	0.0	0.0				0.0	0.0	
3/8"	No. 4	15.5	8.7	0.1	0.0				0.1	0.0	
No. 4	No. 8	0.3	21.2	4.4	0.0				0.7	0.0	
No. 8	No. 16	0.0	3.6	10.5	0.0				0.9	0.0	
No. 16	No. 30	0.0	0.8	6.8	0.0				1.1	0.0	
No. 30	No. 50	0.0	0.2	5.1	0.0				2.1	0.0	
No. 50	No. 200	0.0	0.1	4.6	0.0				0.8	0.3	
No. 200	Pan	0.3	0.7	2.5	1.0				0.1	0.6	
Total:		23.0	35.4	34.0	1.0				5.6	1.0	
Percent of plus No. 4		22.3	8.8	0.1	0.0				0.1	0.0	
Percent of plus No. 8		22.6	30.0	4.6	0.0				0.8	0.0	

Percent of plus No. 4 from class (A) Rock:	22.3
Total Percent of plus No. 4	31.3
Percent of plus No. 4 from class (A) Rock:	**71.2**

Percent of plus No. 8 from class (A) Rock:	22.6
Total Percent of plus No. 8	58.0
Percent of plus No. 8 from class (A) Rock:	39.0

Figure 4—Aggregate Classification

Aggregate Weight, g:	4,700.0
6% Asphalt by Total Weight, g:	300.0
Total Weight, g:	5000.0

6% Asphalt by Total Weight, g:	300.0
Less Asphalt by Weight of Recycled Material, g:	25.6
() Asphalt to Add, g:	**274.4**

			Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7	Bin No.8	Bin No.9	Bin No.10			
		Individual Bin (%):	Bin No.1 = 23 %	Bin No.2 = 35.4 %	Bin No.3 = 34 %	Bin No.4 = 1 %				Bin No.8 = 5.5 %	Bin No.9 = 1.2 %				
		Aggregate Source:	Limestone_Dolomite	Limestone_Dolomite	Limestone_Dolomite					Fractionated RAP	RAS				
		Aggregate Number:	TxDOT	TxDOT	TxDOT					TxDOT	TxDOT				
		Sample ID:	D-Rock	F-Rock	Manufactured Sand								Total Weights	Individual Retained, %	Cumulative Retained, %
	Sieve Size:		Aggregate Weight	Aggregate Weight	Aggregate Weight	Hydrated Lime Weight				Fractionated RAP Weight	RAS Weight				
	Passing	Retained													
INDIVIDUAL	-	3/4"	0.0	0.0	0.0	0.0				0.0	0.0		0.0	0.0	0.0
	3/4"	1/2"	10.8	0.0	0.0	0.0				0.0	0.0		10.8	0.2	0.2
	1/2"	3/8"	309.2	1.7	0.0	0.0				0.0	0.0		310.8	6.6	6.8
	3/8"	No. 4	727.5	411.0	6.4	0.0				3.9	0.0		1,148.7	24.3	31.1
	No. 4	No. 8	16.2	996.6	207.7	0.0				36.3	0.0		1,256.9	26.6	57.7
	No. 8	No. 16	1.1	168.0	492.2	0.0				42.4	0.1		703.8	14.9	72.6
	No. 16	No. 30	0.0	39.9	321.2	0.0				52.6	0.4		414.1	8.8	81.4
	No. 30	No. 50	0.0	8.3	238.1	0.0				101.7	0.9		349.0	7.4	88.8
	No. 50	No. 200	0.0	6.7	215.7	0.0				37.4	20.4		280.2	5.9	94.7
	No. 200	Pan	16.2	31.6	116.7	47.0				2.8	36.9		251.1	5.3	100.0
	Totals		1,081.0	1,663.8	1,598.0	47.0				277.1	58.8		**4,725.6**	Total includes asphalt from the recycled material	
Running Total:															
CUMULATIVE	-	3/4"	0.0	1,081.0	2,744.8	4,342.8				4,389.8	4,666.9		0.0		
	3/4"	1/2"	10.8	1,081.0	2,744.8	4,342.8				4,389.8	4,666.9		10.8		
	1/2"	3/8"	320.0	1,082.7	2,744.8	4,342.8				4,389.8	4,666.9		321.6		
	3/8"	No. 4	1,047.5	1,493.6	2,751.2	4,342.8				4,393.7	4,666.9		1,470.4		
	No. 4	No. 8	1,063.7	2,490.2	2,958.9	4,342.8				4,430.0	4,666.9		2,727.2		
	No. 8	No. 16	1,064.8	2,658.3	3,451.1	4,342.8				4,472.4	4,667.0		3,431.1		
	No. 16	No. 30	1,064.8	2,698.2	3,772.3	4,342.8				4,525.0	4,667.3		3,845.2		
	No. 30	No. 50	1,064.8	2,706.5	4,010.4	4,342.8				4,626.7	4,668.3		4,194.2		
	No. 50	No. 200	1,064.8	2,713.2	4,226.1	4,342.8				4,664.1	4,688.7		4,474.5	Total includes asphalt from the recycled material	
	No. 200	Pan	1,081.0	2,744.8	4,342.8	4,389.8				4,666.9	4,725.6		4,725.6		

Figure 5—Weigh Up Sheet

HMACP MIXTURE DESIGN : SUMMARY SHEET

SAMPLE ID:		SAMPLE DATE:	
LOT NUMBER:		LETTING DATE:	
SAMPLE STATUS:		CONTROLLING CSJ:	
COUNTY:		SPEC YEAR:	2014
SAMPLED BY:		SPEC ITEM:	
SAMPLE LOCATION:		SPECIAL PROVISION:	
MATERIAL CODE:		MIX TYPE:	344-SP-D
MATERIAL NAME:			
PRODUCER:			
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:	Surface	STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :	

Target Density, %:	**96.0**
Number of Gyrations:	**50**

CRM Content, %

Note: This mix design requires an asphalt content of at least 1.7%

to meet the Maximum Ratio of Recycled to Total Binder requirement.

	TEST SPECIMENS								Mixture Evaluation @ Optimum Asphalt Content			
										Hamburg Wheel Tracking Test		
	Asphalt Content (%)	Binder Ratio (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)	Indirect Tensile Strength (psi)	Number of cycles	Rut depth (mm)	Overlay Tester Min. Number of Cycles
1	4.0	12.5	2.241			2.454	91.3	17.4				
2	5.0	10.0	2.262	2.415	2.599	2.419	93.5	17.5				
3	6.0	8.3	2.292	2.380	2.598	2.385	96.1	17.3	126.4	20,000	8.2	
4	7.0	7.1	2.312	2.360	2.615	2.352	98.3	17.4				
5	8.0	6.3	2.307			2.320	99.4	18.5				

Effective Specific Gravity:	2.604
Optimum Asphalt Content :	**6.0**
Binder Ratio @ OAC:	8.3
VMA @ Optimum AC:	17.3
VFA @ Optimum AC:	**76.8**
Interpolated Values	
Specific Gravity (Ga):	*2.291*
Max. Specific Gravity (Gr):	*2.381*
Theo. Max. Specific Gravity (Gt):	*2.386*
Dust/Asphalt Ratio:	**0.9**

Estimated Percent of Stripping, %:

<Not meeting VFA requirement

STONE-ON-STONE CONTACT

VCA(CA, calc.)	
VCA(MIX, calc.)	

Mixing Temp,°F:	
Molding Temp,°F:	

Figure 6—Summary Sheet

PART II—MIX DESIGN FOR DENSE-GRADED HOT-MIX ASPHALT MIXTURES USING THE TEXAS GYRATORY COMPACTOR (TGC) BY VOLUME

7. SCOPE

7.1 Use this method to determine the proper proportion by volume of approved materials to produce a dense-graded mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the TGC for dense-graded mixtures, such as Type A, B, C, D, and F.

7.2 Determine the proper proportions volumetrically when the aggregate stockpile bulk specific gravities vary by 0.300 or more. Volumetric proportioning is always the most correct method; however, when aggregate specific gravities are similar, consider the error introduced by designing by weight as inconsequential.

8. MIX DESIGN EXAMPLE BY VOLUME

8.1 The following example describes the process necessary to develop proper mixtures using approved materials for a given application or surface requirement where material volume is the primary consideration.

8.2 Use the following processed materials to design a dense-graded hot-mix asphalt mix by volume:

- aggregate A—a lightweight aggregate with 12.5 mm (1/2 in.) maximum size and surface aggregate classification of class A;
- aggregate B—a crushed limestone with 9.5 mm (3/8 in.) maximum size and surface aggregate classification of class B;
- limestone screenings;
- field sand; and
- PG 64-22.

8.2.1 Combine the 4 aggregates and asphalt in proportions that meet the requirements for a dense-graded Type D hot-mix asphalt mixture under the applicable specification.

8.3 *Selecting Materials:*

8.3.1 Verify that all the materials comply with the project specifications.

8.3.2 Obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II, using the Sieve Analysis of Fine and Coarse Aggregates template. Figure 1 shows the hypothetical sample gradations of the proposed aggregates.

8.3.3 Consider all factors relating to the production of the available materials and desired mixture properties. Assume that the best combination of the aggregates for this mix

design example will consist of 39% by volume of aggregate A, 23% by volume of aggregate B, 26% by volume of stone screening, and 12% by volume of field sand.

8.3.4 Determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity for the individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F. Test the proposed lightweight aggregate in accordance with Tex-433-A.

8.3.4.1 Normally, specific gravities are not determined for RAP aggregate size fractions consisting of less than 15% of the individual aggregate.

8.3.5 Calculate the average water absorption, average stockpile bulk gravities, and the bulk specific gravity of the combined gradation. Design the mix by volume, since the stockpile specific gravities vary by as much as 1.119, which exceeds 0.300.

8.3.5.1 Assume the differences in the specific gravities of the size fractions within a given stockpile will not have a significant effect on the proportioning of actual materials. This allows the use of the average bulk specific gravity for each stockpile in later calculations.

8.3.6 Calculate the combined volumetric job-mix formula using the assumption that the specific gravities of the size fractions within a given stockpile will not have a significant effect on the proportioning. Table 4 shows the volumetric combined gradation, which results from combining 39% by volume lightweight aggregate A, 23% by volume aggregate B, 26% by volume screenings, and 12% by volume sand. The resulting combined gradation meets the specification master gradation limits, which are identical for volumetric and weight proportioning.

8.3.7 Check the proposed aggregate proportioning for compliance with blending requirements. Check aggregate classification in accordance with Section 5.4.4.

8.3.8 Plot the proposed combined volumetric gradation and specification master limits on a 0.45 power curve.

8.4 *Preparing Laboratory-Mixed Samples:*

8.4.1 Calculate individual aggregate and asphalt weights for the test mixtures. Since all of the calculations to this point have been volumetric, convert to weight percentages so that the necessary weights of individual materials can be determined. Refer to Table 2 for conversion of the stockpile percentages.

8.4.1.1 This is the second application of the assumption that the differences in specific gravities of individual size aggregates within a stockpile will not have a significant effect on the proportioning for the combined gradation.

8.4.1.2 Use the values in the last column of Table 2 to calculate the weight percentage of each aggregate size fraction. See the example shown in Table 5.

8.4.2 Calculate individual aggregate and asphalt weights for the test mixtures as shown in Table 6. The presence of lightweight aggregate in this example means a specimen with a height of 51 mm (2 in.) will weigh less than if all natural aggregate were used.

8.4.2.1 The asphalt contents for the test mixes chosen are 4.0, 5.0, 6.0, 7.0, and 8.0% by weight. Therefore, the corresponding percentages by weight of the aggregate in the mixtures will be 96.0, 95.0, 94.0, 93.0, and 92.0%.

8.4.3 Mix one of the batches calculated in Section 8.4.2 in accordance with Tex-205-F.

8.4.4 Determine the weight of mixture required to produce a specimen height of 51 ± 1.5 mm (2 ± 0.06 in.) by molding a 900-g sample in accordance with Tex-206-F. Measure the height of the specimen. Divide 51 mm (2 in.) by the molded height and multiply by 900 g to give the corrected weight to produce one 51-mm (2-in.) specimen. Refer to the height adjustment formula in Tex-206-F.

8.4.5 Subtract 5 g from the weight of the mix at each asphalt content above that of the trial specimen. Add 5 g to the weight of the mix at each asphalt content below that of the trial specimen. For this example, a 900-g sample with 4.0% asphalt produced a molded specimen with a height of 55.9 mm (2.20 in.). Therefore, the amount of mixture required to produce a 51-mm (2-in.) molded specimen would be (51.0 mm/ 55.9 mm) × [900 g or (2.00 in./2.19 in.) × 900 g] = 821 g. The mix weights for molding specimens with the different asphalt contents for this example are:

- asphalt content 4% ≥ 821 g
- asphalt content 5% ≥ 826 g
- asphalt content 6% ≥ 831 g
- asphalt content 7% ≥ 836 g
- asphalt content 8% ≥ 841 g.

8.4.6 Weigh up the materials for each of the batches containing 4.0, 5.0, 6.0, 7.0, and 8.0% asphalt content. Mix and mold the test specimens in accordance with Tex-205-F and Tex-206-F.

8.4.7 Determine the G_r of the mixtures at 5.0, 6.0, and 7.0% asphalt content in accordance with Tex-227-F. Two of the 3 mixtures should have asphalt contents above the optimum, and one mixture should have asphalt content below the optimum.

8.4.7.1 Perform the dry-back procedure to determine if water absorption has introduced error in the initial G_r result when testing mixtures containing lightweight aggregate.

8.4.7.2 Treat the mix used to perform this test the same as the samples for molding. Remove aggregates retained on the 19.0-mm (3/4-in.) sieve from the G_r sample. Cure the G_r sample for 2 hr. at the compaction temperature for the PG binder used (PG 64-22 for this example) similar to curing the mix before molding.

8.4.8 Determine the G_a of each of the molded specimens in accordance with Tex-207-F.

8.4.9 Calculate the average G_e of the blend in accordance with Section 19.2.

8.4.10 Calculate the G_t in accordance with Section 19.3.

8.4.11 Calculate the percent density of the molded specimens in accordance with Section 19.4.

8.4.12 Calculate the VMA of the specimens to the nearest 0.1% in accordance with Section 19.5.

8.5 *Determining the OAC:*

8.5.1 Plot densities on the vertical axis, versus asphalt content on the horizontal axis for each set of molded specimens. Draw a line at the target laboratory-molded density to where it intersects with the density curve. Draw a vertical line down from this point to where it intersects the horizontal axis to determine the OAC. Alternatively, calculate the OAC by interpolating between the asphalt contents above and below the target density.

8.5.2 Plot asphalt content versus VMA, G_a, and G_r. Report and verify all properties of the combined blend at the determined OAC.

8.6 *Evaluating the Mixture at the OAC*:

8.6.1 Determine the indirect tensile strength of 4 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-226-F.

8.6.2 Determine the rut depth and number of passes of 2 specimens molded at the OAC to 93 ± 1% density in accordance with Tex-242-F.

Table 2—Stockpile Conversion Percentages (Volume to Weight)

Stockpile	Proportions % by Volume		Bulk Specific Gravity		Weight, g	Proportions % by Weight
Lightweight	39.0	×	1.502	=	58.578	27.4
Aggregate B	23.0	×	2.539	=	58.397	27.3
Screenings	26.0	×	2.524	=	65.624	30.6
Sand	12.0	×	2.621	=	31.452	14.7
TOTAL	**100.0**		—		**214.051**	**100.0**

Table 3—Sieve Analysis Worksheet (No. 2)

Project:					**Highway:**				
County:					**Item No.:**				
	Sieve Size								
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**	**Pass #200**	**TOTAL**
Lightweight									
Weight (g)	0	21.2	622.7	71.9	3.3	0.7	0.8	2.3	**722.9**
Ind. % Ret.	0	2.9	86.2	9.9	0.5	0.1	0.1	0.3	**100.0**
Cum. % Ret.	0	2.9	89.1	99.0	99.5	99.6	99.7	---	---
Cum. % Pass.	100.0	97.1	10.9	1	0.5	0.4	0.3	---	---
Aggregate B									
Weight (g)	0	0	2.4	1145.9	37.0	12.4	8.1	11.9	**1217.7**
Ind. % Ret.	0	0	0.2	94.1	3.0	1.0	0.7	1.0	**100.0**
Cum. % Ret.	0	0	0.2	94.3	97.3	98.3	99.0	---	---
Cum. % Pass.	100.0	100.0	99.8	5.7	2.7	1.7	1.0	---	---
Screenings									
Weight (g)	0	0	0	194.2	471.1	367.0	144.1	65.6	**1242.0**
Ind. % Ret.	0	0	0	15.6	37.9	29.6	11.6	5.3	**100.0**
Cum. % Ret.	0	0	0	15.6	53.5	83.1	94.7	---	---
Cum. % Pass.	100.0	100.0	100.0	84.4	46.5	16.9	5.3	---	---
Sand									
Weight (g)	0	0	0	0	480.0	468.1	172.0	74.0	**1194.1**
Ind. % Ret.	0	0	0	0	40.2	39.2	14.4	6.2	**100.0**
Cum. % Ret.	0	0	0	0	40.2	79.4	93.8	---	---
Cum. % Pass.	100.0	100.0	100.0	100.0	59.8	20.6	6.2	---	---

Table 4—Job-Mix Formula Gradation Worksheet (Volumetric % Passing)

Project:				**Highway:**			
County:				**Item No.:**			
	Sieve Size						
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**
Lightweight							
100%	100.0	97.0	7.9	0.4	0.3	0.2	0.1
39%	39.0	37.8	3.1	0.2	0.1	0.1	0.0
Aggregate B							
100%	100.0	100.0	99.8	5.7	2.7	1.7	1.0
23%	23.0	23.0	23.0	1.3	0.6	0.4	0.2
Screenings							
100%	100.0	100.0	100.0	84.4	46.5	16.9	5.3
26%	26.0	26.0	26.0	21.9	12.1	4.4	1.4
Sand							
100%	100.0	100.0	100.0	100.0	59.8	20.6	6.2
12%	12.0	12.0	12.0	12.0	7.2	2.5	0.7
Combined Analysis	100.0	98.8	64.1	35.4	20.0	7.4	2.3
Specification	100	85-100	50-70	32-42	11-26	4-14	1-6[1]

1. Dry sieve analysis

Table 5—Job-Mix Formula Gradation Worksheet (Volumetric Converted to Weight)

Project:				**Highway:**			
County:				**Item No.:**			
	Sieve Size						
	1/2"	**3/8"**	**#4**	**#8**	**#30**	**#50**	**#200**
Lightweight							
100%	100.0	97.0	10.9	1.0	0.5	0.4	0.3
27.4%	27.4	26.6	3.0	0.3	0.1	0.1	0.1
Aggregate B							
100%	100.0	100.0	99.8	5.7	2.7	1.7	1.0
27.3%	27.3	27.3	27.2	1.6	0.7	0.5	0.3
Screenings							
100%	100.0	100.0	100.0	84.4	46.5	16.9	5.3
30.6%	30.6	30.6	30.6	25.8	14.1	5.2	1.6
Sand							
100%	100.0	100.0	100.0	100.0	59.8	20.6	6.2
12%	12.0	12.0	12.0	12.0	7.2	2.5	0.7
Combined Analysis	100.0	99.2	75.5	42.4	23.8	8.8	2.9
Specification[1]	100	85-100	50-70	32-42	11-26	4-14	1-6

1. Volumetric specification limits are not applicable to converted weight percentages.

Table 6—Weigh-Up for 4000g Batch at 4% Asphalt

Material ID	% of Aggregate	% of Mix	Cumulative %	1000 g Cumulative Wt.	4000 g Cumulative Batch Weigh-Up
Lightweight					
1/2" - 3/8"	0.8	0.8	0.8	8	32
3/8" - #4	23.6	22.7	23.5	235	940
#4 - #8	2.7	2.5	26.0	260	1040
Pass #8	0.3	0.3	26.3	263	1052
Aggregate B					
1/2" - 3/8"	0	0	---	---	---
3/8" - #4	0.1	0.1	26.4	264	1056
#4 - #8	25.6	24.6	51.0	510	2040
Pass #8	1.6	1.5	52.5	525	2100
Screenings					
Plus + #8	4.8	4.6	57.1	571	2284
Pass - #8	25.8	24.8	81.9	819	3276
Sand					
Pass - #8	14.7	14.1	96.0	960	3840
Asphalt					
%	---	4.0	(4.0)	(40)	(160)
TOTAL	**100.0**	**100.0**	**100.0**	**1000**	**4000**

PART III—MIX DESIGN FOR LARGE STONE DENSE-GRADED HOT-MIX ASPHALT MIXTURES USING THE SUPERPAVE GYRATORY COMPACTOR (SGC)

9. SCOPE

9.1 Part III has been removed from this test procedure. Refer to Part I, "Mix Design for Dense-Graded Hot-Mix Asphalt Mixtures by Weight."

PART IV—MIX DESIGN FOR SUPERPAVE MIXTURES

10. SCOPE

10.1 Use this method to determine the proper proportions by weight of approved materials to produce a Superpave mixture that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

11. PROCEDURE

11.1 *Selecting Materials:*

11.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

11.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

11.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C). Dry the RAP, when applicable, at a maximum of 140°F (60°C).

11.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available. Extract asphalt from RAP, when applicable, in accordance with Tex-210-F or Tex-236-F before performing a sieve analysis.

11.1.5 When applicable, estimate the binder content of the RAP from the average of 4 samples (RAP only) in accordance to Tex-236-F. Heat the RAP at 140°F (60°C), break apart until friable, and quarter to obtain a representative sample.

11.1.6 Check the aggregate gradations for compliance with the applicable specifications.

11.1.7 Check the asphalt and additives for compliance with the applicable specifications.

11.1.8 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 26—If the specific gravity values are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

11.1.8.1 Normally, specific gravities are not determined for RAP or aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values were determined.

11.1.9 Determine the unit weight in accordance with Tex-404-A and the bulk specific gravity of the combined gradation for the aggregate retained on the No. 8 sieve in accordance with Tex-201-F to verify stone-on-stone contact when shown on the plans.

11.1.10 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified hot-mix asphalt type. Use hydrated lime, when applicable, as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

11.1.11 When applicable, check specification compliance for the proposed blend of recovered asphalt from RAP and virgin asphalt cement or recycling agents before the laboratory-mixture preparation stage. Base the percentage of recovered asphalt in the blend on the percentage of RAP material proposed in the job-mix formula and the average extracted asphalt content of the RAP determined in Section 11.1.5.

11.1.12 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet.

11.1.13 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirements in accordance with Section 19.1.

11.2 *Preparing Laboratory Mixed Samples:*

11.2.1 Separate the material larger than the No. 8 sieve into individual sieve sizes for each stockpile as required by the specification.

11.2.1.1 Do not separate the material passing the No. 8 sieve from each stockpile if it meets the following conditions.

- The RAP and aggregate passing the No. 8 sieve stockpile gradations are uniformly graded.
- The gradation of the material passing the No. 8 sieve is not prone to segregation.

11.2.2 Combine the aggregates to create a trial blend that falls within the master gradation band required in the specification.

Note 27—Mix designs typically use 3–5 stockpiles to produce a combined gradation meeting gradation specifications.

11.2.3 Plot the combined gradation and specification limits on the Grad Chart worksheet.

11.2.4 Select and vary asphalt contents in 0.5% increments. Enter the asphalt percentages in the Summary worksheet.

Note 28—Select 3 or 5 asphalt contents to determine the OAC depending on experience and knowledge of materials used.

11.2.5 Calculate the weights of individual aggregates required to produce batches of mix at each chosen asphalt content from Section 11.2.4. Calculate weights for 2 laboratory-molded specimens and one G_r sample for each asphalt content. Generally, 4500–4700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) It may be necessary to produce a trial specimen to achieve this height requirement. 1900–2000 g of aggregate are required for a sample for the G_r.

11.2.6 Prepare the asphalt mixtures in accordance with Tex-205-F.

11.2.7 Mold 2 specimens for each asphalt content at the design number of gyrations, N_{design}, in accordance with Tex-241-F. Determine the N_{design} according to the specification or as shown on the plans.

11.2.8 Determine the G_a of the specimens at each asphalt content in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

11.2.9 Determine the G_r of the mixtures at each asphalt content in accordance with Tex-227-F. Enter the G_r for each asphalt content in the Summary worksheet.

11.2.10 Use the Mix Design template to calculate the following:

- the average G_e of the blend in accordance with Section 19.2,
- the G_t for each asphalt content in accordance with Section 19.3,
- the percent density of the molded specimens in accordance with Section 19.4, and
- the VMA of the specimens in accordance with Section 19.5.

11.3 *Determining the OAC:*

11.3.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.
- Asphalt content versus VMA—determine the VMA at the OAC.

11.3.2 If the VMA is not within the allowable specification range, redesign by assuming another combination of aggregates or by obtaining different materials.

11.4 *Evaluating the Stone-on-Stone Contact (when required by general note):*

11.4.1 Verify stone-on-stone contact when shown on the plans. Calculate the VCA_{CA} in accordance with Section 19.7.

11.4.2 Calculate the VCA_{Mix} in accordance with Section 19.8. Stone-on-stone contact is verified when the VCA_{Mix} is less than the VCA_{CA}.

11.4.3 Adjust the gradation if the stone-on-stone contact VCA_{Mix} is not less than the VCA_{CA}. Alternatively, use the Bailey Method to verify stone-on-stone contact.

11.5 *Evaluating the Mixture at the OAC:*

11.5.1 Calculate the weights of individual aggregates for laboratory molded specimens at the OAC determined in Section 11.3.1.

11.5.2 Determine the indirect tensile strength in accordance with Tex-226-F.

11.5.3 Determine the rut depth and number of passes in accordance with Tex-242-F.

11.5.4 When requested by the Engineer or shown on the plans, determine the number of cycles to failure in accordance with Tex-248-F and percent loss in accordance with Tex-245-F.

11.5.5 If the rut depth or indirect tensile strength is not within specification, redesign by adding an antistripping agent, adjusting the N_{design}, assuming another combination of aggregates, obtaining different materials, or using a different PG grade.

Note 29—The Engineer must approve any changes made to the N_{design} that results in a value different from that shown on the plans or allowed in the specification.

PART V—MIX DESIGN FOR PERMEABLE FRICTION COURSE (PFC) AND THIN BONDED PERMEABLE FRICTION COURSE (TBPFC) MIXTURES

12. SCOPE

12.1 Use this method to determine the proper proportions by weight of approved materials to produce PFC and PFC-R mixtures that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

13. PROCEDURE

13.1 *Selecting Materials:*

13.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

13.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

Note 30—Polymer-modified asphalt binder with a PG of 76-XX or higher is required or Asphalt Rubber (A-R), Type I or II. Use of fibers is required for mixes with PG 76-XX. Use loose fibers for mixtures prepared in the laboratory. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal.

13.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C).

13.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile

gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available.

13.1.5 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable specifications.

13.1.6 Check the asphalt and additives for compliance with the applicable specifications.

13.1.7 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 31—If the specific gravity values for the aggregate sources are unknown and deemed necessary, determine the 24-hr. water absorption, bulk specific gravity, and apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F.

13.1.7.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fraction for which values were determined.

13.1.8 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified mixture type.

Note 32—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

13.1.9 Add 1% hydrated lime as a mineral filler for mixes with PG 76-XX. Use hydrated lime as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime for mixes with PG 76-XX.

13.1.10 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirement in accordance with Section 19.1.

13.1.11 Plot the combined gradation and specification limits on the Grad Chart worksheet.

13.2 *Preparing Laboratory-Mixed Samples:*

13.2.1 Separate the material larger than the No. 8 sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the No. 8 sieve into individual sizes if it is prone to segregation.

13.2.2 Start the mixture design with the minimum allowable percentage of loose fibers for mixes with PG 76-XX. Increase this percentage when necessary to achieve the required mixture properties.

13.2.3 Select a minimum of 3 asphalt binder contents in increments of 0.5% for the laboratory-molded specimens. Start at an asphalt content of 6.0% or greater for PFC mixtures with

PG 76-XX. Start at an asphalt content of 8.0% or greater for PFC mixtures with A-R binder. Lower asphalt contents are allowed when using an aggregate with a bulk specific gravity greater than 2.750.

13.2.4 Select 3 asphalt binder contents in increments of 0.5% for the G_r samples. Start at an asphalt content of 2.0–3.0%. Ensure all samples are thoroughly coated with asphalt binder.

Note 33—Perform this Section to determine accurate G_r values at the higher asphalt contents selected in Section 13.2.3 for the laboratory-molded specimens. The G_r values for the mixtures with the higher asphalt contents are back-calculated using the equation in Section 19.2.

13.2.5 Calculate the weights of individual aggregates required to produce the specimens and samples specified in Sections 13.2.3 and 13.2.4. Generally, 3500–3700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.); however, this may vary. It may be necessary to produce a trial specimen to achieve this height requirement.

13.2.6 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures per Tex-241-F, Table 1.

13.2.7 Mold 2 specimens at each asphalt content selected in Section 13.2.3 in accordance with Tex-241-F. Mold specimens to 50 gyrations.

13.2.8 Determine the G_r at the asphalt contents selected in Section 13.2.4 in accordance with Tex-227-F. Enter the G_r in the Summary worksheet.

13.2.9 Determine the G_a of the specimens using dimensional analysis in accordance with Tex-207-F, Part VIII. Enter the G_a in the Summary worksheet.

13.2.10 Use the Mix Design template to calculate the following:

- the average G_e of the blend in accordance with Section 19.2 (Use the equation in Section 19.2 and the average G_e for the combined blend to back-calculate the G_r value for the mixtures with the higher asphalt contents used for the laboratory-molded specimens.);
- the G_t in accordance with Section 19.3; and
- the percent density of the molded specimens in accordance with Section 19.4.

13.3 *Determining the OAC:*

13.3.1 Use the Mix Design template to plot densities versus asphalt content for the molded specimens. Determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.

13.3.2 When applicable, adjust the percentage of coarse aggregate or fibers to achieve an OAC that meets the minimum asphalt binder content requirement according to the specification.

13.4 *Evaluating the Mixture at the OAC:*

13.4.1 Evaluate draindown of the optimum mixture in accordance with Tex-235-F.

13.4.2 Evaluate moisture resistance of the optimum mixture in accordance with Tex-530-C.

13.4.3 When required, requested by the Engineer, or shown on the plans, determine the number of cycles to failure in accordance with Tex-248-F and the rut depth and number of passes in accordance with Tex-242-F.

13.4.4 Evaluate the durability of the optimum mixture in accordance with Tex-245-F.

13.4.5 Report all data in the Mix Design Template.

PART VI—MIX DESIGN FOR STONE MATRIX ASPHALT (SMA) MIXTURES

14. SCOPE

14.1 Use this method to determine the proper proportions by weight of approved materials to produce SMA and SMAR mixtures that will satisfy the specification requirements. This mix design procedure incorporates the use of the SGC.

15. PROCEDURE

15.1 *Selecting Materials:*

15.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Take samples in accordance with Tex-221-F.

15.1.2 Obtain an adequate quantity of the asphalt and additives. Take samples in accordance with Tex-500-C.

Note 34—Polymer-modified asphalt binder with a PG 76-XX or higher is required or Asphalt Rubber (A-R), Type I or II. Use of fibers is required for mixes with PG 76-XX. Use loose fibers for mixtures prepared in the laboratory. Provide the Engineer the A-R binder blend design with the mix design (JMF1) submittal.

15.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C). Dry the RAP, when applicable, at a maximum of 140°F (60°C).

15.1.4 If the stockpile gradation in unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile gradation when it is available. Extract asphalt from RAP, when applicable, in accordance with Tex-210-F or Tex-236-F before performing a sieve analysis.

15.1.5 When applicable, estimate the binder content of the RAP from the average of 4 samples (RAP only) in accordance with Tex-236-F. Heat the RAP at 140°F (60°C), break apart until friable, and quarter to obtain a representative sample.

15.1.6 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable aggregate specifications.

15.1.7 Check the asphalt and additives for compliance with the applicable specifications.

15.1.8 If the specific gravity values for the aggregate sources are known, enter these results on the Bulk Gravity worksheet. Test lightweight aggregate, when applicable, in accordance with Tex-433-A.

Note 35—If the specific gravity values for the aggregate sources are unknown and deemed necessary, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-210-F and Tex-202-F.

15.1.8.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fraction for which values were determined.

15.1.8.2 Determine the unit weight in accordance with Tex-404-A and the bulk specific gravity of the combined gradation for the aggregate retained on the No. 8 sieve in accordance with Tex-201-F to verify stone-on-stone contact.

15.1.9 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate such that the blended combination will fall within the specified gradation ranges for the specified mixture type. Use hydrated lime, when applicable, as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

Note 36—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

15.1.10 When applicable, check specification compliance for the proposed blend of recovered asphalt from RAP and virgin asphalt cement or recycling agents before the laboratory-mixture preparation stage. Base the percentage of recovered asphalt in the blend on the percentage of RAP material proposed in the job-mix formula and the average extracted asphalt content of the RAP determined in Section 15.1.5.

15.1.11 Test the combined virgin aggregate in accordance with Tex-203-F. Perform the test on the combined aggregates not including lime. Enter these results on the Material Properties worksheet**.**

15.1.12 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B aggregate. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirements in accordance with Section 19.1.

15.2 *Preparing Laboratory Mixed Samples:*

15.2.1 Separate aggregate larger than the No. 8 sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the No. 8 sieve into individual sizes if it is prone to segregation.

15.2.2 For SMA, start the mixture design with the minimum allowable percentage of loose fibers for mixes with PG 76-XX. Increase this percentage when necessary to achieve the required mixture properties.

15.2.3 Select 3 asphalt contents in increments of 0.5%. Start at the minimum asphalt content based on the bulk specific gravity of the aggregate. Locate the table in the specification that lists the minimum asphalt content based on the bulk specific gravity of the aggregate.

15.2.4 Calculate the weights of individual aggregates required to produce 2 laboratory-molded specimens and one G_r sample for each asphalt content selected in Section 15.2.3. Generally, 4500–4700 g of aggregate are required to achieve the specified molded specimen height of 115 ± 5 mm (4.5 ± 0.2 in.) It may be necessary to produce a trial specimen to achieve this height requirement.

15.2.5 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures per Tex-241-F, Table 1.

15.2.6 Mold 2 specimens at each asphalt content selected in Section 15.2.3 in accordance with Tex-241-F. Mold specimens to 50 gyrations.

15.2.7 Determine the G_a of the specimens at each asphalt content in accordance with Tex-207-F. Enter the average G_a for each asphalt content in the Summary worksheet.

15.2.8 Determine the G_r of the mixtures at each asphalt content in accordance with Tex-227-F. Enter the G_r for each asphalt content in the Summary worksheet.

15.2.9 Use the Mix Design template to calculate the following:

- average G_e of the blend in accordance with Section 19.2,
- the G_t in accordance with Section 19.3,
- the percent density of the molded specimens in accordance with Section 19.4, and
- the VMA of the specimens in accordance with Section 19.5.

15.3 *Determining the OAC:*

15.3.1 Use the Mix Design template to plot the following.

- Densities versus asphalt content for the molded specimens—determine the OAC by interpolating between the asphalt contents above and below the target laboratory-molded density on the Summary worksheet.
- Asphalt content versus VMA—determine the VMA at the OAC.

15.3.2 Redesign by assuming another combination of aggregates or by obtaining different materials if the VMA is not within the allowable specification range.

15.4 *Evaluating the Stone-on-Stone Contact:*

15.4.1 Calculate the VCA_{CA} in accordance with Section 19.7.

15.4.2 Calculate the VCA_{Mix} in accordance with Section 19.8. Stone-on-stone contact is verified when the VCA_{Mix} is less than the VCA_{CA}.

15.4.3 Adjust the gradation if the stone-on-stone contact VCA_{Mix} is not less than the VCA_{CA}. Alternatively, use the Bailey Method to verify stone-on-stone contact.

15.5 *Evaluating the Mixture at the OAC:*

15.5.1 Determine the number of cycles to failure in accordance with Tex-248-F.

15.5.2 Determine the rut depth and number of passes in accordance with Tex-242-F.

15.5.3 If the rut depth or number of cycles is not within specification, redesign by assuming another combination of aggregates, by obtaining different materials, or by using a different PG grade.

15.5.4 Evaluate draindown of the optimum mixture in accordance with Tex-235-F.

15.5.5 Evaluate the moisture resistance of the optimum mixture in accordance with Tex-530-F.

15.5.6 Report all data in the Mix Design template.

PART VII—MIX DESIGN FOR STONE-MATRIX ASPHALT RUBBER (SMAR) MIXTURES

16. SCOPE

16.1 Part VII has been combined with Part VI of the test procedure. Refer to Part VI, "Mix Design for Stone-Matrix Asphalt (SMA) Mixtures."

PART VIII—MIX DESIGN FOR THIN BONDED WEARING COURSE MIXTURES

17. SCOPE

17.1 Use this method to determine the proper proportions by weight of approved aggregates and asphalt, which, when combined, will produce a thin bonded wearing course mixture that will satisfy the specification requirements.

17.2 Refer to Table 1 for Superpave and conventional mix nomenclature equivalents. Replace conventional nomenclature with Superpave nomenclature when required.

18. PROCEDURE

18.1 *Selecting Materials:*

18.1.1 Select the necessary type and source for each aggregate. Obtain representative samples consisting of a minimum of 23 kg (50 lb.) of each aggregate. Sample the aggregates in accordance with Tex-221-F.

18.1.2 Obtain an adequate quantity of the asphalt and additives in accordance with Tex-500-C.

18.1.3 Dry the aggregate to constant weight at a minimum temperature of 100°F (38°C).

18.1.4 If the stockpile gradation is unknown, obtain the average washed gradation of each proposed aggregate stockpile in accordance with Tex-200-F, Part II. Enter the stockpile gradations on the Combined Gradation worksheet. Use the construction stockpile washed gradation when it is available.

18.1.5 Check the aggregate gradations for compliance with the applicable specifications. Check the individual aggregate stockpiles for compliance with the applicable specifications.

18.1.6 Check asphalt and additives for compliance with the applicable specifications.

18.1.7 If the specific gravity values for the aggregate sources are unknown, determine the 24-hr. water absorption, the bulk specific gravity, and the apparent specific gravity of individual sizes of each aggregate in accordance with Tex-201-F and Tex-202-F. Enter the results or the known values from previous history on the Bulk Gravity worksheet.

18.1.7.1 Normally, specific gravities are not determined for aggregate size fractions consisting of less than 15% of the individual aggregate. Assign the water absorption and specific gravity of smaller aggregate size fractions close to the next adjacent size fractions for which values are determined.

18.1.8 Use the Combined Gradation worksheet to calculate the bin percentages with the proposed aggregate so that the blended combination will fall within the specified gradation ranges for the specified mixture type.

Note 37—Consider material availability, mixture strength, handling, compaction, pavement texture, and durability as the primary factors of the combination to be tested.

18.1.9 Consider the use of hydrated lime when necessary. Use hydrated lime as an aggregate type when determining the bin percentages for the combined aggregate blend. The combined gradation will include the hydrated lime.

18.1.10 Calculate the sand equivalent value of the combined virgin aggregate in accordance with Tex-203-F. Enter the value on the Material Properties worksheet.

Note 38—Perform the test on the combined aggregates not including lime.

18.1.11 Check the aggregate classification of the combined aggregate blend using the Aggregate Classification worksheet when blending Class A with Class B. Determine whether the percentage of the Class A aggregate in the combined aggregate blend meets the specification requirement in accordance with Section 19.1.

18.1.12 Plot the combined gradation and specification limits using the Grad Chart worksheet. Confirm that the blend meets the specification requirements.

18.2 *Preparing Laboratory Mixed Samples:*

18.2.1 Separate the material larger than the 2.36 mm (No. 8) sieve into individual sizes for each stockpile for preparation of laboratory mixtures. Separate the material passing the 2.36-mm (No. 8) sieve into individual sizes if it is prone to segregation.

18.2.2 Select 2 asphalt contents around the anticipated OAC. Select the asphalt contents within the allowed tolerances in accordance with specifications.

Note 39—Select the asphalt contents to determine the OAC depending on experience and knowledge of materials used.

18.2.3 Calculate individual aggregate and asphalt weights to produce 2 laboratory-molded samples and one G_r sample for each asphalt content selected in Section 18.2.2.

18.2.4 Prepare the asphalt mixtures in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F.

18.2.5 Determine the G_r of the 2 mixtures in accordance with Tex-227-F. Enter the asphalt content and the G_r values in the appropriate column of the Summary worksheet.

18.2.6 Mold 2 specimens at each asphalt content selected in Section 18.2.2 in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown in plans.

18.2.7 Determine the G_a of the specimens in accordance with Tex-207-F, Part VIII. Enter the height and dry weight for each asphalt content in the appropriate column of the Summary worksheet to calculate the G_a.

18.2.8 Use the Summary worksheet to calculate G_e and G_t for each asphalt content in accordance with Sections 19.2 and 19.3.

Note 40—The worksheet uses the equation in Section 19.2 and the average G_e for the combined blend to back-calculate the G_r value for all other laboratory-molded specimens.

18.2.9 Use the Summary worksheet to calculate the density of the molded samples in accordance with Sections 19.4 and 19.5.

18.3 *Determining the OAC:*

18.3.1 Use the Film Thickness worksheet to calculate the SA and F_T of the mixtures in accordance with Sections 19.9 and 19.10.

18.3.2 Use the graphs in the Film Thickness worksheet to determine the OAC. The mixture at the OAC must meet the density and film thickness requirements, while staying within the

limits for asphalt content as outlined in the specification. If this is not possible according to the predicted estimates, redesign by assuming another combination of aggregates or by obtaining different materials.

18.3.3 Calculate individual aggregate and asphalt weights to produce 2 laboratory-molded samples and one G_r sample at the OAC.

18.3.4 Prepare the asphalt mixture in accordance with Tex-205-F. Determine the mixing and compaction temperatures in accordance with Tex-241-F.

18.3.5 Mold 2 specimens at the OAC in accordance with Tex-241-F. Mold specimens to 50 gyrations or as shown on the plans.

18.3.6 Determine the G_a of the specimens in accordance with Tex-207-F, Part VIII. Enter the heights and dry weights in the appropriate column of the Summary worksheet.

18.3.7 Use the Summary worksheet to backcalculate the G_r, and calculate the density of the molded samples and the F_T for the combined aggregate at the OAC. The calculated density and F_T must meet the specifications.

18.3.8 If the density or F_T does not meet the specifications, modify the OAC and repeat the procedure, starting with Section 18.3.3.

18.4 *Evaluating the Mixture at the OAC:*

18.4.1 Evaluate the draindown of the mixture in accordance with Tex-235-F. Use 350 ± 5°F (177 ± 3°C) for testing temperature.

18.4.2 Evaluate the moisture resistance of the mixture in accordance with Tex-530-C.

18.4.3 Evaluate the durability of the mixture in accordance with Tex-245-F. Mold 2 specimens at the OAC to 50 gyrations. The density of the specimens must meet the specifications.

18.4.4 Report all test results in the Summary worksheet.

18.4.5 If any of the test results does not meet specifications, redesign by assuming another combination of aggregates, by obtaining different materials, or by using a different OAC.

19. CALCULATIONS

19.1 Calculate %Total CL_A:

$$\%\ \text{Total CL}_A = \frac{\%\ CL_A}{\left(\%\ CL_A + \%\ CL_B\right)}$$

Where:

% Total CL_A = total percentage retained of Class A aggregate on the 4.75 mm (No. 4) sieve

% CL_A = percentage retained of Class A aggregate on the 4.75 mm (No. 4) sieve
% CL_B = percentage retained of Class B aggregate on the 4.75 mm (No. 4) sieve.

19.2 Calculate G_e:

$$G_e = \frac{(100 - A_s)}{\left[\left(\frac{100}{G_r}\right) - \left(\frac{A_s}{G_s}\right)\right]}$$

Where:
G_e = effective specific gravity
A_s = asphalt content, %
G_r = theoretical maximum specific gravity
G_s = specific gravity of the asphalt binder.

19.3 Calculate the G_t:

$$G_t = \frac{100}{\left[\left(\frac{A_g}{G_{e(avg)}}\right) + \left(\frac{A_s}{G_s}\right)\right]}$$

Where:
$G_{e(avg)}$ = average of the effective specific gravities obtained
G_t = calculated theoretical maximum specific gravity
A_g = percentage of aggregate in the mixture.

19.4 Calculate the percent density of the molded samples:

$$\%\ \text{Density} = \left(\frac{G_a}{G_t}\right) \times 100$$

Where:
% Density = percentage of the ratio of G_a to G_t
G_a = bulk specific gravity.

19.5 Calculate the design VMA:

$$VMA = \left\{100 - \left[\left(\frac{G_a}{G_t}\right) \times 100\right]\right\} + \left[\frac{G_a \times A_s}{G_s}\right]$$

Where:
VMA = voids in mineral aggregates.

19.6 Calculate the production VMA:

$$VMA = \left\{100 - \left[\left(\frac{G_a}{G_r}\right)\times 100\right]\right\} + \left[\frac{G_a \times A_s}{G_s}\right]$$

19.7 Calculate the VCA_{CA}:

$$VCA_{CA} = \left\{\frac{\left[(G_{CA}\times\gamma_w)-\gamma_s\right]}{(G_{CA}\times\gamma_w)}\right\}\times 100$$

Where:

VCA_{CA} = voids in the coarse aggregate in the dry-rodded condition

G_{CA} = bulk specific gravity of the coarse aggregate blend (retained on the 2.36 mm (No.8) sieve)

γ_w = unit weight of water

γ_s = unit weight of the coarse aggregate blend fraction in the dry-rodded condition.

19.8 Calculate the VCA_{Mix}:

$$VCA_{Mix} = 100 - \left[\left(\frac{G_a}{G_{CA}}\right)\times P_{CA}\right]$$

Where:

VCA_{Mix} = voids in coarse aggregate for the compacted mixture

P_{CA} = percentage coarse aggregate in the total mix.

19.9 Calculate SA:

$$SA = \frac{0.41 + (\%P\#4)0.41 + (\%P\#8)0.82 + (\%P\#16)1.64 + (\%P\#30)2.87 + (\%P\#50)6.14 + (\%P\#100)12.29 + (\%P\#200)32.77}{100}$$

Where:

SA = surface area, m^2/kg

%Pi = Aggregate passing sieve # i, %.

Note 41—*%P#30* and *%P#100* are automatically interpolated in the DATA_Film Thickness worksheet by using the *%P#16–%P#50* and *%P#50–%P#200*, respectively.

19.10 Calculate F_T:

$$P_{ba} = 100 * G_s\left(\frac{G_e - G_{sb}}{G_{sb} * G_e}\right)$$

$$P_{be} = A_s - P_{ba}\left(\frac{100 - A_s}{100}\right)$$

$$F_T = \frac{\left(\frac{P_{be}/100}{1-P_{be}/100}\right)}{SA * G_s * 1000} * 10^6$$

Where:
P_{ba} = absorbed asphalt in mixture, %
G_{sb} = bulk specific gravity of combined aggregates
P_{be} = effective asphalt in mixture, %
F_T = film thickness of asphalt binder in mixture, microns.

20. ARCHIVED VERSIONS

20.1 Archived versions are available.

Test Procedure for

Laboratory Method of Mixing Bituminous Mixtures

TxDOT Designation: Tex-205-F

Document Owner:	***Materials and Tests Division***
Effective Date:	***September 2026***

1. Scope

1.1. Use this test method to combine various sizes of aggregates and blend them with asphalt to obtain uniform bituminous mixtures.

1.2. The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. Apparatus

2.1. *Balance,* Class G2 in accordance with Tex-901-K, with a minimum capacity of 10,000 g.

2.2. *Heating oven,* capable of attaining a temperature of at least 325°F (163°C).

2.3. *Hot plate (optional).*

2.4. *Mechanical mixer and bowl or round pans*.

2.5. *Small, pointed masonry trowels.*

2.6. *Small bowl or round pan,* less than 8 in. (200 mm) in diameter.

2.7. *Mercury thermometer,* marked in 5°F (3°C) divisions or less, or digital thermometer, capable of measuring the temperature specified in the test procedure.

2.8. *Angled pliers (optional).*

2.9. *Insulating gloves*.

3. Materials

3.1. *Asphalt cement.*

3.2. *Graded aggregate*.

3.3. *Additives*, if applicable.

3.4. *Recycled materials*, such as Reclaimed Asphalt Pavement (RAP) or Recycled Asphalt Shingles (RAS), if applicable.

4. Procedure

4.1. Design the bituminous mixture as described in Tex-204-F. Use the calculated amounts of aggregate and asphalt, (including additives and recycled materials, when applicable,) to satisfy the requirements of the specifications.

4.2. Separate the material retained on the No.8 (2.36 mm) sieve for each stockpile into individual sieve sizes as required by the specification.
Note 1—Do not divide the material passing the No.8 (2.36 mm) sieve into smaller sieve sizes unless segregation is apparent or absolute control is necessary, since a minimum amount of segregation occurs in this material.

4.3. Place the pan, with or without a trowel, or small bowl on the balance and tare the balance.
Note 2—It is recommended, but not mandatory, to use a trowel or small bowl. Use the trowel or small bowl to separate the aggregate sizes as they are added. This aids in the removal of excess material if too much is accidentally added.

4.4. Use the individual or cumulative weight for each sieve size calculated.
Note 3—Weigh the fine aggregate passing the No.8 (2.36 mm) sieve last. Adjust the weight of the aggregate batch by adding or removing very small amounts of fines to equal the total weight if necessary.

4.5. Add the calculated amount of aggregate for the largest sieve size from the first stockpile into the pan. Place the blade of the trowel or the small bowl in a flat position on top of this layer as noted in Section 4.3., if desired, and add the calculated amount of the aggregate for the next smaller sieve size on the trowel or to the side of the previous aggregate added. Add all the aggregate sizes for all the stockpiles, mineral filler, and hydrated lime to the pan by repeating this process.
Note 4—The blade of the trowel or the small bowl momentarily separates the aggregate being weighed from the portion that was previously placed in the pan or bowl. Use the trowel to retrieve any excess aggregate.

4.6. Mix the dry aggregate weighed in Section 4.5., until all sizes and materials are blended thoroughly.
Note 5—It is important to blend the dry aggregate thoroughly when adding hydrated lime as an anti-stripping additive.

4.7. Select a mixing temperature from Table 1 based on the asphalt binder specified on the plans. When adding warm mix asphalt (WMA) additives or using WMA processes in the laboratory, select the mixing temperature based on the asphalt binder specified on the plans.
Note 6—If using RAP or RAS and a substitute Performance Grade (PG) binder instead of the PG binder originally specified on the plans, defer to the originally specified binder grade when selecting the mixing temperature.

4.8. Place a thermometer into the aggregate and set the aggregate in an oven maintained at or slightly above the mixing temperature selected in Section 4.7.
Note 7—Do not leave the trowel in the pan when heating materials.

4.9. Place the calculated quantity of asphalt and any required liquid additives into a small can to facilitate handling. Heat this material in an oven slowly to the temperature selected in Section 4.7.

Note 8—Do not allow the asphalt to heat to a temperature above the maximum temperature allowed for storage in accordance with Item 300, "Asphalts, Oils, and Emulsions," or the recommended temperature obtained from the Materials and Tests Division's (MTD), Asphalt Binder Section.
Note 9—Incorporate and mix WMA additives into the laboratory mixture or use WMA processes according to the WMA supplier's recommendations, when applicable.

4.10. Place the calculated quantity of RAP or RAS in a separate pan, when applicable. Heat the material in an oven at the mixing temperature selected in Section 4.7.
Note 10—Keep heating time for recycled materials to a minimum to avoid further hardening of the recycled material asphalt binder.

4.11. Remove the aggregate from the oven after the aggregate has reached the required mixing temperatures. Remove the thermometer.

4.12. Slowly place the heated aggregate into a mixing bowl. When applicable, add the heated recycled materials to the heated aggregate and thoroughly blend the materials.

4.13. Make a small depression in the center of the aggregate using a trowel, without exposing the bottom of the mixing bowl, to receive the asphalt material.

4.14. Place the mixing bowl with the heated aggregate on the scale and tare. Add the required amount of preheated asphalt material.
Note 11—Use gloves or a pair of side angle pliers to avoid burning hands. Remove excess asphalt, if necessary.

4.15. Thoroughly mix to blend the asphalt material and the aggregate, either by hand or with a mechanical mixer. Use a trowel to blend the aggregate around the side of the pan when mixing by hand. Take care to prevent free asphalt material from coming in contact with the side or bottom of the mixing pan.

4.16. Mix the aggregate and asphalt material continuously until the materials are coated thoroughly.

Note 12—It may be necessary to adjust the mixing time or temperature for some mixtures to coat the aggregate particles thoroughly. Carefully consider and calculate the speed and time of mixing and the clearance between the mixing device and the bowl to prevent abnormal degradation of the aggregate, when using a mechanical mixer.

4.17. Split the mixture into the appropriate size, as needed, and place the samples in the oven.

4.18. Identify each mixture with a laboratory number and indicate the percentage of asphalt.

5. Mixing Temperature

5.1. Mixtures containing asphalt materials not listed in Table 1, or those containing viscosity-modifying additives, may require considerably varied mixing temperatures from those listed. For guidance, consult the binder supplier or the Asphalt Binder Section of the Materials and Tests Division.

Table 1 – Asphaltic Material Mixing Temperatures by Grade and Type

Type-Grade[1]	Asphalt Material Temp. °F (°C)	Mixing Temp. °F (°C)[2]
PG 82-22, PG 82-28, PG 88-22, PG 88-28, HPG	325 (163)[3]	325 (163)[3]
PG 70-28, PG 76-22	325 (163)	325 (163)
PG 64-28, PG 70-22	300 (149)	300 (149)
PG 64-22, PG 64-16	290 (143)	290 (143)
AC-3,5,10; PG 58-28, PG 58-22	275 (135)	275 (135)
RC-250	100 (38)	165 (74)
MC-250	100 (38)	165 (74)
MC-800	140 (60)	190 (88)
CMS-2	140 (60)	235 (113)
AES-300	140 (60)	235 (113)
Asphalt-Rubber (A-R) Binder	325 (163)	325 (163)

1. If using RAP or RAS and a substitute PG binder in lieu of the PG binder originally specified on the plans, defer to the originally specified binder grade when selecting the mixing temperature.
2. When using RAP or RAS, mixing temperature may be increased up to 325°F to achieve adequate coating.
3. A higher temperature may be required based on asphalt binder supplier recommendations. The increased temperature must not exceed the flash point.

5.2. The Engineer must approve the use of asphalt material and mixing temperatures different from those listed in Table 1.

6. Archived Versions

6.1. Archived versions are available.

Test Procedure for

DETERMINING ASPHALT CONTENT FROM ASPHALT PAVING MIXTURES BY THE IGNITION METHOD

TxDOT Designation: Tex-236-F

Effective Date: June 2024

1. SCOPE

1.1 Use Part I of this test method to determine the asphalt content of hot mix asphalt (HMA) paving mixtures, reclaimed asphalt pavement (RAP) stockpiles, and recycled asphalt shingles (RAS) stockpiles using an ignition oven. Use the remaining aggregate for sieve analysis in accordance with Tex-200-F.

1.2 Use Part II of this test method to determine aggregate gradation and asphalt content correction factors before the start of production. The type of aggregate in the mixture may affect the ignition procedure. Establish correction factors by testing a set of samples for each mix type produced to optimize accuracy.

1.3 Use Part III of this test method to witness the batching and mixing of material for determination of correction factors.

1.4 The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

2. APPARATUS

2.1 *Ignition oven,* capable of:

2.1.1 Maintaining a temperature to cause combustion with an internal balance thermally isolated from the chamber accurate to 0.1 g. The balance must be capable of weighing a 4,000 g sample in addition to the sample baskets.

2.1.2 Providing an audible alarm and indicator light when the sample reaches constant weight.

Note 1—The oven door must automatically lock when the test procedure begins and must remain locked until the test procedure is completed.

2.1.3 Providing initial sample weight, sample weight loss, correction factor, corrected asphalt content (percent), and test time.

2.2 *Tempered stainless steel No. 8 (2.36 mm) mesh basket,* otherwise perforated basket, or combination of baskets. The basket must incorporate a design that confines the sample during testing.

2.3 *Tempered stainless steel catch pan*, to fit under the basket assembly.

2.4 *Oven*, capable of attaining a temperature of at least 325°F (163°C).

2.5 *Balance,* Class G2, in accordance with Tex-901-K, with a minimum capacity of 17.6 lb. (8 kg) for weighing sample in baskets.

3. SAFETY EQUIPMENT

3.1 *Safety glasses or face shield.*

3.2 *High temperature gloves.*

3.3 *Long sleeve jacket.*

3.4 *Heat-resistant surface,* capable of withstanding heat from the sample baskets.

3.5 *Protective cage,* capable of surrounding the sample baskets.

4. MISCELLANEOUS EQUIPMENT

4.1 *Pan for transferring samples after ignition.*

4.2 *Spatulas.*

4.3 *Bowls.*

4.4 *Wire brushes.*

5. REPORT FORMAT

5.1 The Correction Factor Calculation Report is an Excel template containing the following worksheets:

- Asphalt Content and Combined Aggregate Gradation (Tx236) and
- Summary Sheet (Summary).

5.2 For HMA mixtures, use the QC/QA Excel template for the Ignition Oven Method in conjunction with the HMA specification. Refer to the Instructions tab for guidelines on how to use the template.

5.3 Use the Mix Design Excel template to prepare blank samples when establishing correction factors.

6. SAMPLE PREPARATION

6.1 *Asphalt Paving Mixtures:*

6.1.1 Produce a sample in accordance with Tex-205-F or quarter a sample in accordance with Tex-222-F.

6.1.1.1 When the mixture is not sufficiently workable to separate the mix with a spatula or trowel, place it in a large flat pan and warm to 250 ± 5°F (121 ± 3°C) for 30 min.

Note 2—Do not heat sample for more than 1 hr.

6.1.1.2 For microsurfacing production mix, place the mixture in a large flat pan and dry to constant weight at 230 ± 10°F.

6.1.1.3 The mixture type controls the required sample size, as shown in Table 1.

Table 1
Required Weight of Sample

Mixture Type	Required Weight of Sample, g
Type A, SP-A	3,000–4,000
Type B, SP-B	2,000–3,000
Type C, PFC (PG 76), SP-C, CMHB-C, SMA-C, SMA-D, SMAR-C, UTBWC-C, TBPFC (PG 76)	1,000–2,000
Type D, PFC (A-R), SP-D, CMHB-F, SMA-F, UTBWC-B, TBPFC (A-R)	1,200–1,500
Type F, SMAR-F, Microsurfacing, CAM, UTBWC-A, TOM-C, TOM-F	1,000–1,200

6.1.2 Sample sizes should not be more than 400 g greater than the maximum required sample mass as shown in Table 1. Large samples of fine mixes tend to result in incomplete ignition of the asphalt.

Note 3—When the mass of the sample exceeds the capacity of the equipment used, divide the sample into suitable increments. Appropriately combine the results for calculating the asphalt content (weighted average).

6.1.3 Verify that the mixture contains no more than 0.2% of moisture by weight in accordance with Tex-212-F, Part II. Do not use the same sample used for moisture determination as used for asphalt content determination.

6.2 *Recycled Materials Samples:*

6.2.1 Take a representative sample from the recycled material stockpile in accordance with Tex-222-F.

6.2.2 Oven-dry the sample to constant weight at 140 ± 5°F (60 ± 3°C).

6.2.3 Quarter a test sample to the required size shown in Table 2.

6.2.4 Verify that the mixture contains no more than 0.2% of moisture by weight in accordance with Tex-212-F, Part II. Do not use the same sample used for moisture determination as used for asphalt content determination.

Table 2
Required Weight of Recycled Material Sample

Recycled Material Type	Required Weight of Sample, g
Reclaimed Asphalt Pavement (RAP)[1]	1,000–4,000
Recycled Asphalt Shingles (RAS)[2]	500–700

1. Refer to Table 1 for required sample weights.
2. Sample size exceeding the required weight above may not completely ignite the asphalt.

PART I—DETERMINE ASPHALT CONTENT BY IGNITION METHOD

7. SCOPE

7.1 Use this procedure to determine the asphalt content of HMA paving mixtures using an ignition oven. Use the remaining aggregate for sieve analysis in accordance with Tex-200-F.

8. PROCEDURE

8.1 Pre-heat the ignition oven according to the manufacturer's recommendations.

8.2 Determine and record the weight of the basket assembly to the nearest 0.1 g.

8.3 Place the loose mixture directly into the sample baskets.

Note 4—Reheat the sample in a 250°F (121°C) oven for 30 min. if it gets cold. Do not reheat microsurfacing, limestone rock asphalt (LRA), or hot-mix cold-laid samples. Do not preheat the sample baskets.

8.4 Evenly distribute the sample in the basket assembly, keeping the material away from the edges of the basket.

8.5 Weigh and record the sample and basket assembly to the nearest 0.1 g.

8.6 Calculate and record the initial weight of the sample (total weight minus the weight of the sample basket assembly) and designate as W_S in Section 13.1.

8.7 Input W_S into the ignition oven controller. Verify entry of the correct weight.

8.8 Open the chamber door and place the sample and basket assembly in the ignition oven.

Note 5—Failure of the oven scale to stabilize may indicate that the sample basket assembly is contacting the oven wall. If this occurs, adjust the sample basket inside the oven.

8.9 Close the chamber door and start the test.

Note 6—This should lock the oven chamber for the duration of the test.

8.10 Allow the test to continue until the stable light and audible stable indicator indicate the test is complete.

8.11 Press the stop button.

Note 7—This should unlock the oven chamber.

8.12 Open the chamber door, remove the sample, and allow it to cool to room temperature (approximately 45 min.)

Note 8—Do not use a fan to assist in cooling the sample to room temperature due to the possibility of losing fines.

8.13 Weigh the sample and basket assembly after ignition to the nearest 0.1 g.

8.14 Calculate and record the final weight of the sample (total weight from Section 8.13. minus the weight of the sample basket assembly) and designate this weight as W_A in Section 13.1.

8.15 Calculate the asphalt content of the sample according to Section 13.1.

Note 9—Asphalt content reported by the ignition oven may be used if proven accurate.

8.16 Empty the contents of the basket into a flat pan. Use a small wire sieve brush to ensure removal of any residual fines from the basket. Add those fines to the contents in the flat pan.

8.17 Use the remaining aggregate for the sieve analysis in accordance with Tex-200-F.

PART II—DETERMINE CORRECTION FACTORS

9. SCOPE

9.1 Use this test method to determine aggregate gradation and asphalt content correction factors before the start of production. The type of aggregate in the mixture may affect the ignition procedure. Establish correction factors by testing a set of samples for each mix type produced to optimize accuracy.

10. PROCEDURE

10.1 A Level 2-certified technician must prepare one blank sample in the laboratory in accordance with Tex-205-F, using the Blank Weigh Up worksheet in the Mix Design Excel template. Determine the sample size for the blank sample in accordance with Tex-200-F, Table 1.

Note 10—Do not add any asphalt binder, fibers, or any recycled materials to the blank sample. Do not perform the ignition oven procedure with the blank sample.

10.2 Perform a washed sieve analysis on the blank sample in accordance with Tex-200-F, Part II.

Note 11—Enter the individual or cumulative weight of aggregate retained on each sieve on the Asphalt Content and Combine Aggregate Gradation worksheet.

10.3 When applicable, enter the gradation of any recycled material used in the mixture design, such as RAP or RAS, in the Asphalt Content and Combined Aggregate Gradation worksheet, under the Recycled Materials Section. Use the gradation of the recycled material determined for the mixture design in accordance with Tex-204-F.

Note 12—The Asphalt Content and Combined Aggregate Gradation worksheet calculates the combined gradation of the blank sample and recycled materials, when applicable.

Note 13—The combined gradation, including the use of any recycled materials, must fall within the master gradation limits of the specification used for the project.

10.4 Prepare a "butter batch mix" at the design optimum asphalt content and discard before mixing any other samples for determining correction factors.

Note 14—A "butter batch mix" is a trial batch of asphalt and aggregate design mixture used to coat the mixing bowl and whips with asphalt. This helps prevent a loss of asphalt due to adhesion on the bare walls of the bowl or in the mixing whips to ensure an accurate asphalt content of the samples used to determine correction factors.

10.5 Use the Weigh Up worksheet in the Mix Design Report to prepare two samples in the laboratory at the design optimum asphalt content in accordance with Tex-205-F. Determine the sample size in accordance with Section 6.1.1.3.

Note 15— Add the recycled material when preparing the samples if applicable.

10.6 Perform the ignition oven procedure as described under Section 8 with the samples prepared in Section 10.5.

10.7 Perform a dry gradation sieve analysis in accordance with Tex-200-F, Part I, on the residual aggregate for each ignited sample from Section 10.6.

Note 16—Enter the individual or cumulative weight of aggregate retained on each sieve on the Asphalt Content and Combine Aggregate Gradation worksheet.

10.8 *Determining Asphalt Content Correction Factor:*

10.8.1 Determine the asphalt content for each ignited sample in Section 10.6. in accordance with Section 13.1.

10.8.2 Use the Asphalt Content and Combined Aggregate Gradation worksheet to subtract the measured asphalt content for each ignited sample determined in Section 10.8.1. from the actual asphalt content. Average the two measured differences to determine the asphalt content correction factor.

Note 17—When fibers are added to the mixture, the asphalt content correction factor takes into account the percent fibers in the mixture so that the fibers are excluded from the binder content determination.

10.8.3 If Section 10.8. yielded an asphalt correction factor that was greater than 0.3%, use the Back Calculated Rice Method in Section 10.9. to verify the asphalt content.

Note 18—The type of aggregate in the mixture may affect the ignition procedure. Establish standard Rice values by testing a set of known asphalt contents from a laboratory produced sample. Compare production samples to these standards for verification.

10.9 *Verifying Asphalt Content using the Back Calculated Rice Method:*

10.9.1 Using the current design, produce a laboratory mixture at the design optimum asphalt content in accordance with Tex-205-F. Prepare enough material to test three G_r samples in accordance with Tex-227-F.

10.9.2 During production, compare the production G_r to the average G_r obtained in part 10.9.1.

10.9.3 Use Asphalt Content and Combined Aggregate Gradation (Tx236) to enter these values and verify asphalt contents.

10.10 *Determining Aggregate Gradation Correction Factors:*

10.10.1 Use the Asphalt Content and Combined Aggregate Gradation worksheet to subtract the gradation determined in Section 10.7. (ignited samples) for each sieve size from each corresponding sieve size of the combined gradation determined in Section 10.3. (blank samples and recycled material).

10.10.2 Average the two measured differences for each sieve size to determine the aggregate gradation correction factor for each sieve size. Report the correction factors in percent passing.

10.11 Use the Summary worksheet to report the asphalt content and aggregate gradation correction factors.

Note 19—A correction factor of zero can be used if the aggregate correction factor for a sieve has historically been less than 0.5%.

PART III—WITNESS THE BATCHING AND MIXING OF MATERIAL FOR DETERMINATION OF CORRECTION FACTORS

11. SCOPE

11.1 Use this test method to witness the batching and mixing of material for determination of asphalt correction factors in accordance with Tex-205-F.

12. PROCEDURE

12.1 Ensure that the correction factors are being performed with the materials designated for this project using the combined gradation sheet from the mix design excel template, Figure 1. Ensure the design ID is clearly

identified. Reference documentation for material sources including but not limited to asphalt binder, aggregate, recycled materials, antistrip, fiber, and additives.

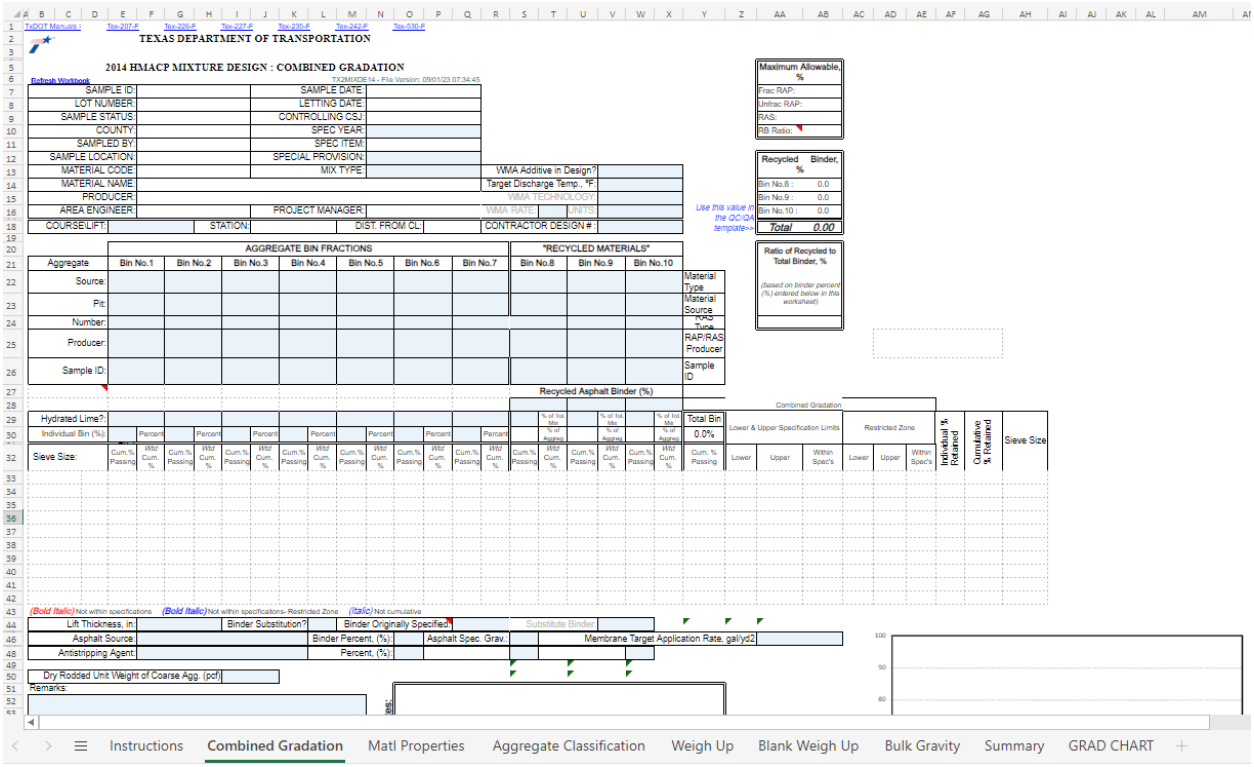


Figure 1
Combined Gradation Template

12.2 Review a copy of the Weigh Up worksheet in the Mix Design Excel template and ensure the design ID is clearly identified, Figure 2.

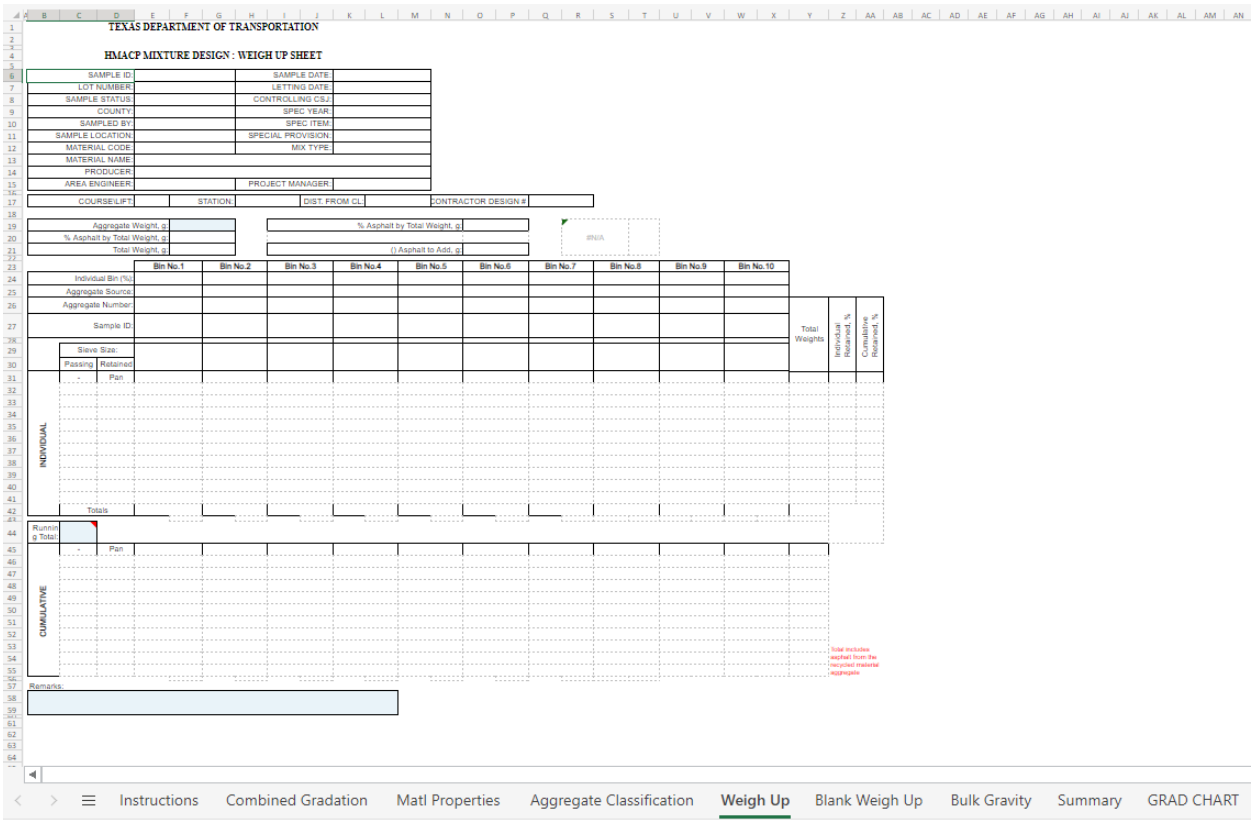


Figure 2
Weigh Up Template

12.3 *Witness Mixing of Material for Asphalt Correction Factors:*

12.3.1 Verify the following information is distinctly specified for asphalt correction factors:

12.3.1.1 Pans are labeled with source information and aggregate bin size according to the governing specification,

12.3.1.2 The proper weight of combined aggregate,

12.3.1.3 The proper weight of recycled materials and additives used,

12.3.1.4 The amount of liquid asphalt used for each batch.

12.3.2 Ensure a "butter batch mix" is performed at the designs optimum asphalt content and discarded before mixing any other samples for determining correction factors.

12.3.3 Ensure samples are prepared in the laboratory at the designs optimum asphalt content in accordance with Tex-205-F and verify the sample size.

12.3.4 Witness the continuous mixing of the aggregate and asphalt until materials are coated thoroughly.

12.3.5 Take immediate possession of the Engineer's sample.

12.4 *Witness Mixing of Material for Blank Samples:*

12.4.1 Verify the following information is distinctly specified for blank samples:

12.4.1.1 Pans are labeled with source information and size fraction according to the governing specification,

12.4.1.2 The proper weight of each individual aggregate size fraction,

Note 20—Ensure that asphalt binder, fibers, or recycled materials are not added to the blank samples.

12.4.2 Take immediate possession of the Engineer's sample.

Note 21—Ensure material is not lost when transporting to the Engineer's laboratory.

13. CALCULATIONS

13.1 Calculate the asphalt binder content of the sample.

13.1.1 For HMA, LRA, hot-mix cold-laid, and recycled materials:

$$AC\% = \left[\frac{W_S - W_A}{W_S}\right] * 100$$

13.1.2 For microsurfacing mixtures:

$$AC\% = \left[\frac{W_S - W_A}{W_A}\right] * 100$$

Where:

$AC\%$ = measured asphalt content

W_A = total weight of aggregate remaining after ignition, g

W_S = total weight of the HMA sample before ignition, g

13.2 Report ignition oven test results to the nearest 0.1%.

14. ARCHIVED VERSIONS

14.1 Archived versions are available.

Item 344
Superpave Mixtures

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, Superpave (SP) mixture of aggregate, asphalt binder, and additives mixed hot in a mixing plant. Payment adjustments will apply to HMA in accordance with this Specification unless the HMA is deemed exempt in accordance with Section 344.4.9.4., "Exempt Production."

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met and document all material source changes when the Contractor makes a source or formulation change. The Engineer may sample and test project materials anytime during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. **Aggregate**. Furnish aggregates from sources that conform to the requirements shown in Table 1 and this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests shown in Table 1. Document all test results in the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis in accordance with Tex-200-F, Part II.

2.1.1. **Coarse Aggregate**. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for HMA listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in HMA.

For sources not listed in the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance;
- allow 30 calendar days for the Engineer to sample, test, and report results;
- use only when tested and approved; and
- once approved, do not add additional material to the stockpile unless otherwise allowed by the Engineer.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements apply only to aggregates used on the surface of travel lanes, unless otherwise shown on the plans. The SAC for

sources in the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. **Blending Class A and Class B Aggregates**. Class B aggregate meeting all other requirements shown in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials, unless otherwise shown on the plans. When blending Class A and Class B aggregates to meet a Class A requirement, ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source, unless otherwise shown on the plans. Blend by volume if the bulk-specific gravities of the Class A and Class B aggregates differ by more than 0.300. Coarse aggregate from RAP and recycled asphalt shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests anytime during production, when the Contractor blends Class A and Class B aggregates to meet a Class A requirement. The Engineer will use the Department's mix design template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks to verify the percent of Class A aggregate retained on the No. 4 sieve. The Engineer will use the gradations supplied by the Contractor in the mixture design report as an input for the template. A failing spot check will require confirmation using a stockpile gradation determined by the Engineer.

2.1.1.2. **Micro-Deval Abrasion**. The Engineer will perform at least one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a rated source soundness magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer will perform testing before the start of production and may perform additional testing anytime during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
RSSM = rated source soundness magnesium
$MD_{act.}$ = actual Micro-Deval percent loss
RSMD = rated source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Materials and Tests Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used, that are free of organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used, that meet the requirements shown in Table 1, unless otherwise approved.

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the fine aggregate properties shown in Table 1 and the gradation requirements shown in Table 2. Supply fine aggregates that are free of organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free of organic impurities. Unless otherwise shown on the plans, a maximum of 10% of the total aggregate may be field sand or other

uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1, unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

Property	Test Method	Requirement
Coarse Aggregate		
SAC	Tex-499-A (AQMP)	As shown on the plans
Deleterious material, %, Max	Tex-217-F, Part I	1.0
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Note [1]
Los Angeles abrasion, %, Max	Tex-410-A	35[2]
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	25[3]
Crushed face count,[4] %, Min	Tex-460-A, Part I	85
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10
Fine Aggregate		
Linear shrinkage, %, Max	Tex-107-E	3
Sand equivalent, %, Min	Tex-203-F	45[5]
Organic impurities	Tex-408-A	Note [6]

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 344.2.1.1.2., "Micro-Deval Abrasion."
2. For base mixtures defined in Section 344.2.7., "Recycled Materials," the Los Angeles abrasion may be increased to a Max of 40%.
3. For base mixtures defined in Section 344.2.7., "Recycled Materials," the magnesium sulfate soundness, 5 cycles, may be increased to a Max of 30%.
4. Only applies to crushed gravel.
5. The Department may perform Tex-252-F on fine aggregates not meeting this Min requirement. Fine aggregates with a methylene blue value of 10.0 mg/g or less may be used.
6. Optional test.

Table 2
Gradation Requirements for Fine Aggregate

Sieve Size	% Passing by Wt. or Volume
3/8"	100
#8	70–100
#200	0–30

2.2. **Mineral Filler**. Mineral filler consists of finely divided mineral matter, such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash, unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used, unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is dry enough, free-flowing, and free of clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements shown in Table 3, unless otherwise shown on the plans.

Table 3
Gradation Requirements for Mineral Filler

Sieve Size	% Passing by Wt. or Volume
#8	100
#200	55–100

2.3. **Baghouse Fines**. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. **Asphalt Binder**. Furnish the type and grade of performance-graded (PG) asphalt binder specified on the plans that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions."

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, emulsified bonding layer (EBL), or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300. Specialized tack coat materials on the MPL for *Tracking Resistant Asphalt Interlayer* (TRAIL) will be allowed or required when shown on the plans. The Engineer may suspend paving operations until there is adequate coverage. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use, unless required in conformance with the manufacturer's recommendation for approved TRAIL products on the MPL.

2.6. **Additives**. Use the type of additive specified when shown on the plans. Use the rate of additive specified in conformance with the manufacturer's recommendation. Additives that facilitate mixing and compaction, or improve the quality of the mixture, are allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

2.6.1. **Lime and Liquid Antistripping Agent**. Lime or liquid antistripping agent is required when shown on the plans. When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.2. **Warm-Mix Asphalt (WMA)**. WMA is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value at or below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

2.6.3. **Compaction Aid**. Compaction aid is defined as a Department-approved chemical warm-mix additive, denoted as "chemical additive" on the MPL, that is used to facilitate mixing and compaction of HMA at a discharge temperature greater than 275°F.

Compaction aid is allowed for use on all projects. Compaction aid is required when shown on the plans or as required in Section 344.4.7.1., "Weather Conditions."

Warm-mix foaming processes, denoted as "foaming process" on the MPL, may be used to facilitate mixing and compaction of HMA at target discharge temperatures greater than 275°F; however, warm-mix foaming processes are not defined as a compaction aid.

2.7. **Recycled Materials**. Use of RAP and RAS is permitted unless otherwise shown on the plans. Use of RAS is restricted to only intermediate and base mixes unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages in shown in Table 4 may be decreased or increased when shown on the plans. Determine the asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F, Part I. The Engineer may verify the asphalt binder content of the stockpiles anytime during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages in accordance with Table 5 during mixture design and HMA production when RAP or RAS are used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes shown in Table 4 and Table 5 are defined as follows, unless otherwise shown on the plans.

- **Surface**. The final HMA lift placed at the top of the pavement structure.
- **Intermediate**. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. below the riding surface.
- **Base**. Mixtures placed greater than 8.0 in. below the riding surface. Unless otherwise shown on the plans, mixtures used for bond breaker are defined as base mixtures.

2.7.1. **RAP**. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Fractionated RAP is defined as a stockpile that contains RAP material with at least 95.0% passing the 1/2-in. sieve, before burning in the ignition oven, unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 1/2-in. screen to fractionate the RAP.

Use of Contractor-owned RAP, including HMA plant waste, is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than eight. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Max Allowable Amounts of RAP[1]

Max Allowable Fractionated RAP (%)		
Surface	**Intermediate**	**Base**
20.0	30.0	35.0

1. Must also meet the recycled binder to total binder ratio shown in Table 5.

2.7.2. **RAS**. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS are processed manufacturer's shingle scrap byproduct. Post-consumer RAS are processed shingle scrap removed from residential structures. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is not permitted in surface mixtures unless otherwise shown on the plans. RAS may be used in intermediate and base mixtures unless otherwise shown on the plans. Up to 3% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS may be used separately or in conjunction with RAP. Comply with all regulatory requirements stipulated for RAS by TCEQ.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8-in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements shown in Table 1 and Table 2, or fine RAP, to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 3.0% of the HMA mixture shown in Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if they have not contacted any hazardous materials. Use RAS from shingle sources listed on the MPL. Remove all materials that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper, before use. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS, unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. **Substitute Binders**. No binder substitution will be allowed when shown on the plans. The Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if using recycled materials, and if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.11., "Performance-Graded Binders;" and
- the mixture has less than 10.0 mm of rutting on the Hamburg wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable PG Binders and Max Recycled Binder Ratios

Originally Specified PG Binder	Allowable Substitute PG Binder for Surface Mixes	Allowable Substitute PG Binder for Intermediate and Base Mixes	Max Ratio of Recycled Binder[1] to Total Binder (%)		
			Surface	Intermediate	Base
76-22	70-22	70-22	15.0	25.0	30.0
70-22	Note [2]	64-22	15.0	25.0	30.0
64-22	Note [2]	Note [2]	15.0	25.0	30.0
76-28	70-28	70-28	15.0	25.0	30.0
70-28	Note [2]	64-28	15.0	25.0	30.0
64-28	Note [2]	Note [2]	15.0	25.0	30.0

1. Combined recycled binder from RAP and RAS. RAS is not permitted in surface mixtures unless otherwise shown on the plans.
2. No binder substitution is allowed.

3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required in accordance with the Specification, the Contractor may perform other QC tests as deemed necessary. Anytime during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a mandatory pre-paving meeting with the Engineer on or before the first day of paving unless otherwise shown on the plans.

4.1. **Certification**. Personnel certified by the Department-approved HMA certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2-certified specialist. Provide

Level 1A-certified specialists at the plant during production operations. Provide Level 1B-certified specialists to conduct placement tests. Provide Level-AGG101 certified specialists for aggregate testing.

Table 6
Test Methods, Test Responsibility, and Min Certification Levels

Test Description	Test Method	Contractor	Engineer	Level[1]
Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A/AGG101
Dry sieve	Tex-200-F, Part I	✓	✓	1A/AGG101
Washed sieve	Tex-200-F, Part II	✓	✓	1A/AGG101
Deleterious material	Tex-217-F, Part I and Part III	✓	✓	AGG101
Decantation	Tex-217-F, Part II	✓	✓	AGG101
Los Angeles abrasion	Tex-410-A	–	✓	Department
Magnesium sulfate soundness	Tex-411-A	–	✓	Department
Micro-Deval abrasion	Tex-461-A	–	✓	AGG101
Crushed face count	Tex-460-A	✓	✓	AGG101
Flat and elongated particles	Tex-280-F	✓	✓	AGG101
Linear shrinkage	Tex-107-E	✓	✓	AGG101
Sand equivalent	Tex-203-F	✓	✓	AGG101
Methylene blue test	Tex-252-F	–	✓	Department
Bulk-specific gravity	Tex-201-F	✓	✓	AGG101
Organic impurities	Tex-408-A	✓	✓	AGG101
Asphalt Binder and Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
Mix Design and Verification				
Design and job-mix formula (JMF) changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (Superpave gyratory compactor [SGC])	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Part I and Part VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Ignition oven correction factors[2]	Tex-236-F, Part II	✓	✓	1A
Indirect tensile strength	Tex-226-F	✓	✓	1A
Hamburg wheel test	Tex-242-F	✓	✓	1A
Witnessing mixing of correction factors	Tex-236-F, Part III	–	✓	1A/Department
Boil test	Tex-530-C	✓	✓	1A
Production Testing				
Selecting production random numbers	Tex-225-F, Part I	–	✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A/1B
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F, Part I and Part VI	✓	✓	1A
Rice gravity	Tex-227-F, Part II	✓	✓	1A
Gradation and asphalt binder content[2]	Tex-236-F, Part I	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F, Part II	✓	✓	1A/AGG101
Hamburg wheel test	Tex-242-F	✓	✓	1A
Micro-Deval abrasion	Tex-461-A	–	✓	AGG101
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F	–	✓	Department

Test Description	Test Method	Contractor	Engineer	Level[1]
Placement Testing				
Selecting placement random numbers	Tex-225-F, Part II		✓	1B
Trimming roadway cores	Tex-251-F, Part I and Part II	✓	✓	1A/1B
In-place air voids	Tex-207-F, Part I and Part VI	✓	✓	1A
In-place density (nuclear method)	Tex-207-F, Part III	✓	–	1B
Establish rolling pattern	Tex-207-F, Part IV	✓	–	1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note[3]
Segregation (density profile)	Tex-207-F, Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F, Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B
Shear bond strength test	Tex-249-F	–	✓	Department

1. Levels 1A, 1B, AGG101, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Refer to Section 344.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
3. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when surface test Type B is specified.

4.2. **Reporting and Responsibilities**. Use Department-provided templates to record and calculate all test data, including mixture design, production and placement QC and quality assurance (QA), control charts, thermal profiles, segregation density profiles, and longitudinal joint density. Obtain the current version of the templates from the Department's website or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is shown in Table 7, unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, or a payment adjustment less than 1.000, or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

Subsequent sublots placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[4]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg wheel test[5]			
Boil test[4]			
Binder tests[5]			
Placement Quality Control			
In-place air voids[2]	Contractor	Engineer	1 working day of completion of the lot
Segregation[1]			
Longitudinal joint density[1]			
Thermal profile[1]			
Placement Quality Assurance			
In-place air voids[1]	Engineer	Contractor	1 working day after receiving the trimmed cores[6]
Segregation[3]			1 working day of completion of the lot
Longitudinal joint density[3]			
Thermal profile[3]			
Aging ratio[5]			
Shear bond strength test[5]			5 working days after receiving the cores
Payment adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every sublot.
2. Optional test. When performed on split samples, report the results as soon as they become available.
3. To be performed at the frequency shown in Table 16 or as shown on the plans.
4. When shown on the plans.
5. To be reported as soon as the results become available.
6. Two days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided template to calculate all payment adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign-off on the payment adjustment summary documentation for the lot.

Use the procedures described in Tex-233-F to plot the results of all QC and QA testing. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP)**. Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting. Receive approval of the QCP before beginning production. Include the following items in the QCP.

4.3.1. **Project Personnel**. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action,
- current contact information for each individual listed, and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage**. For material delivery and storage, include:

- the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- aggregate stockpiling procedures to avoid contamination and segregation;
- frequency, type, and timing of aggregate stockpile testing to assure conformance with material requirements before mixture production; and
- procedure for monitoring the quality and variability of asphalt binder.

4.3.3. **Production**. For production, include:

- loader operation procedures to avoid contamination in cold bins;
- procedures for calibrating and controlling cold feeds;
- procedures to eliminate debris or oversized material;
- procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, RAP, RAS, lime, liquid antistrip, compaction aid, foaming process, and WMA);
- procedures for reporting job control test results; and
- procedures to avoid segregation and drain-down in the silo.

4.3.4. **Loading and Transporting**. For loading and transporting, include:

- type and application method for release agents, and
- truck-loading procedures to avoid segregation.

4.3.5. **Placement and Compaction**. For placement and compaction, include:

- proposed agenda for mandatory pre-paving meeting, including date and location;
- proposed paving plan (e.g., production rate, paving widths, joint offsets, and lift thicknesses);
- type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- procedures for the transfer of mixture into the paver while avoiding physical and thermal segregation and preventing material spillage;
- process to balance production, delivery, paving, and compaction to achieve continuous placement operations and good ride quality;
- paver operations (e.g., speed, operation of wings, and height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- procedures to construct quality longitudinal and transverse joints.

4.4. **Mixture Design**.

4.4.1. **Design Requirements**. Use the SP design procedure provided in Tex-204-F, unless otherwise shown on the plans. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

Design the mixture using an SGC and 50 gyrations as the design number of gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value shown in Table 9. The Ndesign level may be reduced to at least 35 gyrations at the Contractor's discretion.

Use a Department-approved laboratory listed on the MPL to perform the Hamburg wheel test and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg wheel test. Upon receiving the sample from the Contractor, the Engineer will be allowed 10 working days to provide the Contractor with Hamburg wheel test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design anytime during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor may begin production.

Provide the Engineer with a mixture design report using the Department-provided template. Include the following items in the report.

- the combined aggregate gradation, source, specific gravity, and percent of each material used
- the binder source and optimum design asphalt content
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles
- the Ndesign level used on the SGC
- results of all applicable tests
- the mixing and molding temperatures
- the signature of the Level 2 person or persons who performed the design
- the date the mixture design was performed
- a unique identification number for the mixture design

Table 8
Master Gradation Limits (% Passing by Wt. or Volume) and Voids in Mineral Aggregates (VMA) Requirements

Sieve Size	SP-B Intermediate	SP-C Surface	SP-D Fine Mixture
2"	–	–	–
1-1/2"	100.0[1]	–	–
1"	98.0–100.0	100.0[1]	–
3/4"	90.0–100.0	98.0–100.0	100.0[1]
1/2"	Note[2]	90.0–100.0	98.0–100.0
3/8"	—	Note[2]	90.0–100.0
#4	23.0–90.0	28.0–90.0	32.0–90.0
#8	23.0–34.6	28.0–37.0	32.0–40.0
#16	2.0–28.3	2.0–31.6	2.0–37.6
#30	2.0–20.7	2.0–23.1	2.0–27.5
#50	2.0–13.7	2.0–15.5	2.0–18.7
#200	2.0–8.0	2.0–10.0	2.0–10.0
Design VMA, % Min			
–	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Min			
–	13.5	14.5	15.5

1. Defined as Max sieve size. No tolerance allowed.
2. Must retain at least 10% cumulative.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, %	Tex-207-F	96.0
Design gyrations (Ndesign)	Tex-241-F	50[1]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[2]
Dust/asphalt binder ratio[3]	–	0.6–1.4
Boil test[4]	Tex-530-C	–

1. Adjust within a range of 35–100 gyrations when shown on the plans or specification or mutually agreed between the Engineer and Contractor.
2. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg wheel rut depth is greater than 2.5 mm and less than 12.5 mm.
3. Defined as % passing #200 sieve divided by asphalt binder content.
4. When shown on the plans. Used to establish baseline for comparison to production results.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Min # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. The Hamburg wheel test will have a Min rut depth of 2.5 mm.
2. May be decreased to a Min of 5,000 passes when shown on the plans.
3. May be decreased to a Min of 10,000 passes when shown on the plans.

4.4.2. **Job-Mix Formula Approval**. The JMF is the combined aggregate gradation, Ndesign level, and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive, foaming process, or compaction aid. When WMA or a compaction aid is used, document the additive or process used and recommended rate in the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch, unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than two trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities**.

4.4.2.1.1. **Providing Superpave Gyratory Compactor (SGC)**. Provide an SGC in accordance with Item 504, "Field Office and Laboratory," and make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors**. Use Tex-206-F Part II, to perform a gyratory compactor correlation when the Engineer uses a different SGC. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1**. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 25 lb. of the design mixture if opting to have the Department perform the Hamburg wheel test on the laboratory mixture, and request that the Department perform the test.

4.4.2.1.4. **Supplying Aggregates**. Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt**. Provide at least 1 gal. of the asphalt material and enough quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors**. Notify the Engineer before performing Tex-236-F, Part II. Allow the Engineer to witness the mixing of ignition oven correction factor samples. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F, Part II.

If the Engineer witnesses the mixing of the ignition oven correction factor samples, provide the Engineer with identically prepared samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for QA testing during production.

Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used, unless otherwise directed. Correction factors must be performed every 12 mo.

4.4.2.1.7. **Boil Test**. When shown on the plans, perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production.

4.4.2.1.8. **Trial Batch Production**. Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch. If applicable, include the WMA additive, foaming process, or compaction aid for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements shown in Tables 4, 5, and 11. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment**. Use only equipment and materials proposed for use on the project to produce the trial batch.

4.4.2.1.10. **Trial Batch Quantity**. Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches**. Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling**. Obtain a representative sample of the trial batch and split it into three equal portions in accordance with Tex-222-F. Label these portions as "Contractor," "Engineer," and "Referee." Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements shown in Table 11. Ensure the trial batch mixture is also in compliance with the Hamburg wheel test requirement shown in Table 10. Use a Department-approved laboratory on the MPL to perform the Hamburg wheel test on the trial batch mixture, or request that the Department perform the Hamburg wheel test. Provide approximately 25 lb. of the trial batch mixture if opting to have the Department perform the Hamburg wheel test, and request that the Department perform the test. Upon receiving the sample from the Contractor, the Engineer will be allowed 10 working days to provide the Contractor with Hamburg wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2**. After the Engineer grants full approval of JMF1, evaluate the trial batch test results, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements shown in Table 4 and Table 5.

4.4.2.1.15. **Mixture Production**. Use JMF2 to produce Lot 1 as described in Section 344.4.9.3.1.1., "Lot 1 Placement," after receiving approval for JMF2 and a passing Hamburg wheel result on the trial batch from a laboratory listed on the MPL. Once JMF2 is approved, and without receiving the results from the Department's Hamburg wheel test on the trial batch, the Contractor may proceed to Lot 1 production at their own risk.

Notify the Engineer if electing to proceed without Hamburg wheel test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg wheel test to be removed and replaced at the Contractor's expense.

4.4.2.1.16. **Development of JMF3**. Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, make the adjustment before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot,
- be numbered in sequence to the previous JMF,
- meet the mixture requirements shown in Table 4 and Table 5,
- meet the master gradation limits shown in Table 8, and

- be within the operational tolerances of JMF2 shown in Table 11.

4.4.2.1.18. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 344.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between JMF2 and JMF1 Target[1]	Allowable Difference Between Current JMF and JMF2[2]	Allowable Difference Between Contractor and Engineer[3]
Individual % retained on #8 sieve and larger	Tex-200-F or Tex-236-F	Must be within master gradation limits in Table 8	±5.0[4]	±5.0
Individual % retained on sieves smaller than #8 and larger than #200			±3.0[4]	±3.0
% passing the #200 sieve			±2.0[4]	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3	±0.3
Dust/asphalt binder ratio[5]	–	Note [6]	Note [6]	–
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±0.5
In-place air voids, %		–	–	±1.0
Laboratory-molded bulk specific gravity		–	–	±0.020
VMA, %, Min	Tex-204-F	Note [7]	Note [7]	–
Theoretical Max specific (Rice) gravity	Tex-227-F	–	–	±0.020

1. JMF1 is the approved laboratory mixture design used for producing the trial batch. JMF2 is the approved mixture design developed from the trial batch used to produce Lot 1.
2. Current JMF is JMF3 or higher. JMF3 is the approved mixture design used to produce Lot 2.
3. Contractor may request referee testing only when values exceed these tolerances.
4. When within these tolerances, mixture production gradations may fall outside the master gradation limits; however, the % passing the #200 and the % passing the #8 will be considered out of tolerance when outside the master gradation limits.
5. Defined as % passing #200 sieve divided by asphalt binder content.
6. Verify that Table 9 requirements are met.
7. Verify that Table 8 requirements are met for VMA.

4.4.2.2. **Engineer's Responsibilities**.

4.4.2.2.1. **Superpave Gyratory Compactor**. The Engineer will use a Department SGC, calibrated in accordance with Tex-241-F, to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch**. The Engineer will review and verify conformance with the following information within 2 working days of receipt.

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg wheel test results;
- all required materials including aggregates, asphalt, additives, and recycled materials; and
- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 344.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after 2 working days, conditional approval of JMF1 will still be granted within 2 working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

The Contractor is authorized to produce a trial batch after the Engineer grants conditional approval or JMF1.

4.4.2.2.3. **Hamburg Wheel Testing of JMF1**. If the Contractor requests the option to have the Department perform the Hamburg wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg wheel test requirement shown in Table 10. Upon receiving the sample from the Contractor, the Engineer will be allowed 10 working days to provide the Contractor with Hamburg wheel test results on the laboratory mixture design.

4.4.2.2.4. **Ignition Oven Correction Factors**. The Engineer will determine ignition oven correction factors by one of the following options.

- Witness the mixing of ignition oven correction factor samples by the Contractor in accordance with Tex-236-F, Part III. The Engineer will use the identically prepared samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven in accordance with Tex-236-F, Part II.
- If the Engineer does not witness the mixing of ignition oven correction factor samples, the Engineer will prepare the samples to determine the aggregate and asphalt correction factors for the ignition oven in accordance with Tex-236-F, Part II. Notify the Contractor before performing Tex-236-F, Part II. Allow the Contractor to witness the Engineer performing Tex-236-F, Part II.

Correction factors must be performed every 12 mo. to be used for QA testing during production.

4.4.2.2.5. **Testing the Trial Batch**. Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements shown in Table 11. If the Contractor requests the option to have the Department perform the Hamburg wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg wheel test requirement shown in Table 10.

The Engineer will have the option to perform the following tests on the trial batch:

- Tex-226-F, to verify that the indirect tensile strength meets the requirement shown in Table 9; and
- Tex-530-C, to retain and use for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1**. The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements shown in Tables 8, 9, and 10. The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2**. The Engineer will approve JMF2 within 1 working day if the mixture meets the requirements shown in Table 5 and Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

4.4.2.2.8. **Approval of Lot 1 Production**. The Engineer will authorize the Contractor to proceed with JMF2 for Lot 1 production after a passing Hamburg wheel test result on the trial batch is achieved from a laboratory listed on the MPL. The Contractor may proceed at their own risk with Lot 1 production without the results from the Hamburg wheel test on the trial batch.

If the Department-approved laboratory's sample from the trial batch fails the Hamburg wheel test, the Engineer will suspend production until further Hamburg wheel tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg wheel test be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes**. JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4 and Table 5, and the master gradation limits shown in Table 8, and they are within the operational tolerances of JMF2 shown in Table 11. Current JMF changes

that exceed the operational tolerances of JMF2 shown in Table 11 may require a new laboratory mixture design, trial batch, or both. The addition of a WMA additive to facilitate mixing or as a compaction aid does not require a new laboratory mixture design or trial batch.

4.5. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. All source changes for asphalt will require a passing Hamburg wheel test result from a laboratory listed on the MPL. The Contractor may proceed at their own risk with Lot 1 production without the results from the Hamburg wheel test on the trial batch. All aggregate source changes will require a new laboratory mixture design and trial batch. Take corrective action and receive approval to proceed after any production suspension for noncompliance with the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown in the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown in the mixture design report.

4.5.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperatures specified in Item 300, or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and HMA discharge temperatures (in legible and discernible increments) in accordance with Item 320, unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials**. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed the maximum production temperatures shown in Table 12. The Department will not pay for or allow placement of any mixture produced above the maximum production temperatures shown in Table 12.

Table 12
Max Production Temperature

High-Temperature Binder Grade[1]	Max Production Temperature (°F)
PG 64	325[2]
PG 70	335[2]
PG 76	345[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The Max production temperature of WMA is 275°F.

Produce WMA within the target discharge temperature range of 215–275°F when WMA is required. Take corrective action anytime the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck and perform the test promptly.

4.6. **Hauling Operations**. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent listed on the MPL to coat the inside bed of the truck when necessary. Do not use diesel or any release agent not listed on the MPL.

Use equipment for hauling as defined in Section 344.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations**. Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a handheld thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or material transfer device (MTD) before or as the mix enters the paver. Measure the mixture temperature at a minimum frequency of one per ten trucks, or as approved. Include an approximate station number or Global Positioning System coordinates of the location where the temperature was taken on each ticket. Ensure the mixture meets the temperature requirements shown in Table 12. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide within 6 in. of lane lines, are not placed in the wheel path, or will not be covered with pavement markings, or as directed. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines shown in Table 13 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb. per square yard for each inch of pavement unless otherwise shown on the plans.

Table 13
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Min Untrimmed Core Height Eligible for Testing (in.)
	Min (in.)	Max (in.)	
SP-B	2.50	4.0	2.00
SP-C	2.00	3.0	1.25
SP-D	1.25	2.0	1.25

4.7.1. **Weather Conditions**.

4.7.1.1. **When Using a Thermal Imaging System**. Place mixture when the roadway surface is dry and the roadway surface temperature is at or above the temperatures shown in Table 14A, unless otherwise approved or shown on the plans. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 344.4.7.3.1.2., "Thermal Imaging System."

Table 14A
Min Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Min Pavement Surface Temperatures (°F)	
	Subsurface Layers	Surface Layers
PG 64	35	40
PG 70	45[2]	50[2]
PG 76	45[2]	50[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. Contractors may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture or when using WMA.

4.7.1.2. **When Not Using a Thermal Imaging System**. When using a thermal camera instead of the thermal imaging system, place mixture when the roadway surface temperature is at or above the temperatures shown in Table 14B, unless otherwise approved or shown on the plans. Measure the roadway surface temperature using a handheld thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer.

Table 14B
Min Pavement Surface Temperatures

High-Temperature Binder Grade[1]	Min Pavement Surface Temperatures (°F)	
	Subsurface Layers	Surface Layers
PG 64	45	50
PG 70	55[2]	60[2]
PG 76	60[2]	60[2]

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The Contractor may pave at temperatures 10°F lower than these values when a chemical WMA additive is used as a compaction aid in the mixture, when using WMA, or when using a paving process with equipment that eliminates thermal segregation. In such cases, for each sublot and in the presence of the Engineer, use a handheld thermal camera operated in accordance with Tex-244-F to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

4.7.2. **Tack Coat**.

4.7.2.1. **Application**. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 gal. and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply the tack coat to all surfaces that will contact the subsequent HMA placement, unless otherwise directed. Apply adequate overlap of the tack coat in the longitudinal direction during placement of the mat to ensure bond of adjacent mats, unless otherwise directed. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. The Engineer may suspend paving operations until there is adequate coverage. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use, unless required in conformance with the manufacturer's recommendation for approved TRAIL products listed on the MPL.

4.7.2.2. **Sampling.** The Engineer will obtain at least one sample of the tack coat binder per project per source in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300. The Engineer will notify the Contractor when the sampling will occur and will witness the collection of the sample from the asphalt distributor immediately before use. Label the can with the corresponding lot and sublot numbers, producer, name; producer facility location, grade, District, date sampled, all applicable bills of lading (if available), and project information including highway and control-section-job (CSJ) number. For emulsions, the Engineer

may test as often as necessary to ensure the residual of the emulsion is greater than or equal to the specification requirement in accordance with Item 300.

4.7.3. **Lay-Down Operations**. Use the placement temperatures in accordance with Table 15 to establish the minimum placement temperature of mixture delivered to the paving operation.

Table 15
Min Mixture Placement Temperature

High-Temperature Binder Grade[1]	Min Placement Temperature[2,3,4] (°F)
PG 64	260˚F
PG 70	270˚F
PG 76	280˚F

1. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
2. The mixture temperature must be measured using a handheld thermal camera or infrared thermometer immediately before entering MTD or paver.
3. Min placement temperatures may be reduced 20°F if using a chemical WMA additive as a compaction aid, MTD with remixing capabilities, or paver hopper insert with remixing capabilities.
4. When using WMA, the Min placement temperature is 215°F.

4.7.3.1. **Thermal Profile**. Use a handheld thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 344.4.9.3.1.4., “Miscellaneous Areas.”

4.7.3.1.1. **Thermal Segregation**.

4.7.3.1.1.1. **Moderate**. Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F.

4.7.3.1.1.2. **Severe**. Any areas that have a temperature differential greater than 50°F.

4.7.3.1.2. **Thermal Imaging System**. Review the output results when a thermal imaging system is used, and provide the automated report described in Tex-244-F to the Engineer daily, unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system.

The Engineer may suspend paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe thermal segregation. Density profiles are not required and not applicable when using a thermal imaging system.

Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots daily or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera**. Provide the Engineer with the thermal profile of every sublot within 1 working day of the completion of each lot. When requested by the Engineer, provide the thermal images generated using the thermal camera. Report the results of each thermal profile in accordance with Section 344.4.2., “Reporting and Responsibilities.” The Engineer will use a handheld thermal camera to obtain a thermal profile at least once per project.

Take immediate corrective action to eliminate recurring moderate thermal segregation when a handheld thermal camera is used.

Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains severe thermal segregation. Evaluate areas with severe thermal segregation

by performing density profiles in accordance with Section 344.4.9.3.3.3., "Segregation (Density Profile)." Remove and replace the material in any areas that have severe thermal segregation and a failing result for segregation (density profile) unless otherwise directed. The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

4.7.3.2. **Windrow Operations**. Operate windrow pickup equipment so that when hot mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. **Hauling Equipment**. Use belly dump, live-bottom, or end dump trucks to haul and transfer mixture. Except for paving miscellaneous areas, end dump trucks are allowed only when used in conjunction with an MTD with remixing capability, or when a thermal imaging system is used, unless otherwise approved.

4.7.3.4. **Screed Heaters**. Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 344.4.9.3.3.5., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction**. Compact the pavement uniformly to contain between 3.7% and 7.5% in-place air voids. Take immediate corrective action to bring the operation within 3.7% and 7.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.7% and 7.5% in-place air voids.

Obtain cores in areas placed under exempt production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.0%. Areas defined in Section 344.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers necessary to ensure desired compaction. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method in accordance with Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids, unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction using rollers. The Engineer may require rolling using a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations using breakdown rollers before the pavement temperature drops below 180°F, unless otherwise allowed. Compaction using a pneumatic or light finish roller operated in static mode is allowed for pavement temperatures above 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic, unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan**. Payment adjustments for the material will be in accordance with Article 344.6., "Payment."

Sample and test the hot mix on a lot-and-sublot basis. Suspend production if the production payment factor in accordance with Section 344.6.1., "Production Payment Adjustment Factors," or the placement payment factor in accordance with Section 344.6.2., "Placement Payment Adjustment Factors," for two consecutive lots is below 1.000. Resume production once test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in payment factors of at least 1.000.

4.9.1. **Referee Testing**. The Materials and Tests Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference in accordance with Table 11 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within 5 working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than three referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

The Materials and Tests Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk-specific gravity of the cores, as determined by the referee laboratory, and the Engineer's average maximum theoretical specific gravity for the lot. Except for "remove and replace" conditions, referee test results are final and will establish payment adjustment factors for the sublot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any sublot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 344.6.2.2., "Placement Sublots Subject to Removal and Replacement."

4.9.2. **Production Acceptance**.

4.9.2.1. **Production Lot**. A production lot consists of four equal sublots. The default quantity for Lot 1 is 1,000 ton; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 ton. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately three–four sublots are produced each day. The lot size will be between 1,000 ton and 4,000 ton. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 to confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi, unless otherwise directed.

4.9.2.1.1. **Incomplete Production Lots**. If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 344.6.1., "Production Payment Adjustment Factors." Close all lots within 5 working days unless otherwise allowed.

4.9.2.2. **Production Sampling**.

4.9.2.2.1. **Mixture Sampling**. The Engineer will perform or witness the sampling of production sublots from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into three equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample**. At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample**. For one sublot per lot, the Engineer will sample, split, and test a "blind" production sample instead of the random sample collected by the Contractor. The location of the Engineer's "blind" sample will not be disclosed to the Contractor before sampling. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer may

sample and test an additional blind sample when the random sampling process does not result in obtaining a sample.

For one sublot per lot, the Contractor must obtain from the Engineer a "blind" production sample collected by the Engineer. If desired, the Contractor may witness the collection of blind samples. Test either the "blind" or the random sample; however, referee testing for the sublot (if applicable) will be based on a comparison of results from the "blind" sample.

4.9.2.2.2. **Asphalt Binder Sampling**. The Engineer will witness the Contractor obtain a 1-qt. sample of the asphalt binder for each lot of mixture produced. The Contractor will notify the Engineer when the sampling will occur. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill and upstream from the introduction of any additives in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers, producer name, producer facility, grade, District, date sampled, all applicable bills of lading (if available), and project information, including highway and CSJ number. The Engineer will retain these samples for 1 yr. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample and upon request of the Contractor, the Engineer will split a sample of the asphalt binder with the Contractor.

At least once per project, the Engineer will collect split samples of each binder grade and source used. The Engineer will submit one split sample to the Materials and Tests Division to verify accordance with Item 300, and will retain the other split sample for 1 yr.

4.9.2.3. **Production Testing**. The Contractor and Engineer must perform production tests shown in Table 16. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances shown in Table 11 for all sublots.

Take immediate corrective action if the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 97.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F, Part I does not yield reliable results. Provide evidence that results from Tex-236-F, Part I are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 16
Production and Placement Testing Frequency

Description	Test Method	Min Contractor Testing Frequency	Min Engineer Testing Frequency
Individual % retained on #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained on sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	–	1 per sublot[1]
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile)	Tex-207-F, Part V	1 per sublot[2]	1 per project
Longitudinal joint density	Tex-207-F, Part VII	1 per sublot[3]	1 per project
Moisture content	Tex-212-F, Part II	When directed	1 per project
Theoretical Max specific (Rice) gravity	Tex-227-F		1 per sublot[1]
Asphalt binder content	Tex-236-F, Part I	1 per sublot	1 per lot[1]
Thermal profile	Tex-244-F	1 per sublot[2]	1 per project
Hamburg wheel test	Tex-242-F	–	
Deleterious in Recycled Asphalt Shingles (RAS)[4]	Tex-217-F, Part III	–	
Asphalt binder sampling and testing[4,5]	Tex-500-C, Part II	–	
Tack coat sampling and testing	Tex-500-C, Part III	–	
Boil test[6]	Tex-530-C	1 per lot	
Shear bond strength test[7]	Tex-249-F	–	

1. For production defined in Section 344.4.9.4., "Exempt Production," the Engineer will perform one test per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. To be performed in the presence of the Engineer when not using the thermal imaging system, unless otherwise approved.
3. To be performed in the presence of the Engineer.
4. Testing performed by the Materials and Tests Division or designated laboratory.
5. Sampling performed by the Contractor. The Engineer will witness sampling and retain the samples for 1 yr.
6. When shown on the plans.
7. Testing performed by the Materials and Tests Division or District for informational purposes on a sample obtained by the Contractor within the first four lots of the project.

4.9.2.4. **Operational Tolerances**. Control the production process within the operational tolerances shown in Table 11. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.2.4.1. **Gradation**. Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances shown in Table 11 for three consecutive sublots on the same sieve or four consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content**. A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values shown in Table 11. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot.

4.9.2.4.3. **VMA**. The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production shown in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA results on two consecutive sublots are below the minimum VMA requirement for production shown in

Table 8. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that does not meet the minimum VMA requirement for production shown in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production shown in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel Test**. The Engineer may perform a Hamburg wheel test on plant-produced mixture anytime during production. Suspend production until further Hamburg wheel tests meet the specified values when the production samples fail the Hamburg wheel test criteria shown in Table 10. The Engineer may require up to the entire sublot of any mixture failing the Hamburg wheel test to be removed and replaced at the Contractor's expense.

If the Department-approved laboratory's Hamburg wheel test on plant-produced mixture results in a "remove and replace" condition, the Contractor may request that the Materials and Tests Division determine the final disposition of the material in question by re-testing the failing material.

4.9.2.5. **Individual Loads of Hot Mix**. The Engineer may reject individual truckloads of hot mix. When a load of hot mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance**.

4.9.3.1. **Placement Lot**. A placement lot consists of four placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Lot 1 Placement**. Placement payment adjustments greater than 1.000 for Lot 1 will be in accordance with Section 344.6.2., "Placement Payment Adjustment Factors"; however, no placement adjustment less than 1.000 will be assessed for any sublot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.0%. Remove and replace any sublot with in-place air voids less than 2.7% or greater than 9.0%.

4.9.3.1.2. **Incomplete Placement Lots**. An incomplete placement lot consists of the area placed as described in Section 344.4.9.2.1.1., "Incomplete Production Lots," excluding areas defined in Section 344.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production sublot.

4.9.3.1.3. **Shoulders, Ramps, Etc**. Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and payment adjustments unless shown on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

4.9.3.1.4. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, pavement repair sections less than 300 ft., and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness shown on the plans is less than the minimum untrimmed core height eligible for testing in accordance with Table 13. The specified layer thickness is based on the rate of 110 lb. per square yard for each inch of pavement unless another rate is shown on the plans. When "Level Up" is listed as part of the item bid description code, a payment adjustment factor of 1.000 will be assigned for all placement sublots as described in Article 344.6., "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with

Section 344.4.8., "Compaction." Miscellaneous areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

4.9.3.2. **Placement Sampling**. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers only immediately after the sublot is completed. Mark the roadway location at the completion of each sublot and record the station number. Determine one random sample location for each placement sublot in accordance with Tex-225-F. Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the sublot and a 1.000 pay factor will be assigned to that sublot.

Provide the equipment and means to obtain and trim roadway cores onsite. Onsite is defined as in close proximity to where the cores are taken. Obtain the cores within 1 working day of the time the placement sublot is completed, unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement sublot. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining them from the roadway in accordance with Tex-251-F if the core heights meet the minimum untrimmed value shown in Table 13. Trim the cores onsite in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and sublot numbers on each core, as well as the designation as Core A or Core B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after witnessing the trimming of the cores and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the roadway core custody protocol located on the Department's website to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that sublot if the core height before trimming is less than the minimum untrimmed value in accordance with Table 13. Trim the cores as described in the preceding paragraphs before delivering to the Engineer if electing to have the cores included in the air void determination. If electing to not have the cores included in air void determination, inform the Engineer of the decision and deliver untrimmed cores to the Engineer. The placement pay factor for the sublot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores onsite immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location, such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture, and properly compact the mixture. Repair core holes using other methods when approved.

4.9.3.3. **Placement Testing**. Perform placement tests in accordance with Table 16. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are shown in Table 11.

4.9.3.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be pre-dried using a CoreDry or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required in accordance with Tex-207-F. The Engineer will use the test results from the unsealed core to determine the placement payment adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

4.9.3.3.2. **Informational Shear Bond Strength Testing**. The Engineer will select one random sublot within the first four lots of the project for shear bond strength testing. Obtain full-depth cores in accordance with Tex-249-F unless the HMA is being placed directly on concrete pavement. Label the cores with lot and sublot numbers, and provide to the Engineer. Inspector must use pertinent Department form to document the CSJ number, producer of the tack coat, mix type, and shot rate. The Engineer will ship the cores to the Materials and Tests Division or District laboratory for shear bond strength testing. Results from these tests will not be used for specification compliance.

4.9.3.3.3. **Segregation (Density Profile**). Test for segregation using density profiles in accordance with Tex-207-F, Part V. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 344.4.9.3.1.4., "Miscellaneous Areas."

Perform at least one density profile per sublot. Perform additional density profiles when any of the following conditions occur, unless otherwise approved.

- Areas that are identified by either the Contractor or the Engineer with severe thermal segregation.
- Any visibly segregated areas that exist.
- The paver stops due to lack of material being delivered to the paving operations and the temperature of the uncompacted mat before the initial breakdown rolling is lower than the temperatures shown in Table 17.

Table 17
Min Uncompacted Mat Temperature Requiring Segregation Profile[1]

High-Temperature Binder Grade[2]	Min Temperature of Uncompacted Mat Allowed Before Initial Breakdown Rolling[3,4,5] (°F)
PG 64	<250
PG 70	<260
PG 76	<270

1. Applicable only to paver stops that occur due to lack of material being delivered to the paving operations and when not using a thermal imaging system.
2. The high-temperature binder grade refers to the high-temperature grade of the virgin asphalt binder used to produce the mixture.
3. The surface of the uncompacted mat must be measured using a handheld thermal camera or infrared thermometer.
4. Min uncompacted mat temperature requiring a segregation profile may be reduced 20°F if using a chemical WMA additive as a compaction aid, MTD with remixing capabilities, or paver hopper insert with remixing capabilities.
5. When using WMA, the Min uncompacted mat temperature requiring a segregation profile is 215°F.

Provide the Engineer with the density profile of every sublot in the lot within 1 working day of the completion of each lot. Report the results of each density profile in accordance with Section 344.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances shown in Table 18. When a thermal imaging system is not used, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 344.4.9.3.3.6., "Irregularities." The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if two consecutive density profiles fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

Table 18
Segregation (Density Profile) Acceptance Criteria

Mixture Type	Max Allowable Density Range (Highest to Lowest)	Max Allowable Density Range (Average to Lowest)
SP-B	8.0 pcf	5.0 pcf
SP-C & SP-D	6.0 pcf	3.0 pcf

4.9.3.3.4. **Longitudinal Joint Density**.

4.9.3.3.4.1. **Informational Tests**. Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf below the density taken at or near the center of the mat. Adjust the rolling pattern, if needed, to achieve the desired joint density. Perform additional joint density evaluations, at least once per sublot, unless otherwise directed.

4.9.3.3.4.2. **Record Tests**. Perform a joint density evaluation for each sublot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 344.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density

verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every sublot in the lot within 1 working day of the completion of each lot. Report the results of each joint density in accordance with Section 344.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on two consecutive sublots fail, unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

4.9.3.3.5. **Recovered Asphalt Dynamic Shear Rheometer (DSR)**. The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Materials and Tests Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high-temperature PG of the asphalt. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores in accordance with Tex-211-F.

4.9.3.3.6. **Irregularities**. Identify and correct irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities. The Engineer may also require the Contractor to remove and replace (at the Contractor's expense) areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than 1 day while the Contractor is taking appropriate corrective action.

4.9.4. **Exempt Production**. The mixture may be deemed as exempt production when mutually agreed between the Engineer and the Contractor or when shown on the plans. Exempt production may be used for the following conditions.

- Anticipated daily production is less than 500 ton.
- Total production for the project is less than 5,000 ton.
- Pavement repair sections are equal to or greater than 300 ft. For pavement repair sections less than 300 ft., refer to Section 344.4.9.3.1.4., "Miscellaneous Areas."

Exempt production is not eligible for referee testing. For exempt production, the Contractor is relieved of all production and placement QC and QA sampling and testing requirements, except for coring operations when required by the Engineer. When mutually agreed between the Engineer and the Contractor, production sampling will be allowed at the point of delivery. When 100 ton or more per day is produced, the Engineer must perform acceptance tests for production and placement shown in Table 16. If the specification requirements listed below are met, the production and placement pay factors are 1.000.

- Produce, haul, place, and compact the mixture in accordance with the Specification and as directed.
- Control mixture production must yield a laboratory-molded density that is within ±1.0% of the target laboratory-molded density as tested by the Engineer.
- Compact the mixture in accordance with Section 344.4.8., "Compaction."
- When a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification; and
- Complete all other specification requirements.

4.9.5. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

5.1. **Superpave Mixtures**. Hot mix will be measured by the ton of composite hot mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

5.2. **Tack Coat**. Tack coat will be measured at the applied temperature by strapping the tank before and after road application and determining the net volume in gallons from the calibrated distributor. The Engineer will witness all strapping operations for volume determination. All tack, including emulsions, will be measured by the gallon applied.

The Engineer may allow the use of a metering device to determine asphalt volume used and application rate if the device is accurate within 1.5% of the strapped volume.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 344.5.1., "Superpave Mixtures," will be paid for at the unit price bid for "Superpave Mixtures" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials, placement, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under Section 344.5.2., "Tack Coat," will be paid for at the unit price bid for "Tack Coat" of the tack coat provided. These prices are full compensation for materials, placement, equipment, labor, tools, and incidentals. Payment adjustments will be applied as determined in accordance with this Item; however, a payment adjustment factor of 1.000 will be assigned for all placement sublots for level-ups only when "Level Up" is listed as part of the bid item description. A payment adjustment factor of 1.000 will be assigned to all production and placement sublots when "Exempt" is listed as part of the bid item description, and all testing requirements are met.

Payment for each sublot, including applicable payment adjustments greater than 1.000, will be paid only for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC and QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 344.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports in accordance with Tex-244-F are required.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585.

6.1. **Production Payment Adjustment Factors**. The production payment adjustment factor is based on the laboratory-molded density using the Engineer's test results. The bulk-specific gravities of the samples from each sublot will be divided by the Engineer's maximum theoretical specific gravity for the sublot. The individual sample densities for the sublot will be averaged to determine the production payment adjustment factor shown in Table 19 for each sublot, using the deviation from the target laboratory-molded density shown in Table 9. The production payment adjustment factor for completed lots will be the average of the payment adjustment factors for the four sublots sampled within that lot.

Table 19
Production Payment Adjustment Factors for Laboratory-Molded Density[1]

Absolute Deviation from Target Laboratory-Molded Density	Production Payment Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.075
0.1	1.075
0.2	1.075
0.3	1.066
0.4	1.057
0.5	1.047
0.6	1.038
0.7	1.029
0.8	1.019
0.9	1.010
1.0	1.000
1.1	0.900
1.2	0.800
1.3	0.700
>1.3	Remove and replace

1. If the Engineer's laboratory-molded density on any sublot is <95.0% or >97.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

6.1.1. **Payment for Incomplete Production Lots**. Production payment adjustments for incomplete lots, described under Section 344.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production payment factors from all sublots sampled.

A production payment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples within the first sublot.

6.1.2. **Production Sublots Subject to Removal and Replacement**. If after referee testing the laboratory-molded density for any sublot results in a "remove and replace" condition as shown in Table 19, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.2. **Placement Payment Adjustment Factors**. The placement payment adjustment factor is based on in-place air voids using the Engineer's test results. The bulk-specific gravities of the cores from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the placement payment adjustment factor shown in Table 20 for each sublot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire sublot when the random sample location falls in an area shown on the plans as not subject to in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 344.4.9.3.1.4., "Miscellaneous Areas." The placement payment adjustment factor for completed lots will be the average of the placement payment adjustment factors for up to four sublots within that lot.

Table 20
Placement Payment Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Payment Adjustment Factor	In-Place Air Voids	Placement Payment Adjustment Factor
<2.7	Remove and replace	5.9	1.048
2.7	0.710	6.0	1.045
2.8	0.740	6.1	1.042
2.9	0.770	6.2	1.039
3.0	0.800	6.3	1.036
3.1	0.830	6.4	1.033
3.2	0.860	6.5	1.030
3.3	0.890	6.6	1.027
3.4	0.920	6.7	1.024
3.5	0.950	6.8	1.021
3.6	0.980	6.9	1.018
3.7	1.000	7.0	1.015
3.8	1.015	7.1	1.012
3.9	1.030	7.2	1.009
4.0	1.045	7.3	1.006
4.1	1.060	7.4	1.003
4.2	1.075	7.5	1.000
4.3	1.075	7.6	0.980
4.4	1.075	7.7	0.960
4.5	1.075	7.8	0.940
4.6	1.075	7.9	0.920
4.7	1.075	8.0	0.900
4.8	1.075	8.1	0.880
4.9	1.075	8.2	0.860
5.0	1.075	8.3	0.840
5.1	1.072	8.4	0.820
5.2	1.069	8.5	0.800
5.3	1.066	8.6	0.780
5.4	1.063	8.7	0.760
5.5	1.060	8.8	0.740
5.6	1.057	8.9	0.720
5.7	1.054	9.0	0.700
5.8	1.051	>9.0	Remove and replace

6.2.1. **Payment for Incomplete Placement Lots**. Payment adjustments for incomplete placement lots described under Section 344.4.9.3.1.2., “Incomplete Placement Lots,” will be calculated using the average of the placement pay factors from all sublots sampled and sublots where the random location falls in an area shown on the plans as not eligible for in-place air void determination.

If the random sampling plan results in production samples, but not in placement samples, the random core location and placement adjustment factor for the sublot will be determined by applying the placement random number to the length of the sublot placed.

If the random sampling plan results in placement samples, but not in production samples, no placement adjustment factor will apply for that sublot placed.

A placement payment adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any production samples.

6.2.2. **Placement Sublots Subject to Removal and Replacement**. If after referee testing the placement payment adjustment factor for any sublot results in a “remove and replace” condition as listed in Table 20, the Engineer will choose the location of two cores to be taken within 3 ft. of the original failing core location. The Contractor must obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Materials and Tests Division, where they will be trimmed, if necessary, and tested for bulk-specific gravity within 10 working days of receipt.

The bulk-specific gravity of each core from each sublot will be divided by the Engineer's average maximum theoretical specific gravity for the lot. The individual core densities for the sublot will be averaged to determine the new payment adjustment factor of the sublot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that sublot. If the new payment adjustment factor is less than 0.700, no payment will be made for the sublot. Remove and replace the failing sublot, or the Engineer may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.3. **Total Adjusted Pay (TAP) Calculation**. TAP will be based on the applicable payment adjustment factors for production and placement for each lot.

TAP = (A+B)/2

where:
A = Bid price × production lot quantity × average payment adjustment factor for the production lot
B = Bid price × placement lot quantity × average payment adjustment factor for the placement lot + (bid price × quantity placed in miscellaneous areas × 1.000)

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas.