HMA Quality Control Technician Certification Program

Conducted by the Clemson University Civil Engineering Department and SCDOT

Any Questions/Comments?

- Please Contact:

  - Serji Amirkhanian
    Civil Engineering Dept.
    Clemson University
    P.O. Box 340911
    Clemson, SC 29634-0911
  - Phone: 864-656-3316
  - Fax: 864-656-2670
  - E-Mail: kcdoc@clemson.edu

Course Contents

Chapter 1

Responsibilities and Qualifications of the HMA Quality Control Technician

Chapter 1: Contents

Introduction

- The technician is a person who is knowledgeable about many aspects of roadway construction (mix design, plant problems, etc.). In addition, this person is capable of following all of the requirements of the plans and specifications.

Purpose of Inspection

- Inspection is needed to ensure that the HMA mix and finished pavement meet the project requirements according to the plans and specifications.

Definitions

- Contract: A document that contains the agreement made between the owner (SCDOT, for example) and the contractor.
- Plans: These are contract documents that show the location, physical aspects, and dimensions of the work.
- Specifications: The written technical requirements for the work.

Technician's Responsibilities

- Proper sampling and testing.
- Required record keeping.
- Perform tasks in a safe manner.

Technician's Qualifications

- Must successfully pass the exam at the end of Level I class.
- Must know at least the following test procedures:
  - Reducing Field Samples of Aggregate to Testing Size (AASHTO T-248)
  - Washed and Dry Sieve Analysis (AASHTO T-11 and T-27)
  - Bulk Specific Gravity of Asphalt Mixtures (AASHTO T-166)
  - Maximum Specific Gravity of Asphalt Mixtures (AASHTO T-209)
  - Determination of Air Voids and VMA (SC-T-68)
  - Marshall Stability (SC-T-66)
  - Determination of Asphalt Binder Content by the Ignition Oven (SC-T-75)

Technician's Qualifications

- A valid certificate of qualification must be in the technician's possession.
- Questions: Contact Mr. Chad Hawkins, SCDOT Bituminous Engineer, at 803-737-6700.

Summary

- Technician is the agent of the contractor.
- Technician must ensure that the plans and specifications for the job are followed.
- Technician must be capable of maintaining neat, legible, and thorough records and reports.
- Technician must inform the contractor of situations when job plans and specifications are not followed.
- Technician must be a very knowledgeable person.

End of Chapter 1

Any Questions?

Chapter 2

Aggregates

Chapter 2: Objectives

- Properties of aggregates.
- Sampling procedures for aggregates.
- Aggregate gradation and blending.
- Aggregate testing procedures.
- Effects of aggregates on various HMA mix properties.

Definition

- The word “Aggregate” refers to any combination of sand, gravel, and crushed stone in their natural or processed state.

Aggregate Types

- Fine Aggregate (FA)
  - Virtually all passes the #4 (4.75 mm) sieve and predominantly retained on the #200 (0.75 mm) sieve.
- Coarse Aggregate (CA)
  - Virtually all is retained on the #4 (4.75 mm) sieve.

Fine Aggregate Types

- Stone Screenings
- Creek Sand
- Natural Sand
- Processed Sand

Creek Sand

- Creek sand, or river sand, is dredged from creeks or rivers, screened, and used as is.
- More commonly used by concrete industry.
- Typically have a low dust content.

Stone Screenings

- By-product of the crushing operation at the quarry.
- Regular Screenings
  - High dust content (generally >10%)
- Washed Screenings (also known as Manufactured Sand)
  - Low dust content (generally <5%)

Natural Sand

- Sand that is common to a particular location.
- Typically found below the Fall Line. The Fall Line runs through Augusta, Columbia, and Florence.
- Generally have low dust contents.

Processed Sand

- Sands that go through some formal process (sieving or blending for example).
- Done to achieve a certain gradation.

Coarse Aggregate Types

- Crushed stone
- Gravel
- Marine limestone
- Slag
- RAM

Crushed Stone

- Most common type of CA.
- Three types in SC
  - Granite
  - Granite Gneiss
  - Marble Schist

Crushed Stone Background

- Good stone at the location.
- Site suitability
  - Transportation access
  - Overburden ratio
  - Drainage
  - Buffer zones
  - Water availability
  - Reclamation
- Crushing process (# and types of crushers, etc.)

Gravel

- Mined from the natural surroundings.
- No blasting involved.
- Can be crushed if so desired.
- Screened, washed, and separated into various sizes.

Marine Limestone

- Also called fossiliferous limestone.
- Made from fossils of marine creatures.
- One source in SC.
- Production is similar to that of crushed stone.
- Absorptive aggregate.

Slag

- By-product of the steel industry.
- When iron ore is heated to extreme temperatures, it becomes molten.
- The heavy iron sinks to the bottom, while impurities rise to the top.
- Impurities are poured off and quenched with water. This is slag.
- Can then be crushed into various sizes.
- Has a high specific gravity and high absorption.

RAM

- RAM: Reprocessed Aggregate Material
- Aggregate portion of our RAP.

RAM Troubleshooting

- Dirty stone
- Gradation changes
- Specific Gravity changes
- Material breakdown
- Mica
- Clay balls
- Roots

Aggregate Properties

Aggregate Properties

- Size and Grading
  - Nominal Maximum Aggregate Size
  - Maximum Aggregate Size

Size and Grading

- Nominal Maximum Aggregate Size: The sieve size that is one size larger than the first sieve to retain more than 10% of the material.
- Maximum Aggregate Size: One size larger than the nominal maximum aggregate size.

Size and Grading

- Aggregate gradations are graphed on a 0.45 Power chart.
- Maximum Density Line (MDL) is also drawn on the 0.45 Power chart.
- The MDL is drawn using our Maximum Aggregate Size.
- Examples to follow.

Size and Grading

- Aggregates can be described based on their gradation.
  - Dense (well) graded
  - Open graded
  - Fine graded
  - Coarse graded
  - One size (uniformly) graded
  - Gap graded

Aggregate Properties

- Cleanliness
  - Want our aggregates to be washed.
  - Dust on aggregate surface can lead to stripping problems.

Aggregate Properties

- Cleanliness
- Toughness
  - Los Angeles Abrasion Test
  - Soundness Test (Sodium Sulfate or Magnesium Sulfate)

Aggregate Properties

- Cleanliness
- Toughness
- Particle Shape
  - Affects the strength of our HMA mix.

Particle Shape

- Irregular or angular shaped particles tend to interlock.
- Rounded particles tend not to have the interlocking qualities.

Aggregate Properties

- Cleanliness
- Toughness
- Particle Shape
- Surface Texture
  - Surface texture influences both workability and strength.

Surface Texture

- A rough (sand paper like) texture as opposed to a smooth surface tends to increase the HMA mix strength.
- A smooth, rounded surface (like gravel) tends to increase the workability of the HMA mix.

Aggregate Properties

- Cleanliness
- Toughness
- Particle Shape
- Surface Texture
- Absorption: Water and/or Asphalt Binder

Absorption

- An aggregate with 1% or less absorption is good for asphalt mixtures.
- All aggregates in SC except slag and marine limestone have absorption rates less than 1%.

Aggregate Properties

- Cleanliness
- Toughness
- Particle Shape
- Surface Texture
- Absorption
- Affinity for Asphalt: Lime and/or antistripping agents

Aggregate Properties

- Cleanliness
- Toughness
- Particle Shape
- Surface Texture
- Absorption
- Affinity for Asphalt
- Specific Gravity

Specific Gravity

- Specific Gravity is defined as: the ratio of the mass (or weight) of a given volume of aggregate to the mass (or weight) of an equal volume of water.
- Example: 1 ft^3 of water weighs 62.4 lbs. 1 ft^3 of solid stone weighs 156 lbs. The specific gravity is 156/62.4, or 2.500.

Bulk Specific Gravity

- The ratio of the weight of dry aggregate to the weight of water having a volume equal to the volume of the aggregate including both its permeable and impermeable pores.

Apparent Specific Gravity

- The ratio of the weight of dry aggregate to the weight of water having a volume equal to the solid volume of the aggregate excluding its permeable pores.

Bulk Specific Gravity (SSD)

- The ratio of the weight of the aggregate (including the weight of water it contains when its permeable voids are saturated) to the weight of an equal volume of water.

Aggregate Sampling

- We want to obtain a REPRESENTATIVE sample.
- Accuracy in sampling is just as important if not more so than testing.

Aggregate Sampling

- Stockpile sampling
- Belt sampling
- Must reduce these field samples to an appropriate testing size. There are two methods to do this:
  - Quartering
  - Sample splitter

Aggregate Gradations

- Main reason why we are sampling our aggregates.
- Sieve analysis gives us our gradation.
- Typically we are interested in the percent passing any given sieve.

Aggregate Gradations

- There are two types of gradations.
  - Dry Sieve Analysis
  - Wet Sieve Analysis

Wet Sieve Analysis (AASHTO T-11)

- The preparation is the same as for a dry sieve analysis except that before sieving the sample is immersed in water containing a wetting agent.
- The sample is agitated, and the water is poured off over a #200 sieve.
- This process is repeated until the wash water becomes clear.
- Material retained on the #200 sieve must be washed back into the sample.

Gradation Calculations

- To determine the % Passing any given sieve, divide the weight passing by the total weight.
- For a wet sieve analysis, remember to add back weight lost from washing.
  - Weight passing: Add loss to all sieves.
  - Weight retained: Add loss only to the Pan.
- Examples to follow.

Aggregate Blending

- Why is it necessary to blend aggregates?

Aggregate Blending

- For most HMA mixes, SCDOT requires at least 3 aggregate sources.
- RAP does count as an aggregate source.
- Ways to blend aggregates:
  - Graphical
  - Computer programs
  - Trial and error

Recycled Asphalt Pavement

- Allowable RAP percentages are shown below.

Type of Mix	% RAP
Asphalt Base Mixes	10 – 30
Binders, Surf. T-3, T-4	10 – 25
Surface T-1	10 – 20
19.0 mm and 25.0 mm	10 – 15

Recycled Asphalt Pavement

- Requirements for RAP use:
  - Milled from an SCDOT project
  - Date milled and approximate tons
  - Extraction and gradation data
  - Stockpile for each RAP source
  - Stockpile identification

End of Chapter 2

Any Questions?

Chapter 3

Asphalt Binder

Objectives

- Properties of Binder (AC)
- Previous Grading Systems
- Previous and Current Binder Testing Procedures
- Temperature-Viscosity Relationships

Historical Background

- Shipbuilding in Sumeria (6000 BC)
- Waterproofing, building and paving construction, mummification (2600 BC)
- Road construction (Roman Empire)
- First use of asphalt paving blocks (1824)
- First modern asphalt road (Paris 1858)
- First US road construction (New Jersey 1870)

Nature of Asphalt Binders

- Occur naturally in geological strata
  - Soft asphalt material (e.g., Trinidad Lake, western Canada)
  - Hard, friable, black material in rock formations
- Produced through crude petroleum refining

Definitions

- Bitumen:
  Mixtures of hydrocarbons soluble in carbon disulfide (CS_2)
- Asphalt:
  Dark brown to black cementitious material of solid or semisolid consistency at ambient temperatures in which the predominant constituents are bitumens which occur in nature as such or are obtained as residue by refining petroleum (ASTM D8)

Definitions

- Tar:
  Brown to black bituminous material of liquid or semisolid consistency obtained as condensates by destructive distillation of coal, petroleum, wood, and other organic materials (ASTM D8)

  Note: Bitumen content in coal tars is relatively low compared to petroleum asphalts. Although both tars and asphalts are referred to as bituminous materials, their physical and chemical properties differ greatly.

Crude Oil Classification

- Asphalt based crude
- Paraffin based crude
- Mixed base crude
- Low API Gravity (<25) or Heavy Crudes
- High API Gravity (>25) or Light Crudes
  - API: American Petroleum Institute
  - API Gravity: Density or weight of a unit volume of material expressed at 60°F

Crude Oil Refining

- Heat Exchanger
  - Temperature of crude oil is raised for initial distillation
- Atmospheric Distillation
  - Fractions are separated based on their boiling ranges
  - Lightest compounds vaporize and are drawn off for further processing
- Vacuum Distillation
  - Residuum from the atmospheric distillation is processed into asphalt binder by removing heavier gas oils

Asphalt Production and Classification

- Straight-Run Asphalt:
  Asphalt binder of desirable consistency is produced directly through vacuum distillation
- "Solvent Deasphalting" Process:
  Precipitate (hard) asphalt binder is produced via solvent extraction processing of vacuum residuum
- Air-Blown or Oxidized Asphalts:
  Special application (e.g., roofing, pipe coating) asphalts are produced by blowing air at high temperatures through asphalts of proper consistency

Molecular Structure of Asphalt

- Complex mixture of hydrocarbon groups
  - Aliphatic or Paraffinic
  - Napthenic or Cycloparaffins
  - Aromatic
- Heteroatoms: Sulfur, Oxygen, and Nitrogen
- Percent by weight:

Carbon:	70 - 85%
Hydrogen:	7 - 12%
Sulfur:	1 - 7%
Oxygen:	0 - 5%
Nitrogen:	0 - 1%

Asphalt Binder Composition

- Asphaltenes:
  High molecular weight fraction of asphalt binder. Exhibits strong tendencies to interact and associate into conglomerates.
- Resins:
  Medium molecular weight fraction of asphalt binder. Resins act as agents that peptize asphaltenes, thus providing a balanced and homogeneous system.
- Oils:
  Low molecular weight fraction of asphalt binder. Constitute the dispersion medium of peptized asphaltenes.

Asphalt Binder Types

- Asphalt Binders
  - Solid or semisolid at ambient temperatures
  - Liquefied by heat application
- Emulsified Asphalts
  - Emulsion of asphalt, water, and emulsifying agent
  - Liquid at ambient temperatures
- Cutback Asphalts
  - Blend of asphalt and petroleum solvents
  - Liquid at ambient temperatures

Properties of Asphalt Binders

- Thermoplastic material
- Strong cement with excellent adhesive properties
- Resistant to most acids, alkalies, and salts
- Waterproof
- Durable

Consistency of Asphalt Binders

- Measure of the fluidity of asphalts at any particular temperature
- Asphalt binders were graded based on consistency ranges at a standard temperature
- Old Consistency Tests
  - Penetration (empirical method)
  - Viscosity Tests (scientific method)
  - Softening Point

Penetration Testing (AASHTO T 49 or ASTM D 5)

- Empirical method of determining consistency.
- Penetration testing is usually conducted at 25°C (77°F) which approximates the average in-service temperature of asphalt pavements.
- Penetration is the distance in tenths of a millimeter that a standard needle can penetrate the asphalt binder sample vertically under known loading, timing, and temperature conditions.

Absolute Viscosity Testing (AASHTO T 202 or ASTM D 2171)

- Viscosity is the ratio between applied shear stress and rate of shear and is a measure of the resistance to flow of a liquid.
- Testing is conducted at a constant temperature of 60°C (140°F), which approximates the maximum in-service temperature of asphalt pavements.
- Viscosity at 60°C was used for asphalt binder grading.
- Unit: Poise (P)

Kinematic Viscosity Testing (AASHTO T 201 or ASTM D 2170)

- Ratio of the viscosity to the density of a liquid.
- Measure of the resistance to flow under gravity.
- Testing is conducted at a constant temperature of 135°C (275°F), which approximates the mixing and laydown temperatures used in the construction of HMA pavements.
- Unit: Centistoke (cSt)

Thin Film Oven Test (TFOT) (AASHTO T 179 or ASTM D 1754)

- Accelerated weathering test developed by the Bureau of Public Works (1940).
- Simulates the change in consistency (age hardening) of asphalt binders that takes place in hot mix plants.
- Measure of age hardening resistance of asphalts.
  - Loss of weight following TFOT
  - Penetration and viscosity changes following TFOT

Additional Asphalt Tests

- Rolling Thin Film Oven Test
  - Accelerated weathering test.
  - Variation of the TFOT used by highway agencies in the western US.
- Ductility Test
  - Measure of the adhesiveness and elasticity of asphalt binders.
  - Defined as the distance an asphalt briquette specimen stretches before breaking when the two ends are pulled apart at a specified rate of speed under standard temperature conditions.

Asphalt Binder Grading (Old Methods)

- Penetration grading (ASTM D 946)
  - Old, empirical method
  - Five standard grades: 40-50, 60-70, 85-100, 120-150, 200-300
- Absolute viscosity grading (ASTM D 3381)
  - Grading based on original asphalt binder
  - Viscosity grades: AC-2.5, AC-5, AC-10, AC-20, AC-30, AC-40
- AR absolute viscosity grading (ASTM D 3381)
  - Grading based on residue from the rolling thin film oven test
  - Viscosity grades: AR-1000, AR-2000, AR-4000, AR-8000, AR-16000

Asphalt Binder Grading

- Now we use “Performance Graded” asphalt binders.
- The grade of asphalt binder to be used is based on the environment where it is going to be used.
- This topic will be covered in greater detail soon!!

New Binder Test Methods

- Rotational Viscosity
- Dynamic Shear Rheometer
- Bending Beam Rheometer
- Direct Tension Test
- Binder Aging Procedures
  - Rolling Thin Film Oven Test (short term)
  - Pressure Aging Vessel (long term)

Viscosity Testing

- Viscosity is a measure of the resistance to flow.
- In the past, we used absolute and kinematic viscosities.
- Absolute viscosity
  - Measured at 140°F
  - Simulated “maximum” temperature that the asphalt mixture would see in the field
  - Measured in units called Poises (P)

Viscosity Testing

- Kinematic viscosity
  - Measured at 275°F
  - Simulated average compaction temperature of an asphalt mixture
  - Measured in units of centistokes (cSt)

New Method for Determining Viscosity

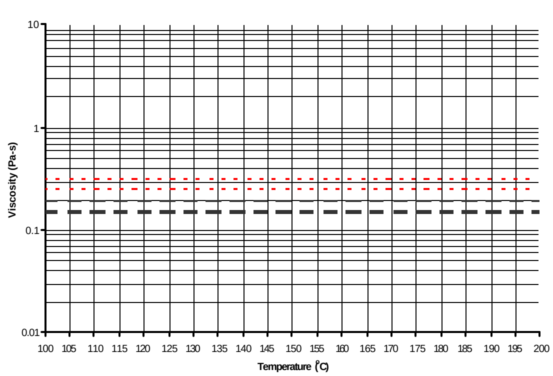
- Viscosities are now measured using a rotational viscometer.
- Samples are tested at 135℃ and 165℃.
- Measuring the torque required to rotate a spindle in the sample at a given speed (rpm).
- Measured in units of centiPoises (cP).

Brookfield Rotational Viscometer

Spindles and Test Tubes

Temp-Viscosity Chart

- Chart is in units of Pa-s.
- Must convert our results from rotational viscometer from cP to Pa-s.
- To do this, we divide the cP by 1000.
- So, 350 cP would be 0.35 Pa-s.



Temp-Viscosity Chart

- Our objective is to determine the "ideal" mixing and compaction temperatures for our asphalt binder. Procedure is the same as it was before.
- Mixing temperatures correspond to 0.15 to 0.19 Pa-s.
- Compaction temperatures correspond to 0.25 to 0.31 Pa-s.

End of Chapter 3

Any Questions?

Chapter 4

Hot Mix Asphalt (HMA)
Volumetrics and Introduction to
Marshall Mix Design

Chapter 4: Objectives

- Introduction
- Definitions and Equations
- Marshall Method of Mix Design
- Mix Design Properties
- Potential Problems

Introduction

- HMA: Hot Mix Asphalt
- Asphalt Plants: 2 Main Types
  - Drum Mix Plant
  - Batch Mix Plant

Definitions

- Voids in Mineral Aggregate (VMA): The volume of void space between the aggregate particles of a compacted asphalt mixture. In other words, VMA is the air voids and the effective asphalt binder.
- %VMA = %Binder by Volume + %Air Voids

Definitions

- Air Voids (or Voids in Total Mix):
  - The total volume of small pockets of air between the aggregate particles (coated with binder) expressed as a percent of the total volume of the mix.
  - Usually, the % Air Voids is in the range of 3% to 7%.

Definitions

- Voids Filled with Asphalt (VFA):
  - The percent of the VMA that consists of asphalt binder.
- In order to calculate the %VMA, %VFA, and %Air Voids, the following must be known:
  - BSG of the mix
  - MSG of the mix
  - SG of the binder

Effective Specific Gravity of Aggregate

$$ESG = \frac{100 - \%Binder}{\frac{100}{MSG} - \frac{\%Binder}{SGofBinder}}$$

Maximum Specific Gravity of the Mixture

$$MSG = \frac{100}{\frac{\%Binder}{SGofBinder} + \frac{\%Agg}{ESG}}$$

Density and Air Voids

- Density or Unit Weight:
  - Density = BSG * 1.0 kg/m^3 (or 62.4 lbs/ft^3)
- % Air Voids:

$$\%AV = \frac{MSG - BSG}{MSG} * 100$$

VMA Calculations

- %VMA = % Binder by Volume + % Air Voids
  - % Binder by Volume = $\frac{\%Binder * BSGofMix}{SGofBinder}$
- % VFA = $\left(\frac{\%BinderbyVolume}{\%VMA}\right)*100$

Hot Mix Asphalt (HMA) Mix Design Methods

- Marshall
  - The US Army Corps of Engineers developed mix design criteria based on the original concepts formulated by Bruce Marshall, Bituminous Engineer with the Mississippi State Highway Department.
- Hveem
  - The original concepts of this method were formulated and advanced by Francis N. Hveem, Research Engineer with the California Department of Transportation.

Mix Design Objective

- The purpose of mix design is to determine the optimum combination of asphalt binder and aggregate that will provide a durable asphalt pavement which can perform well under a variety of loading and environmental conditions.

Mix Design Process

- Select aggregate source
  - Must meet aggregate requirements such as:
    - Los Angeles Abrasion
    - Sand Equivalent
    - Specific Gravity
    - Absorption
    - etc.
- Develop aggregate blend that will meet the specifications

Mix Design Process

- Dry aggregates to a constant weight (105°C to 110°C).
- Sieve and separate aggregates into the desired size fractions (1/2", 3/8", etc.).
- Prepare "pans" according to your aggregate blend.

Aggregate Pan Preparation

- Total aggregate weight: 1140-1160 grams
- Want an aggregate weight that will yield a 2.5" thick asphalt sample.
- Hydrated Lime: Add 1% by total weight of aggregate (this must be included in your aggregate blend)
- Water: 5% by total weight of aggregate

Asphalt Binder Selection

- Must determine which grade of binder to use.
- For Marshall mixtures in SC, use PG 64-22.
- Measure rotational viscosity at 135°C and 165°C.
- Additional binder tests:
  - Dynamic Shear Rheometer
  - Bending Beam Rheometer

Mixing and Compaction Temperature of the Asphalt Mix

- Mixing temperature
  - Asphalt binder should be heated to a viscosity range of 0.17 ± 0.20 Pa-s.
- Compaction temperature
  - Asphalt binder should be heated to a viscosity range of 0.28 ± 0.30 Pa-s.

Preparation of Marshall Samples

- Determination of Optimum Binder Content
  - Four binder percentages at 0.5% increments
  - Two percentages above and two below the expected optimum binder content
  - Minimum of two Marshall samples for each binder content
  - Minimum of eight samples for each mix design series

Preparation of Marshall Samples

- Prepare a minimum of eight aggregate pans (˜1140 grams).
- Heat aggregate pans to a temperature not to exceed 50°F above the mixing temperature range.
- Heat binder to mixing temperature range.

Preparation of Marshall Samples

- Asphalt binder should be used within one hour after reaching mixing temperature.
- Determine the weight of binder, by total weight of the mix, required to obtain each desired binder content.
- Molds, spoons, mixing bowls, spatulas, and compaction hammer to a temperature of 200°F to 300°F.

Preparation of Marshall Samples

- Charge mixing bowl with heated aggregate and pre-determined amount of binder.
- Mixing temperature should be within the established range.
- Mix the aggregate and binder quickly and thoroughly until all aggregate particles are evenly coated with binder.
  - Mechanical mixer
  - Hand mixing

Preparation of Marshall Samples

- Place a paper disc in the bottom of the mold.
- Pour entire batch into the mold.
- Tamp the mixture vigorously with a heated spatula.
  - 15 times around the perimeter
  - 10 times in the middle
- Smooth mix to a rounded shape.
- Place a paper disc on top of the mix.

Preparation of Marshall Samples

- Temperature of the mix should be within the compaction temperature range.
  - Allow sample to cool if temperature is too high.
  - Discard sample if temperature is too cool.
  - Do not reheat the mix.
- Place charged mold on the compaction pedestal.
- Position compaction hammer vertically into the mold.

Preparation of Marshall Samples

- Apply 50 or 75 blows to the top surface of the sample as specified by the design traffic category.
- Reverse mold and apply the same number of blows to the reverse face of the sample.
- After compaction, remove collar, base plate, and paper discs. Label sample with a wax crayon.
- Allow sample to cool in air (fans can be used in this process).

Preparation of Marshall Samples

- When samples can be handled without gloves, extrude samples from molds using a hydraulic jack.
- Allow samples to continue to cool until they reach room temperature (77°F).
- All samples will be tested as follows:
  - Bulk Specific Gravity determination
  - Stability and Flow testing
  - Determination of volumetric properties

Bulk Specific Gravity Testing

- Conduct BSG testing on samples after they have reached room temperature (77°F).
- Follow AASHTO T 166 procedures.
- Average BSG values of all samples at the same binder content.
- Samples at the same binder content must be within ± 0.020 of one another.

Marshall Stability and Flow

- Immerse samples in a hot water bath (140°F ± 1.8°F) for 30 to 40 minutes.
- Remove sample from water bath and dry surface.
- Place sample in the center of the breaking head.
- Position breaking head in the center of the testing apparatus.
- Apply load at a rate of 51 mm (2 inches) per minute until sample fails.
- Testing must be completed within 30 seconds of removing sample from hot water bath.

Marshall Stability and Flow

- Stability
  - Maximum load resistance in pounds (Newtons).
  - Must correct stability for samples that are not 2.5 inches in height by using a correction factor.
- Flow
  - Total movement, or strain, measured in units of .01 inches (0.25 mm), occurring during stability testing between points of no load and maximum load.

Rice (Maximum) Specific Gravity

- Prepare two aggregate pans identical to those batched for determination of optimum binder content.
- Samples are mixed at the highest binder content.
- Follow AASHTO T 209 procedures.
- MSG samples must be within ± 0.018 of one another.
- Use MSG values to calculate Effective Specific Gravity (ESG) of the aggregate.
- The calculated ESG value is used to determine MSG values at binder contents other than the binder content chosen for mixing MSG samples.

Volumetric Calculations

- Must calculate the following at each binder content:
  - % Air Voids
  - % VMA
  - % VFA
- Use formulas given earlier in this section.

Interpretation of Results

- Plot "best fit" curves for all mix properties.
  - Binder Content vs. % Air Voids
  - Binder Content vs. % VMA
  - Binder Content vs. % VFA
  - Binder Content vs. Stability
  - Binder Content vs. Flow
  - Binder Content vs. Density

Optimum Binder Content

- The optimum binder content is the average of three binder values determined as listed below:
  - Binder Content vs. % Air Voids (4.0% Air)
  - Binder Content vs. % Air Voids (4.5% Air)
  - Binder Content vs. % VFA (75% VFA)

Now What??

- Must check all mix properties at the optimum binder content to see if the mix design meets the specifications (including dust to binder ratio).
- Must also perform Moisture Susceptibility Testing (ITS).
- Samples are batched in the same manner and mixed at the optimum binder content.
- Samples must have 6% to 8% air voids, so the number of blows must be reduced.
- Mix must meet ITS requirements.
  - Wet Tensile Strength = 65 psi
  - Tensile Strength Ratio = 85%

Asphalt Mixture Properties

- Stability
- Durability
- Permeability
- Flexibility
- Workability
- Moisture Susceptibility Resistance
- Fatigue Resistance
- Skid Resistance

Potential Mix Problems

- High or low air voids
- High or low %VMA
- High or low %VFA
- High or low flow
- Low stability
- Low Wet Tensile Strength
- Low Tensile Strength Ratio

End of Chapter 4

Any Questions?

Chapter 5

Introduction to SHRP, Superpave, and PG Grading

Chapter 5: Objectives

- Introduction
- Definitions
- PG Grading
- Aggregate Requirements
- Gyratory Compactor

Introduction

- Strategic Highway Research Program (SHRP)
- $50 million in funding for asphalt related research
- Program lasted from October 1987 until March 1993
- Objective of SHRP: To develop new methods to specify, test, and design asphalt mixtures.

SUPERPAVE

- End result of SHRP: SUPERPAVE
- SUperior PERforming asphalt PAVEments
- Superpave software program was also developed that aids in selection of materials and design of mixtures.
- Superpave is an improved system for specifying asphalt mixtures and pavement performance prediction.

SUPERPAVE

- One portion of SUPERPAVE is a new asphalt binder specification that included new test methods.
- New binder tests incorporate performance based specifications.
- Climate and pavement temperatures in which the pavement is expected to serve are considered.

PG Grading

- Performance Graded (PG) binders are graded based on their physical properties at set temperatures.
- The PG grading includes both a high and low temperature grade.
- In SC, PG 64-22 is primarily used.

PG Grading

- PG 64-22
  - 64°C: The binder will have adequate physical properties at temperatures as high as 64°C
  - -22°C: The binder will have adequate physical properties at temperatures as low as -22°C.

Binder

- When the high temperature grade is 76°C or higher, it is called polymer modified binder.
- Polymer: Material added to the binder that enhances the physical properties of the binder.
- Examples of polymers used in asphalt binders: plastics, rubber

Aggregates

- No new aggregate tests were developed.
- Two types of aggregate properties:
  - Consensus properties
  - Source properties
- Consensus properties, as the name implies, are used by all state DOT's.
- Each state DOT can choose their own source properties as they see fit.

Aggregates

- Consensus Properties:
  - Coarse Aggregate Angularity
  - Fine Aggregate Angularity
  - Flat and Elongated Particles
  - Sand Equivalent/Clay Content
- Source Properties (for SC):
  - Toughness (LA Abrasion)
  - Soundness
  - Deleterious Materials

Gyratory Compactor

- Texas used it. French operational characteristics were added.
- Samples are 150 mm in diameter.
- Samples are up to a 37.5 mm (1.5 inch) nominal maximum aggregate size.
- Gyratory compactor is able to record the height of the sample at each gyration.

Gyratory Compactor Components

- Reaction frame (rotating base)
- Loading system (ram)
- Molds
- Calibration devices
- Printer
- Control panel

Pine Gyratory Compactor

Troxler Gyratory Compactor

Gyratory Compactor Calibrations

- Sample height
  - Calibration kit includes a “dummy sample” that is precision milled to a known height.
- Ram pressure
  - Calibration kit includes a load cell that can determine the ram pressure.
- Gyration angle
  - Calibration kit includes a digital micrometer. Using the length measured, the gyratory compactor can calculate the angle. Note: You will need a heated sample to run this calibration.
- Rotational speed
  - The gyratory compactor can calculate the speed at which it operates.

Superpave Concepts

- N: The number of gyrations.
  - $N_{initial}$: Represents compaction by the paver screed.
  - N_{design}: Represents compaction after the rolling process.
  - $N_{maximum}$: Represents compaction at the end of the pavement design life.
- The gyration values can be found in the contract documents.

Superpave Concepts

- Compaction pressure of 600 kPa (roughly 87 psi)
- Samples are compacted at an angle of 1.25°. This simulates the angle created as the roller wheel passes any given location on the mat.
- Gyratory compactor operates at a speed of 30 gyrations (revolutions) per minute. The Marshall hammer operates at 1 blow per second.

End of Chapter 5

Any Questions?