TDOT
Department of Transportation

HOT MIX ASPHALT PLANT TECHNICIAN CERTIFICATION

(V. 18.0)

Division of Materials and Tests 2018

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Helpful Links

Specs, Circulars, Etc:	https://www.tn.gov/tdot/article/transportation-construction-2015-standard-specifications
SOP:	https://www.tn.gov/tdot/topic/materials-and-tests-sop
Blank Forms:	https://www.tn.gov/tdot/article/transportation-materials-tests-division-field-operations-forms
Training Information:	https://www.tn.gov/tdot/article/transportation-materials-tests-field-operations-training

Tennessee Department of Transportation
Certified Asphalt Plant Technician Workshop

Class Schedule

Monday

Registration	9:30 – 10:00
Introduction to the Course	10:00 – 10:30
Basic Materials	10:30 – 11:30
Lunch	11:30 – 1:00
Plant Overview	1:00 – 2:15
Break	2:15 – 2:30
Aggregate Storage and Metering System	2:30 – 3:15
Break	3:15 – 3:30
Aggregate Storage and Metering System (Continued)	3:30 – 4:15

Tuesday

Asphalt Storage and Metering Systems	8:30 – 10:00
Break	10:00 – 10:15
HMA Storage and Delivery	10:15 – 11:30
Lunch	11:30 – 12:45
Overview of Job Mix Formula	12:45 – 1:15
Sampling and Testing (Part 1: Aggregates) *T-2, T-248, T-11, T-27, Glassy Particles, Fractured Faces*	1:15 – 2:45
Break	2:45 – 3:00
Quiz 1 (T-27)	3:00 – 3:30
Sampling and Testing (Part 2: Mixture) *T-164, T-168, Mix Temperature, Boil Test*	3:30 – 4:15

Wednesday

Homework Review	8:30 – 9:00
Specification Quiz	9:00 – 9:30
Sampling and Testing (Part 3: Marshalls and Volumetrics) *T-209, T-166, T-245, T-166*	9:30 – 10:15
Break	10:15 – 10:30
Sampling and Testing (Part 4: More Mixture Testing) *T-308, D-4867, LOI*	10:30 – 11:30
Lunch	11:30 – 12:45
Sampling and Testing (Part 5: Additional Information) *In-Class T-164 handout*	12:45 – 2:00
Break	2:00 – 2:15
Quiz	2:15 – 2:30
Homework, Review, and Questions	2:30 – 4:00

Thursday

Homework Review	8:30 – 9:00
Daily Plant Reports and Pay Factors	9:00 – 10:15
Break	10:15 – 10:30
Overview of Electronic Workbook and SiteManager	10:30 – 11:30
Lunch	11:30 – 1:00
Review of Field Manual	1:00 – 2:00
Break	2:00 – 2:15
Review of Specifications	2:15 – 3:15
Review for Exam	3:15 – 4:00

Certified Asphalt Plant Technician Course

ADA Notice of Requirements

- Can be found at the following website:
  - http://www.tn.gov/tdot/topic/transportation-americans-with-disabilities-notice
- To be in compliance with TDOTs requirements listed on the website above, it is our goal to provide reasonable accommodations to those who identify themselves as having a disability and request such accommodations.
- Please feel free to bring it to any of the course instructors and accommodations will be administered as discretely as possible.

No Tobacco Related Product Inside Building!!!!!!!!!!!!!!

No Electronic Cigarette
No Chewing Tobacco Allowed
Spitting into a bottle disturbs others

Plant Tech School

- Welcome
- Introductions
- Basic Information
  - Class Schedule
  - Restroom Locations
  - Smoking Locations

Plant Tech School

- Workbook Description General Information/Presentations
  - Operations
  - Sampling & Testing
  - AASHTO/ASTM/TDOT Test Methods
  - Department Specifications
  - Reports
  - Electronic Workbook

Plant Tech School

- Presentations
- Performing Calculations
- Test (Half Day)
  - Test Methods
  - Specifications/Results Interpretation

Why have a Plant Tech course?

- QUALITY!
- In the past, plants were set up by TDOT and ran by TDOT.
  - Now this is no longer the case.
- Method Specifications vs. End Result Specifications

407.03.D.2 Contractor Quality Control System (page 305)

"Develop, implement, and maintain a quality control system that will provide reasonable assurance that all materials and products submitted to the Department for acceptance conform to the specified requirements."

407.03.D.2.a Quality Control Technician (page 305)

"Ensure that a Quality Control Technician, who is currently certified by the Department as a Certified Asphalt Plant Technician, is present at the asphalt plant during mix production. If the Department finds that the Quality Control Technician cannot perform as required by the position, the Department will revoke the certification and require replacement with a certified technician."

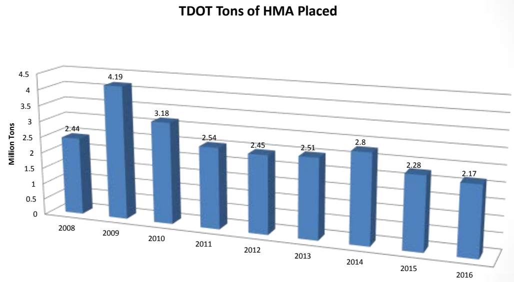
Code of Federal Regulations (CFR 637) tells us ...

- "Each SHA's quality assurance program shall provide for an acceptance program and an independent assurance (IA) program consisting of..."
- "The sampling and testing has been performed by qualified laboratories and qualified sampling and testing personnel."

TDOT's Mission & Vision

- ***Mission***
  - To provide a safe and reliable transportation system for people, goods and services that supports economic prosperity in Tennessee
- ***Vision***
  - To serve the public by providing the best multimodal transportation system in the nation.

This Job Is Important!



Asphalt Qualifications are:

- Asphalt Roadway Paving Inspector
- Asphalt Concrete Mixture Design Technician
- Asphalt Concrete Plant Technician

Asphalt Plant Technician Class

- Introduction
- Basic Materials
- Overview of Asphalt Plant
- Materials Storage
- Materials Feeding and Metering Systems
- Asphalt Job Mix Formulas
- Sampling & Testing
- Daily Reports
- TDOT Specifications

Quality

Meets or exceeds the expectations or needs of the customer

Class Discussion:

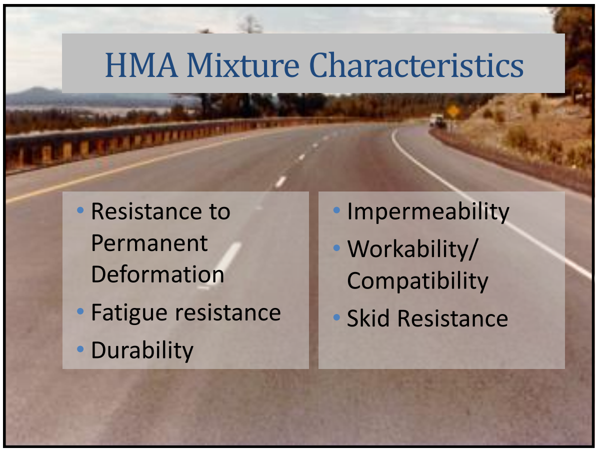
- What makes a good Pavement?

Quality HMA Mixtures

- Constructability
- Conforms to specifications
- Satisfies functional requirements

Customer Driven Expectations Of HMA Mixtures

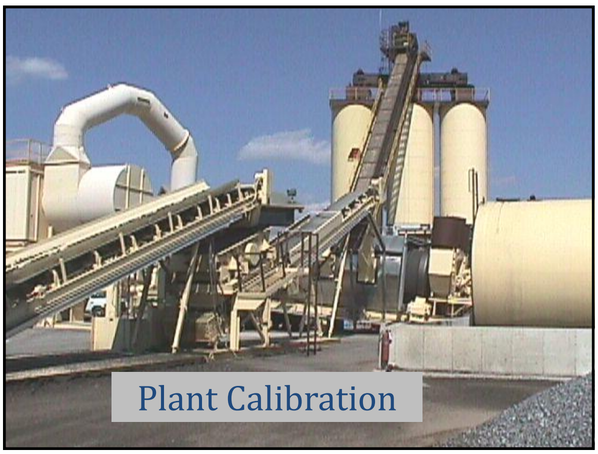
- Smooth surface without hydroplaning in the rain.
- Minimization of traffic disruptions.
- Adequate friction at surface.
- Minimization of overall costs.


HMA Mixture Characteristics
Resistance to Permanent Deformation
Fatigue resistance
Durability
Impermeability
Workability/ Compatibility
Skid Resistance


Quality will not result from focusing on a couple of key parts of an operation...
it will result only when EVERYTHING is done right.


Quality Starts Here!

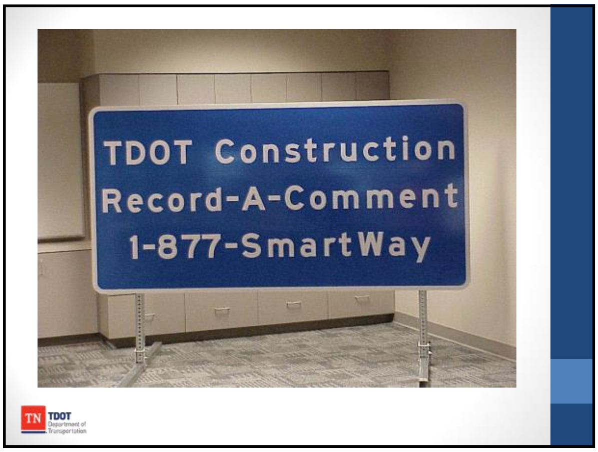

Good Materials Management is Important


Plant Calibration


Well Equipped Labs and Knowledgeable People


And It Continues


How Should We Measure Quality?


TDOT Construction
Record-A-Comment
1-877-SmartWay
TN TDOT

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Basic Materials

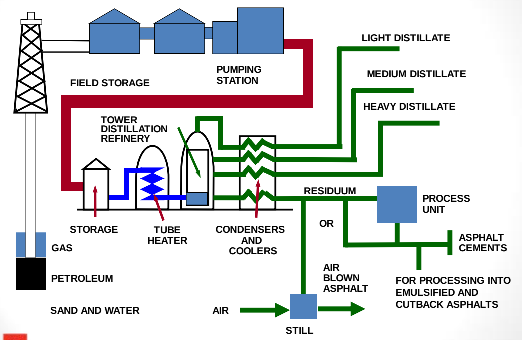
Basic Materials

Asphalt, Additives, and Aggregate

Materials

- Asphalt
  - Background
  - Properties
- Aggregate
  - Background
  - Properties

Refinery Operation



Asphalt Binder Spec (Section 904.01)

- Grading System Based on Climate

PG 64-22

Performance Grade | **Average 7-day max pavement design temp** | **Min pavement design temp**

64°C = 147.2°F
-22°C = -7.6°F

"Rule of 90" *(More like a guideline!)*

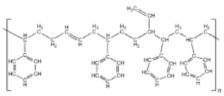
- **Between High and Low Temp Physical Properties**
  - Absolute difference between high and low temp grade
  - <u>Difference **less than 90** probably unmodified asphalt</u>
  - <u>Difference **greater than 90** probably modified asphalt</u>
- **PG 64-22**
  - Difference = 86
  - Probably unmodified
  - Probably AC-20
- **PG 70-22**
  - Difference = 92
  - Very well-balanced AC-20 or lightly modified AC-10

Asphalt Additives

- Additives include:
  - Anti-strip Additive (Section 921.06.B.1)
  - Lime (Section 921.06.B.1)
  - Silicone (921.06.B.2)
  - Warm Mix Additives (921.06.B.3)

Asphalt Modifiers

- Permitted Asphalt Modifiers:
  - Styrene butadiene (SB)
  - Styrene-butadiene-styrene (SBS)
  - Styrene butadiene rubber (SBR)



Aggregate Processing

- Excavation
- Crushing
- Sizing
- Washing

Excavation

- Natural Sands and Gravels
  - Underwater Sources
    - Rivers and Lakes
    - Barge-Mounted dredges, draglines, scoops, conveyers, or pumps.
  - Land Sources
    - Gravel or Sand Pits
    - Bucket Loader

Stockpiling

Sampling

- Why do we take samples?
  - To evaluate the potential quality of a proposed aggregate source.
  - To determine compliance with project specification requirements.

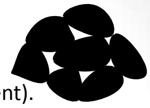
Sieves

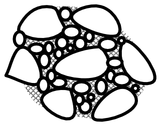
Individual Sieve

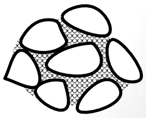
Stack of Sieves

Types of Gradations

- Uniformly-Graded
  - Few points of contact.
  - Poor interlock (Shape dependent).
  - High permeability.
- Well-Graded
  - Good interlock.
  - Low permeability.
- Gap-Graded
  - Only limited sizes.
  - Good interlock.
  - Low permeability.

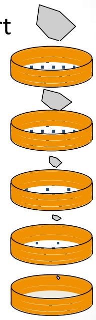




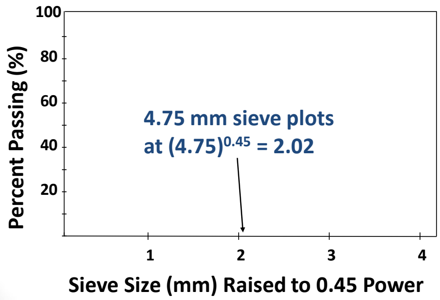


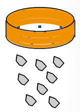
Aggregate Gradation

- Use 0.45 Power Gradation Chart
- Blend Size Definitions
  - Maximum size.
  - Nominal maximum size.
- Gradation Limits
  - Control points.
  - Restricted zone.



Power 0.45 Grading Chart





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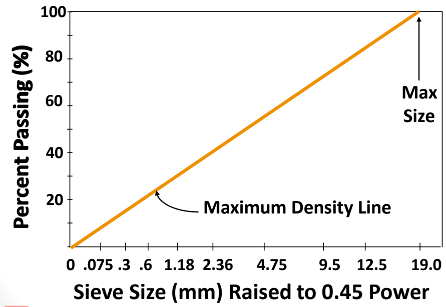
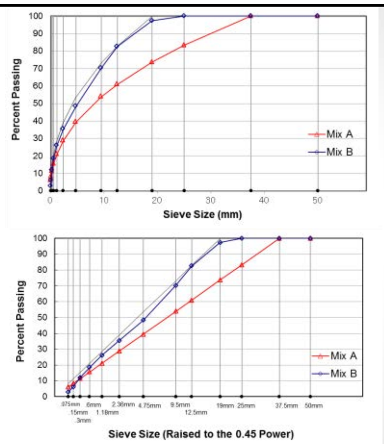


0.45 Power Chart



Aggregate Gradation Terms

- <u>Sieve Size</u> – The opening size for a given sieve, i.e. 1-inch. Numbered sieves (i.e. #50, #16, etc) indicate the number of openings per linear inch.
- <u>Percent Passing</u> – The percent of material that is *smaller* than a given sieve value.

  i.e. "75% passing 3/8-in sieve" indicates 75% of the aggregate in that sample is *smaller than 3/8-inch.*

Aggregate Gradation Terms

- Percent Retained - The percent of material that is *larger* than a given sieve value.
- Individual Percent Retained – The percent of material that sits on a single sieve in a stack.

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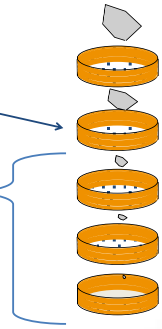
Aggregate Gradation Terms

- Percent Passing:
  - This sieve is the percent of all the material that is capable of passing through this sieve.



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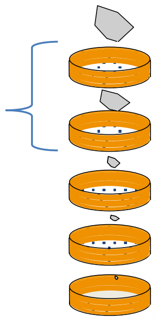
Aggregate Gradation Terms

- Percent Retained:
  - On this sieve is the percent of all the material that is NOT capable of passing through this sieve.



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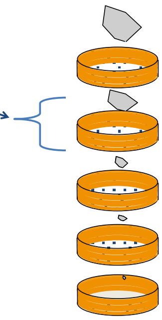
Aggregate Gradation Terms

- Individual Percent Retained:
  - On this sieve is the percent of all the material makes it to this sieve, but does not pass through.



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Aggregate Size Definitions

- Nominal Maximum Aggregate Size:
  - One size larger than the first sieve to retain more than 10%.
- Maximum Aggregate Size:
  - One size larger than nominal maximum size.

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Aggregate Size Definitions

- ***Example 1:***

What is the NMAS for the mixture shown here?

Max aggregate size?

3/4"	100
5/8"	100
1/2"	90
3/8"	72
No.4	65
No.8	48
No.16	36
No.30	22
No.50	15
No.100	9
No.200	4

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Aggregate Size Definitions

- ***Example 2:***

What is the NMAS for the mixture shown here?

Max aggregate size?

3/4"	100
5/8"	99
1/2"	89
3/8"	72
No.4	65
No.8	48
No.16	36
No.30	22
No.50	15
No.100	9
No.200	4

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Coarse Vs Fine Aggregate

- Coarse Aggregate is Material retained above the #4 Sieve.
- Fine Aggregate is Material that passes through the #4 Sieve.

	% Retained Individual	% Retained Cumulative	% Passing
3/4"	0	0	100
5/8"	1	1	99
1/2"	10	11	89
3/8"	8	18	72
No.4	27	45	65
No.8	7	52	48
No.16	12	64	36
No.30	14	78	22
No.50	7	85	15
No.100	6	91	9
No.200	5	96	4

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Blending of Aggregates

- P = Aa + Bb + Cc + ….
  - P = % of material passing a given sieve for blended aggregates A, B, C,…
  - A, B, C, … = % material passing a given sieve for each aggregate A, B, C, …..
  - a, b, c, …. = Proportions (decimal fractions) of aggregates A, B, C, … to be used in Blend

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Densities

- Density is the unit weight of a material in lb/ft^3 or kg/m^3
- Density of Water:
  - g_w = 1.000 g/cm^3
  - g_w = 1,000 kg/m^3
  - g_w = 62.4 lbs/ft^3

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Specific Gravity

- Ratio of the density of a material to that of water.
- Specific gravities are always expressed to three decimal places.

$$\text{Specific Gravity} = \frac{\text{Density of Material}}{\text{Density of Water}}$$

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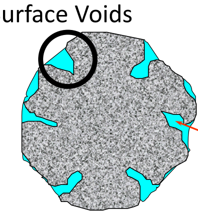
Bulk Specific Gravity, Dry

$$G_{sb} = \frac{\text{Mass (Oven Dry)}}{\text{(Volume of Agg. + Surface Voids)}}$$

Surface Voids



Volume of water-permeable voids.

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Percent Fractured Faces

- Gravel
  - Helps ensure proper aggregate/binder adhesion.
  - Quarried materials always 100% crushed.
  - Defined as percentage by count with one or more fractured faces.

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Percent Fractured Faces

0% Crushed

100% with 2 or More Crushed Faces

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Overview of TDOT Mixes

- 307 Mixes: A, ACRL, AS, B, BM, BM2, CS, and CW
  - These mixes are called “307” mixes because they are specified in Section 307 of the Standard Specification book for Bituminous Plant Mix Base.
  - Not all of the mixes listed are true base mixes.

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Overview of TDOT Mixes

- 307 Mixes:
  - BASE Mixes (Lowest in the pavement structure)
    - A – Dense-Graded Base
    - ACRL – Crack Relief Base
    - AS – Gap-Graded Base

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Overview of TDOT Mixes

- 307 Mixes:
  - BINDER Mixes (Intermediate – in between base and surface)
    - B – Not used often. Can be a base or binder.
    - BM – aka “B Modified.”
    - BM2 – Most common binder mix.

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Overview of TDOT Mixes

- 307 Mixes:
  - CW – Occasionally used for surface mix in areas with low traffic volume and slow-moving traffic.
    - (i.e. – County, Local Programs projects.)
  - CS – “Scratch mix” or leveling course. Fine-graded, higher asphalt content mix used to correct uneven surface or other surface deficiencies prior to placement of final surface mix.

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Overview of TDOT Mixes

- 313 Mixes:
  - TPB – Treated Permeable Base
    - Drainable base mostly used under concrete pavements.

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Overview of TDOT Mixes

- 411 Mixes: D, E, E-Shoulder
  - Surface mixes are the wearing courses that make direct contact with automotive tires.
  - D – Most common TDOT surface mix.
  - E – Occasionally in low-traffic areas.
  - E-Shoulder – Similar to D and E with slight modifications for application on shoulders.

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Overview of TDOT Mixes

- 411 Mixes: TL, TLD, OGFC
  - TL – Fine-graded (~1/4") mix for thin surface paving. Placed as thin as 5/8".
  - TLD – Moderately fine-graded (~3/8") mix for thin surface paving. Placed as thin as 7/8".
  - Open-Graded Friction Course (OGFC) – A porous, open-graded mixture used at surface to reduce hydroplaning.

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Nominal Maximum Agg. Size

- These are values of what we could expect based on gradation specifications in 904.
  - There is a way to know the actual NMAS of a mixture.

Mixture	NMAS	
	in	mm
307-ACRL	1-1/2	37.5
307-AS	1-1/2	37.5
307-A	1-1/2	37.5
307-B	1-1/2	37.5
307-BM	3/4	19.5
307-BM2	3/4	19.5
307-C	3/8 - 3/4	9.5 - 19.5
307-CW	3/8	9.5
307-CS	1/4	4.75
411-TL	1/4	4.75
411-TLD	3/8	9.5
411-D	1/2	12.5
411-E	1/2	12.5
411-OGFC	1/2	12.5

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Basic Materials Summary

- Asphalt
  - Hot, Black, and Sticky.
  - Correct performance grade.
- Aggregates
  - Angular, with good surface texture.
  - Hard and Sound.
  - Well-Blended with Consistent Gradations.

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Intro to Specs

- <u>Labs</u> – Section 106
- <u>Aggregate</u> – Section 903
- <u>Asphalt Binder</u> – Section 904
- <u>HMA and WMA</u> –Sections 307 & 411
- <u>Operations (Plants and Paving)</u> – Section 407
- <u>Plant Scales</u> – Section 109

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2

Plant Overview

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Asphalt Plant Overview

Requirements for All Plants

<u>407.04 – Bituminous Mixing Plant</u>

1. Liquid Asphalt Storage Tanks
2. Cold Feed Bins for aggregate
3. Dryer for aggregate
4. Screens
5. Metering system
6. Capable of determining mix temperature
7. Dust Collector
8. Safety Requirements
9. Field Lab
10. Surge and Storage System

Types of Asphalt Plants

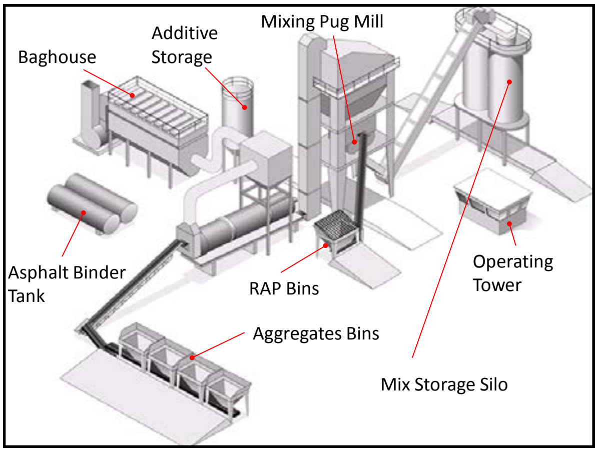
Batch Plant

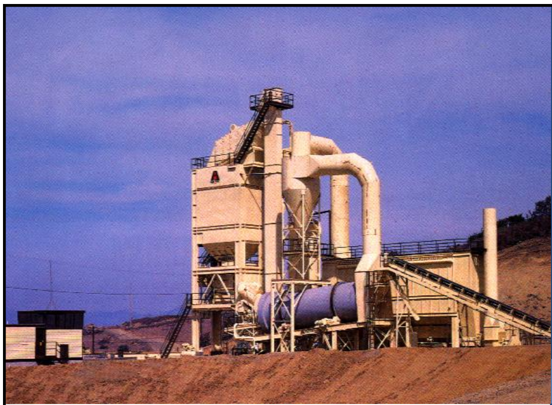
Drum-Mix Plant

What Is The Difference?

- Batch plants make a set amount of hot mix.
- Continuous drum plants are constantly producing hot mix asphalt at a rate.
- Continuous Drum plants do not have Hot Bins
- A large continuous drum plant can produce 400 tph.
- Batch plants handle smaller projects.
  - Patching, parking lots, driveways, city work, etc.

Batch Plant Facility





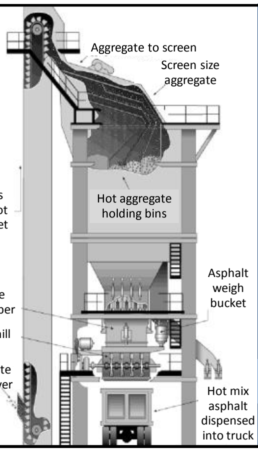
Batch Plant Facility

What You Will Learn

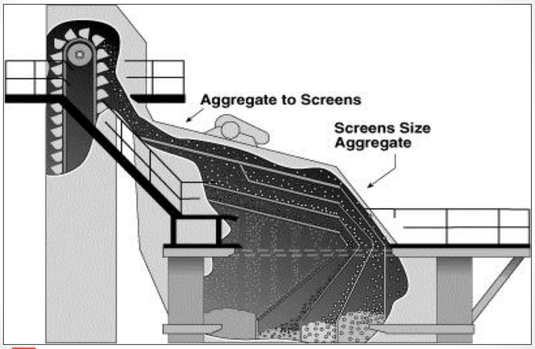
- How gradation is controlled in a batch plant.
- How asphalt is controlled in a batch plant.
- Operational principles and BMPs for batch plants.
- Using RAP & recycle production with a batch plant.

The Modern Batch Plant Facility

- Gradation control at the hot bins.
- Asphalt control at the weigh bucket.



Screen Deck



Screen Deck

Best Management Practices: Screen Deck

- Check for worn cloth or holes (hot bin gradations typically get coarser)
- Check side plates for wear (can contaminate bins by causing fine particles to flow to coarse bins)
- Check chutes for worn holes (hot bin gradations get coarser)
- All these items negatively affect gradations in hot bins.

Section 407.04 (a)

Screens:

Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of full capacity of the mixer, shall be provided.

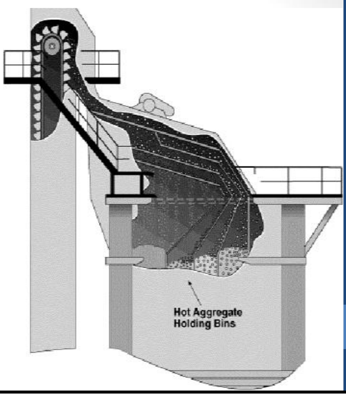
A consistent carry-over, but not to exceed 20 per cent, will be allowed on any screen. If any bin contains more than 20 per cent of material which is undersized for that bin, the bin shall be emptied and correction of the cause for such condition shall be made.

Approved scalping screens shall be required on all dryer-drum mixing plants, but additional screens will not be required.

Best Management Practices: Screen Deck

- Do not overfeed a screen beyond its capability (causes finer material to carry over into the larger hot bins)
- Make sure the aggregate is dry…wet material can "blind" a screen (also causes finer material to carry over into the larger hot bins)
- All these items negatively affect gradations in hot bins.

Hot Storage Bins

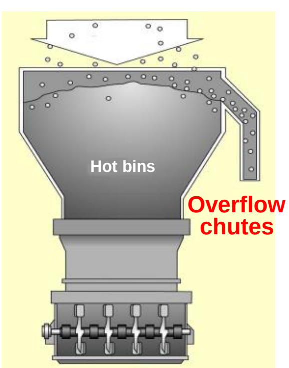


Section 407.04 (a)

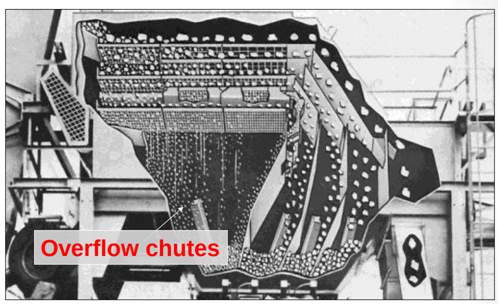
Bins:

The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Each bin shall be provided with overflow pipes of such size and at such location as to prevent backing up of material into other compartments or bins. Each compartment shall be provided with an outlet gate constructed so that when closed there shall be no leakage.

Overflow Chutes



Overflow Chutes



Over Flow Chute (Why two chutes?)

Best Management Practices: Hot Bins

- Watch side wall wear (contaminates other hot bins - gradations typically get finer due to slope of bin wall).
- Watch overflow chutes from filling up or plugging up (damage to screen and carryover to other bins).
- All these items negatively affect gradation.

Best Management Practices: Hot Bins

- Malfunctioning hot bin indicators can also cause carryover to another bin by incorrectly over-filling a bin.
- Match cold feed flow to hot bin pull, especially on plant with small hot bins (can affect both production rates and consistency of mix)
- All these items negatively affect gradation.

Hot Bin Gates

Aggregate Sampling at Hot Bin Gate

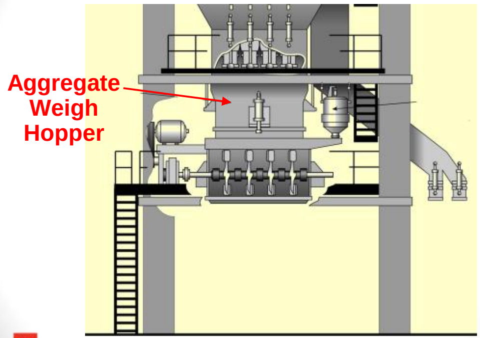
Best Management Practices: Hot Bins Gates

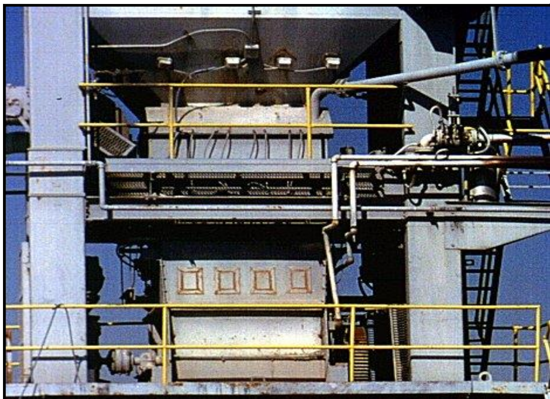
- Gates wear (can cause overflow into weigh hopper)
- Gates hinge pins fail (causing gates not to close correctly - negatively affecting gradation)
- Gate/bin opening clearances wear (can also cause leakage)
- All items affect material gradation.

Best Management Practices: Hot Bins Gates

- Take samples across full flow of material from hot bin (might not represent actual hot bin gradation)
- Gate cylinders wear causing them to not close smoothly or quickly (can affect cutoff values on hot bin draws changing gradation)
- All items affect material gradation.

Aggregate Weigh Hopper





Weigh Hopper

Section 407.04(b)

Weigh box or hopper:

The equipment shall include a means for accurately weighing each size of aggregate and mineral filler in a weigh box or hopper suspended on scales. The weigh box or hopper shall be of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

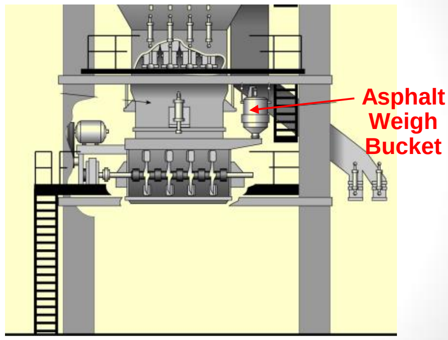
Mechanical Lever Scales for Weigh Hopper

Modern Load Cell Style Weigh Hopper with Lever Arm Scale

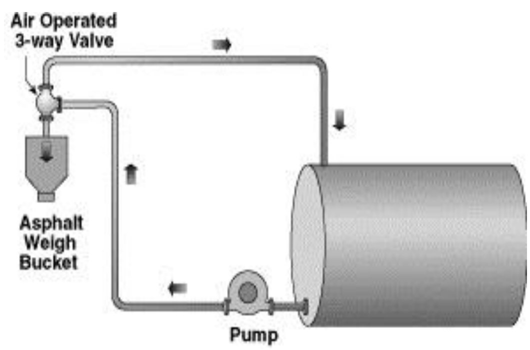
Best Management Practices: Aggregate Weigh Hopper

- Check "knife edges" and linkage for wear and buildup (hopper won't weigh correctly)
- Watch cylinders and solenoids for wear (causing hopper to not release material completely)
- Watch for gate not closing completely or leaking (causes material to flow from hopper)
- Items can negatively affect gradation & batch weights.

Aggregate Weigh Bucket



Asphalt Weigh Bucket



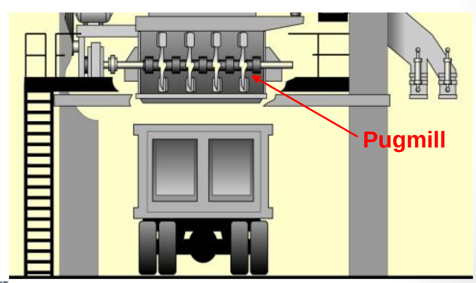
Asphalt Flow

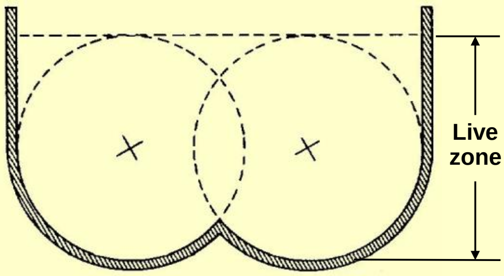
Section 407.04(b) Plant Scales

- Asphalt weigh bucket is also a weigh scale, and must be calibrated every six months, just like the aggregate weigh hopper.
- All dial scales shall be accurate within a tolerance of 0.5%.

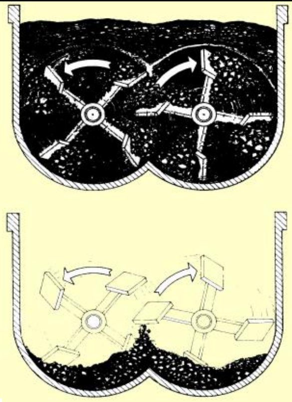
Pugmill

(Dry mix cycle, Wet mix cycle)

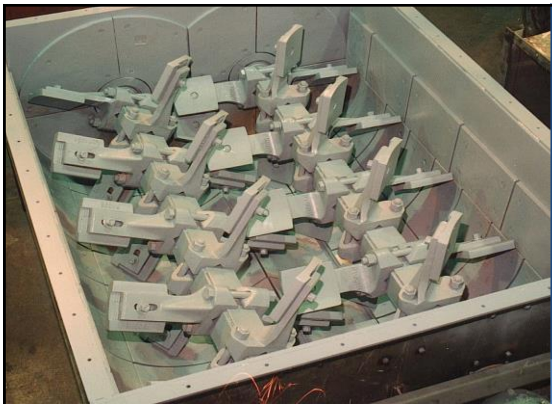




Live Zone in Pugmill



Overfilling & Underfilling Pugmills



Inside of Pugmill

Best Management Practices: Pugmill

- Routinely inspect tips, liners for clearance and missing parts (affects coating and mixing).
- Make sure discharge gates properly functioning and fit (eliminates mess and losing aggregates on charging mixer).
- Monitor batch weights to not charging above live zone (affects coating and mixing).

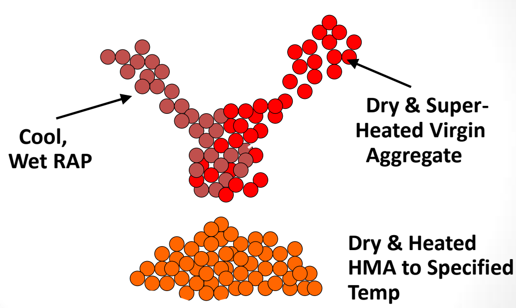
Using RAP in a Batch Plant

Two methods typical:

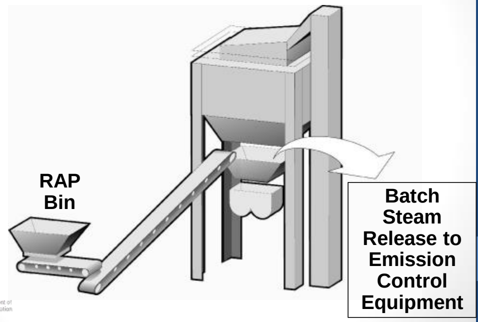
- Weigh Hopper / Weigh Batcher
- Bucket Elevator

(Both rely on conductive heat transfer)

Conductive Heat Transfer

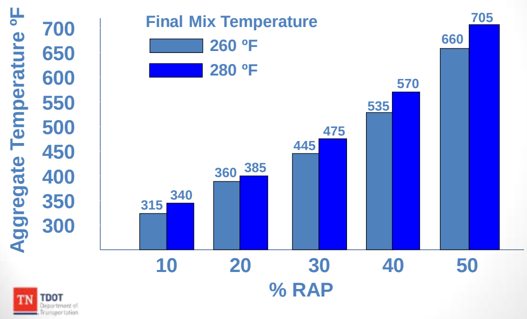


“Weigh Box” Batch Facility Recycling Technique



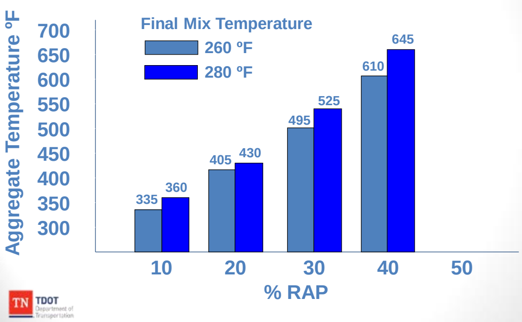
Recycling with Batch Plant

Required Virgin Agg. Temp. with 3% H20 in RAP



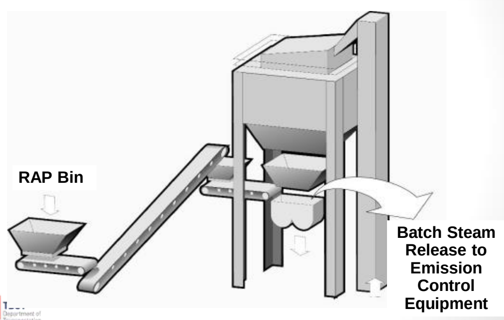
Recycling with Batch Plant

Required Virgin Agg. Temp. with 5% H20 in RAP

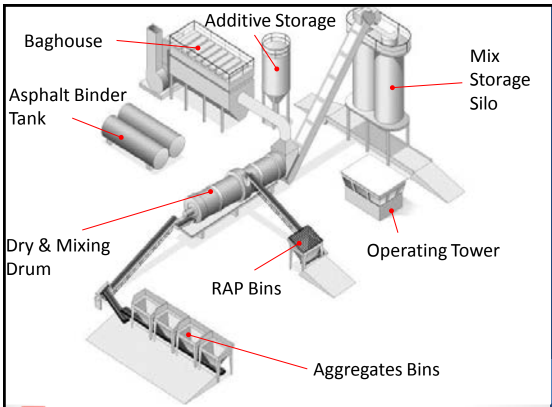


“Weigh Box” Batch Facility Recycling Technique

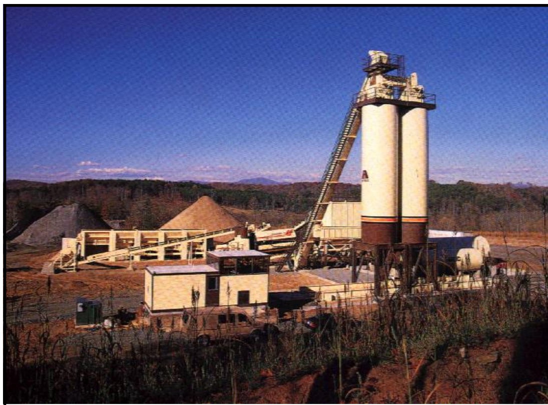
“Pugmill” Recycling Technique with Separate Weigh Hopper



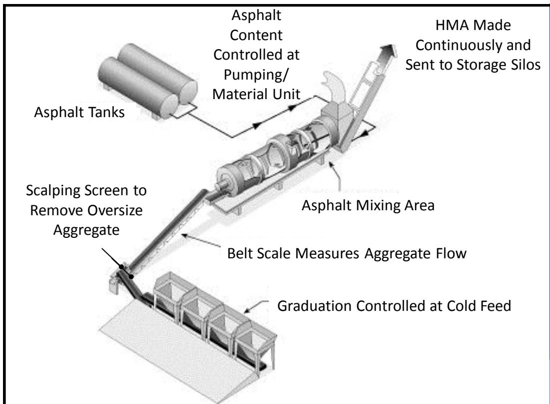
Drum-Mix Plant Facility



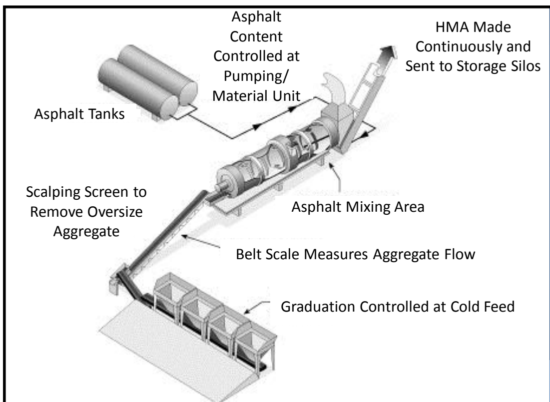
Drum Mix Facility



Drum Mix Facility



Scalping: Rejecting oversized or tramp materials from the aggregate blend

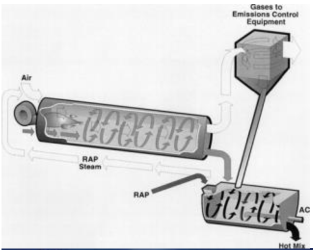


Drum Mix Facility

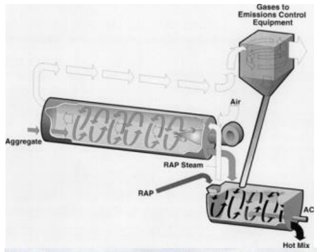
Types of Drum-Mixers

- New types of drums have been introduced since the 1980's.
- Environmental excellence is the goal.
- All are called "drum-mixers".

Parallel-Flow Drum Mixer



Counter-Flow Drum Mixer



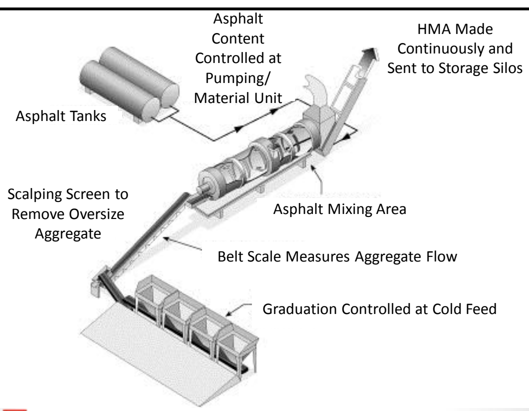
What You Will Learn

- How gradation is controlled in a drum-mixer.
- How asphalt is controlled in a drum-mixer.
- Different styles of drum-mixers.
- RAP production with a drum-mixer.

Drum-Mix Production

Hot Mix production characterized by:

- Gradation Control at Cold Feed.
- Measure aggregate flow with belt scale.
- Meter asphalt to aggregate flow.
- Produce mix continuously.



Section 407.04 - Cold Feeds

- Separate feeders shall be provided for each size aggregate, and each size shall be fed onto the belt going to the dryer by mechanical feeders with separate adjustable gates. The feeders shall be capable of delivering the separate aggregates onto the belt in proper proportions.
- Adequate means shall be provided to assure a constant and uniform flow of material from each bin. Bins containing fine aggregate shall be equipped with vibrators if necessary.

Cold Feed Proportioning

- Composite gradation is controlled at cold feed by proportioning material from individual bins.
- Gradation and quality of the individual materials is controlled at the quarry.

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Electronically controlled variable speed belt conveyors at the individual feeders

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Cold Feed Proportioning

Variation in material flow from individual bins:

- Based on variable speed motor on belt
- Adjustable manual gates help control minimum and maximum flow

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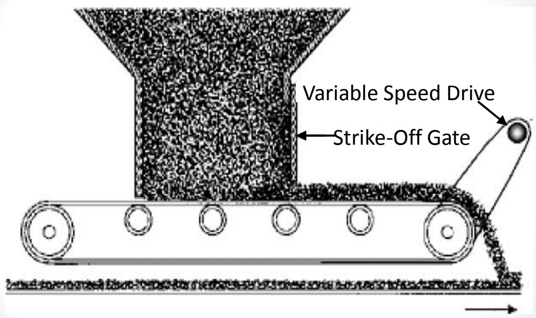

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Cold Feed Proportioning "No-flow" warning

- "No-flow" paddles warn of lack of feed.
- Positioned in opening of feeder.
- Lights or interlocks to plant shutdown in control room for operator (not a department spec).

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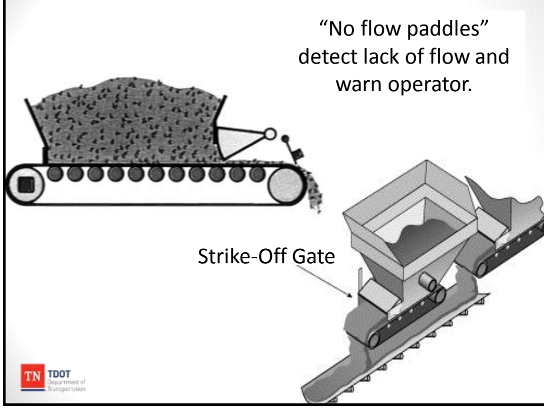

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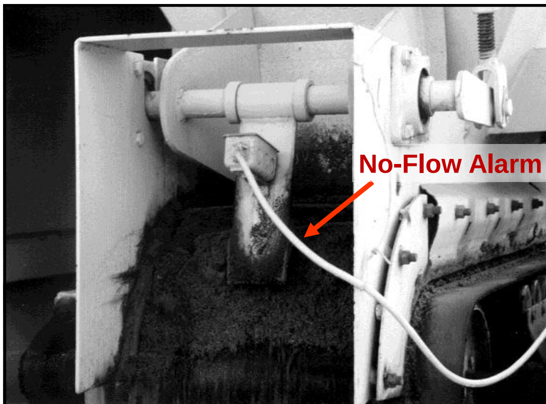
No-flow ski-type paddle

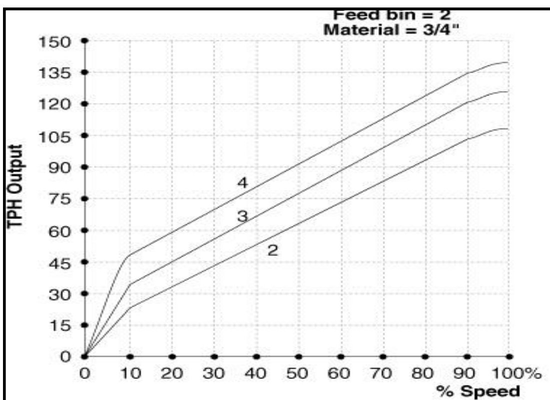


No-Flow Alarm

No-flow alarm on drum-mix cold feed control panel

Cold Feed Proportioning

- Accomplished by calibrating the feeders.
- Material output is charted against belt speed in calibration charts.
- Different charts are created for different gate settings on the same feeder.



Best Management Practices Cold Feed Proportioning

It is best to run each feeder above 10% and below 90% speed to ensure that the feeder is operating in a stable range, and output is more predictable.

Class Discussion
Cold Feed Proportioning

Field conditions are reported as follows:

- Laydown visual feedback “appears bony”
- Brand new drum-mix plant, just calibrated
- Sand being fed from one large feeder
- Sand feed percentage only 15% of mix
- Sand percentage varying in test results

(What areas might we start investigating?)

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BMP - Class Discussion
Cold Feed Calibration

- Feeder calibration charts should be created with dry material weight figures not wet. WHY?

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Cold Feed Gradation Control

- Many styles of feeder controls found in field.
- All can perform satisfactory proportioning.
- What do you think is most common now?

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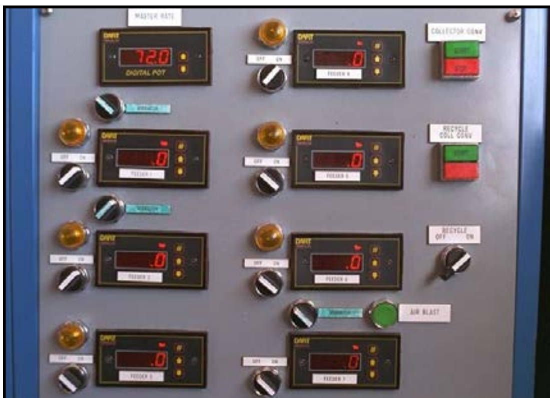
Feeder Speed Control Panel



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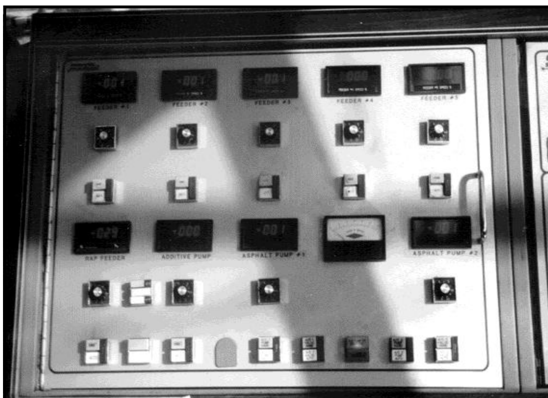
Feeder System with Digital Readout



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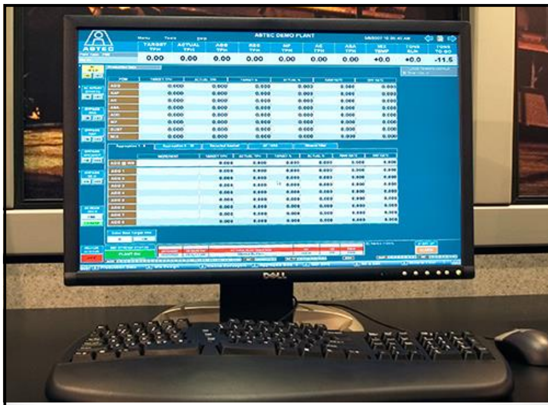
Manual Speed Control Panel

Drum Mix Plant Control Screen



Asphalt Proportioning

Section 407.04 Bituminous Control Unit

Bituminous control unit:

Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

Asphalt Proportioning

Section 407.04 (d) Synchronization

Satisfactory means shall be provided to afford a positive interlocking control between cold aggregate feed and asphalt. The control setting for the asphalt flow will be based on the dry weight of the aggregate. There must be an acceptable method provided for proportioning asphalt flow as variations in aggregate flow take place.

Asphalt Proportioning

- Asphalt flow must be proportionate to aggregate flow.
- First step in asphalt proportioning is measuring aggregate flow.
- Belt scale is used to measure aggregate flow.

Belt Scale on a Drum Mix Plant

How a Belt Scale Works

- Weigh bridge measures weight of aggregate.
- Speed sensor measures speed of belt.
- "Integrator / Totalizer" calculates aggregate flow in ton (tonnes) per hour.
- "Integrator / Totalizer" reports flow rate to plant control system.

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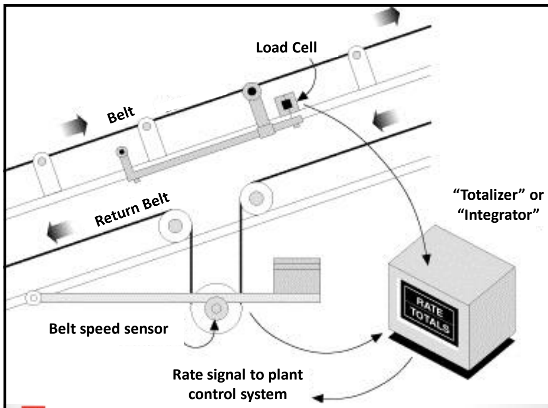

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TN TDOT **Integrator/Totalizer in Control Room**

Asphalt Proportioning

Asphalt flow must be proportionate to aggregate flow.

Second step is regulating asphalt flow. Asphalt pumping / metering unit is used to regulate asphalt flow.

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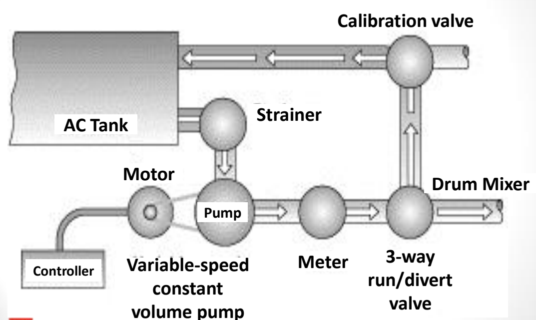
Asphalt metering system for Drum-mixer plants with variable speed, constant volume pump



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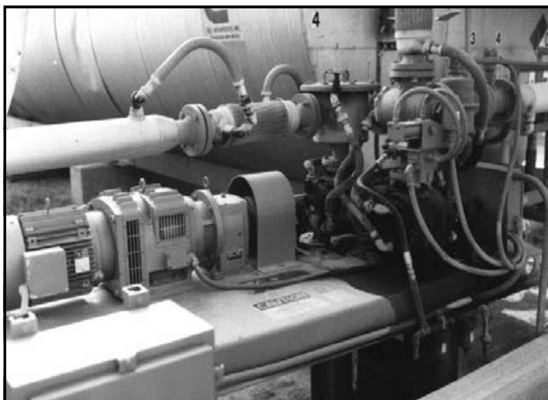
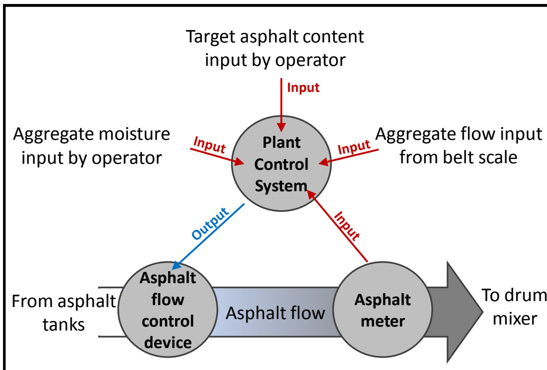


TN TDOT **Asphalt Pumping and Metering System**

How Asphalt Proportioning Systems Work

- Controls system reads wet aggregate flow from belt scale.
- Controls accepts moisture content entered by operator to establish dry flow rate of aggregate.
- Control system accepts target asphalt content entered by operator.
- Control system drives pumping/metering unit flow control device.
- Control system adjusts asphalt flow control system based on signal received back from meter.



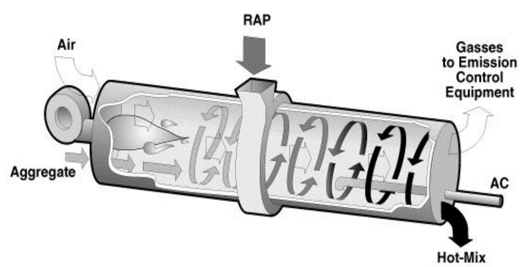
Process of the Plant Control System in Regulating Asphalt Flow to Aggregate Flow

Warm Mix Asphalt

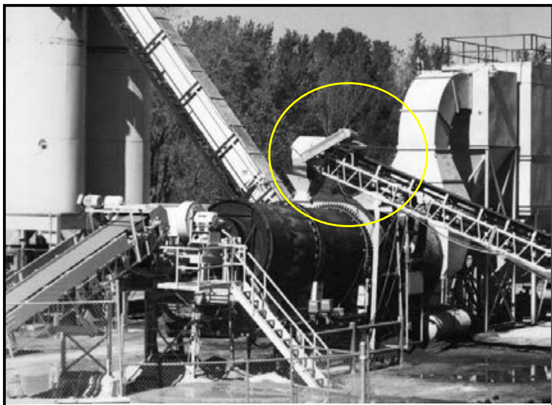
- TDOT Spec Section 407.11.B
- Lower temperatures achieved either by chemical additive (921.06.B.3) or plant-mounted foaming device (407.04.A.12)
- Maximum 300°F
- Approved systems and additives on Qualified Products List.
- Reduced temperatures to conserve fuel use and emissions.

Recycling with a Drum-Mixer

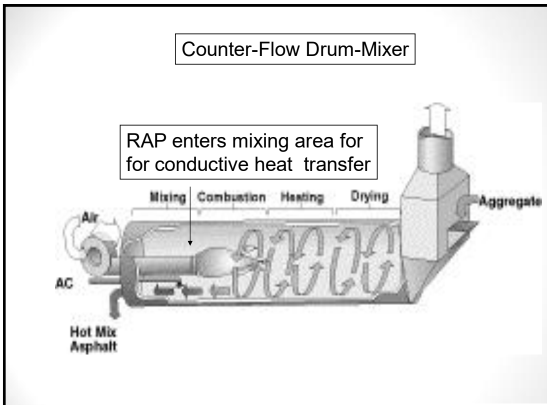
- Parallel-flow drum-mixers heat RAP convectively with hot gases in dryer.
- Counter-flow drum-mixers heat RAP conductively with super-heated virgin aggregate.
- Regardless of drum-mix type, RAP is introduced similar to another aggregate in the plant process.
- Plant automation adjusts for asphalt content and moisture in the RAP.



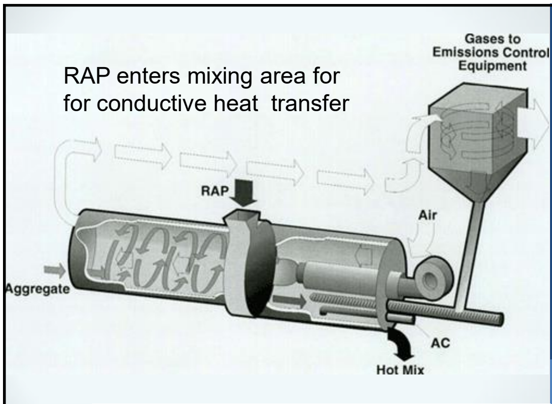
Parallel-Flow Drum Mixer



Parallel-Flow Drum Mixer



Counter-Flow Drum Mixer



Counter-Flow Drum Mixer

Counter-Flow Drum-Mixer

Mixing Temperature

407.11-Preparation of Bituminous Material. The bituminous materials for hot mixes shall be heated to the required mixing temperature in accordance with the following table:

PG Binder Grade	Minimum Temp.	Maximum Temp.
PG 64-22, PG 67-22	270° F	310° F
PG 70-22	290° F	330° F
PG 76-22	290° F	330° F
PG 82-22	290° F	330° F

Why have temperature Requirements?

- Manufacturer recommends it.
- Protects asphalt from over-cooking.
  - Blue Smoke.
- Having a minimum temperature helps with compaction on the road.
- Environmental Concerns.


Batch or Drum-Mixer?
Q: Which is Best?
A: Choice based mostly on economics.
Both make quality mix.
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3

Aggregate Storage and Metering Systems

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Aggregate Storage and Metering Systems

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What You Will Learn

- Aggregate Stockpiling Alternatives
- Managing Stockpiles for Quality
- Types of Feeders
- Managing Feeders for Quality & Accuracy
- Unique Aspects of Storing and Feeding RAP

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Aggregate Quality is Determined at the Quarry

- Aggregate quality and gradation is assured at the quarry it originated from.
  - Quality cannot be fixed at the asphalt plant.

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Aggregate Quality is Determined at the Quarry

- Hot Mix Producer must make sure they have quality aggregates with consistent gradations.
- Technicians must know the materials they work with!

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Section 407.02 - Materials

"Store each size and type of aggregate in a separate pile, bin, or stall. Maintain the storage yard in an orderly condition, clearing a walkway between stockpiles that are not separated by partitions. Make the stockpiles readily accessible for sampling."

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Section 407.03.D.3
Contractor's Quality Control Plan

Table 407.03-3, A

1. Stockpiles
   a) Determine gradation of all incoming aggregates.
   b) Inspect stockpiles for separation, contamination, segregation, etc.

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Section 407.03.D.3
Contractor's Quality Control Plan

c) Conduct a fractured face count when gravel is used as coarse aggregate.

d) Determine the percent of glassy particles in slag coarse aggregate.

e) Determine gradation and asphalt content of reclaimed asphalt pavement when used as a component material.

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Stockpiling

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Stockpiling

Horizontal Stockpiling

- Horizontally stockpiled aggregates can be delivered by:
  - Transport truck and dumped in yard.
  - Barge and unloaded with crane.

Horizontal Stockpiling

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Stockpile to Cold Feed

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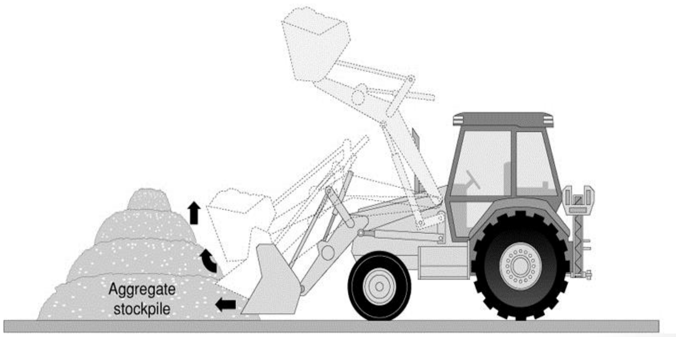
Proper Removal Technique

- Remove material from just above grade.
  - Avoids contamination.
- Rotate up and through material.
  - Reduces possibility of segregation.



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Cold Feed Bins

- Most common form of feeding into plants.
- Typically charged with rubber-tired loader.
- One bin for each material.
- Used on both batch and drum plants.

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Cold Feed Bins

Cold Feed Bins

Material bins should not be heaped above divider walls.

Proper Operation

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Best Management Practices
Cold Feed Bins

- Avoid contamination caused by removing material from grade.
  - The ground the stockpile sits on is not part of the stockpile.
- Have dividers between cold feed bins.
  - Avoids co-mingling of different materials.
- Do not overfill bins with bin wall dividers.
  - Avoids co-mingling of different materials.

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Plant Calibration

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Step 1 - Calibrating Belt Scale

- Verify belt scale reads zero per manufacturers guidelines.
- Set the cold feed gates at an opening that will allow a good material feed.
- Start main conveyor belt.
- Run the variable speed belt feeder for the coarse aggregate bin - about 50% of desired production rate.
- Starting with empty belt run material in tared truck and stop material flow to end with empty belt.

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Step 1 - Calibrating Belt Scale

- Record the total weight indicated on the belt scale.
- Compare weight total on belt scale with actual weight on truck.
- Following manufacturers guidelines, adjust belt scale instrument based on weight difference.
- Repeat test, adjusting instrument, until two consecutive tests are within tolerance.

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Calculate Percent Error

$$\% \text{ Error} = \frac{(\text{Applied Weight} - \text{Measured Weight})}{\text{Applied Weight}} \times 100$$

$$\% \text{ Error} = \frac{(\text{Truck Weight} - \text{Scale Weight})}{\text{Truck Weight}} \times 100$$

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Calculate Percent Error

- Start belt scale and verify reads zero.
- Start feeder at approximately 50% flow.
- Fill truck and stop and empty belt.
- Tonnage on aggregate scale was 9.22 tons.
- Tonnage in the truck at 9.51 tons.

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Calculate Percent Error

$$\% \text{ Error} = \frac{(\text{Truck Weight} - \text{Scale Weight})}{\text{Truck Weight}} \times 100$$

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407.04 – Plant Scales

"…..All dial scales shall be accurate within a tolerance of 0.5 percent."

- Our % Error is _____?
- What do we do?

Best Management Practices: Calibrating Belt Scales

- Larger truck tests rather than smaller truck tests decrease probability of error.
- Weigh bridges should be checked for wear and binding prior to tests.
- If belt scale is out of tolerance on one flow rate, but not another, and adjustments to instrument do not correct error consider re-aligning weigh bridge.

Best Management Practices: Calibrating Belt Scales

- Wind can affect scale readings - consider installing wind guard over weigh bridge.
- Belts should have gravity take-up to keep belt tension constant.
- Belts of different widths and thicknesses are very difficult to calibrate.

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Best Management Practices: Calibrating Belt Scales

- Weigh bridge must be square with weigh idler slightly higher than other belt idlers.
- Watch for build up on the belt and weigh idler.
  - Remove or install scraper.

TN TDOT Department of Transportation

Step 2 - Belt feeder calibration

- After belt scale has been calibrated.
- Develop a chart of aggregate rate (tons/hr) vs. belt speed (feet per minute) for each cold feed bin.

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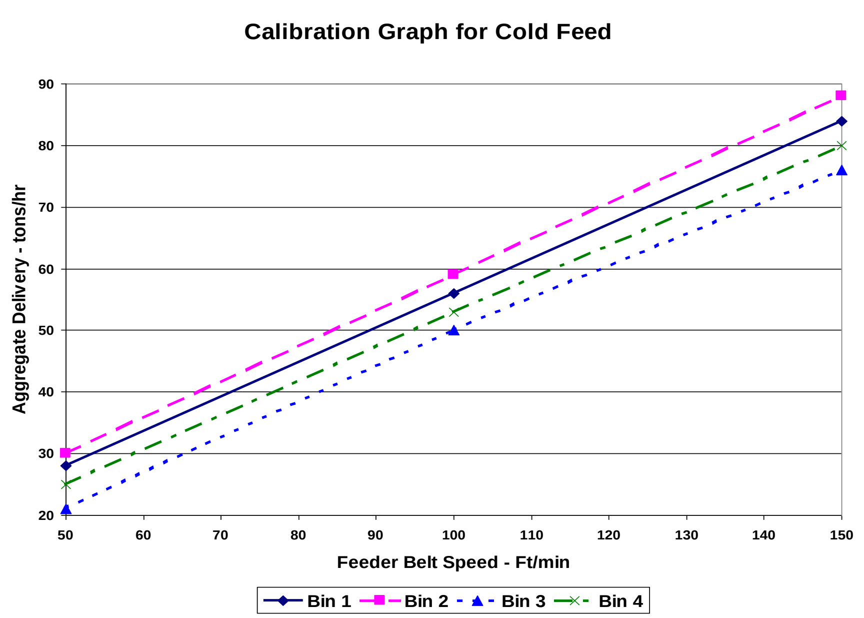

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Step 3: Establish Belt Speeds

- Desired plant production 200 tph.
- Aggregate proportions:
  - Bin 1: 20%
  - Bin 2: 35%
  - Bin 3: 30%
  - Bin 4: 15%
- Asphalt content: 6 %

TN TDOT Department of Transportation

Step 3.A: Correct Aggregate Percentages for Total Weight

- Bin # 1: 20% x 0.94 =
- Bin # 2: 35% x 0.94 =
- Bin # 3: 30% x 0.94 =
- Bin # 4: 15% x 0.94 =

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Step 3.B: Compute Demand for Each Aggregate in Tons/Hour

- Bin # 1: 18.8 % x 200 TPH =
- Bin # 2: 32.9 % x 200 TPH =
- Bin # 3: 28.2 % x 200 TPH =
- Bin # 4: 14.1 % x 200 TPH =

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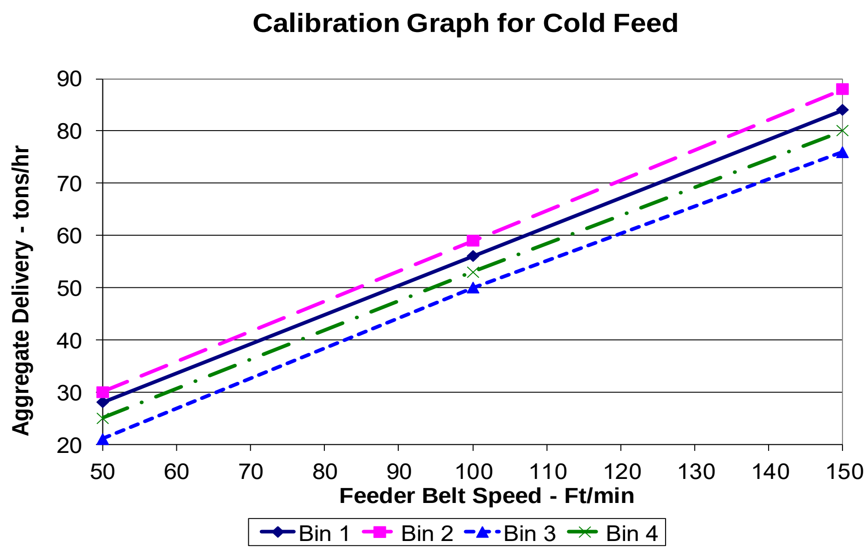
Step 3.C: Pick Belt Speeds

- Bin # 1: 37.6 tons =
- Bin # 2: 65.8 tons =
- Bin # 3: 56.4 tons =
- Bin # 4: 28.2 tons =

TN TDOT Department of Transportation



RAP Cold Feed Bins

RAP Cold Feed Bins

- Special Requirements and Designs:
  - More horsepower (larger output required).
  - Special designs to promote flow of material.
  - RAP more prone to bridge.
  - "Lump breaker" often found at discharge.
- Why have a separate bin for RAP?
  - The drying flame for the virgin aggregate should not come into contact with the binder on the RAP.

TN TDOT Department of Transportation

Section 307

RAP in Hot Mix Asphalt (Base and Binder Mixes)

Mix Type	Percent RAP (Non-Processed)	Percent Maximum RAP (Processed)	Percent Maximum RAP (Processed & Fractionated)	Maximum Particle Size (Inches)
307-ACRL	0	0	-	-
307-AS	0	0	15	-
307-A	15	20	35	1.50
307-B	15	30	35	1.50
307-BM	15	30	35	0.75
307-BM2	15	30	35	0.75
307-C	15	30	35	0.38
307-CW	15	30	35	0.50
307-CS	0	15	25	0.31

TN TDOT Department of Transportation

(Table 307.03-3)

Section 307

- (1) “Non-processed” refers to RAP that has not been crushed and screened or otherwise sized prior to its use.
- (2) “Processed” refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed in Table 307.03-3 prior to entering the dryer drum.
- (3) “Fractionated” refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

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Section 307

- (4) RAP for 307-AS must be processed in a manner such that the minimum particle size is no smaller than 3/4” prior to solvent extraction. For RAP containing gravel as coarse aggregate, the maximum allowable RAP content shall be 10%.
- All mixes shall contain at least 65% virgin asphalt.

TN TDOT Department of Transportation

Section 411

RAP in Hot Mix Asphalt (Surface Mixes)

Mix Type	Percent RAP (Non-Processed)	Percent Maximum RAP (Processed)	Percent Maximum RAP (Processed & Fractionated)	Maximum Particle Size (Inches)
411-D (PG64, PG67)	0	15	20	0.50
411-D (PG70, PG76, PG82)	0	10	15	0.50
411-E (Roadway)	0	15	20	0.50
411-E (Shoulder)	15	30	35	0.50
411-TL (PG64, PG67)	0	15	15	0.31
411-TL (PG70, PG76, PG82)	0	10	10	0.31
411-TLD (PG64, PG67)	0	15	15	0.31
411-TLD (PG70, PG76, PG82)	0	10	10	0.31

TN TDOT Department of Transportation

(Table 411.03-6)

Section 411

- (1) “Non-processed” refers to RAP that has not been crushed and screened or otherwise sized prior to its use.
- (2) “Processed” refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed in Table 307.03-3 prior to entering the dryer drum.
- (3) “Fractionated” refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced
- All mixes shall contain at least 80% virgin asphalt, except for 411E (65%).

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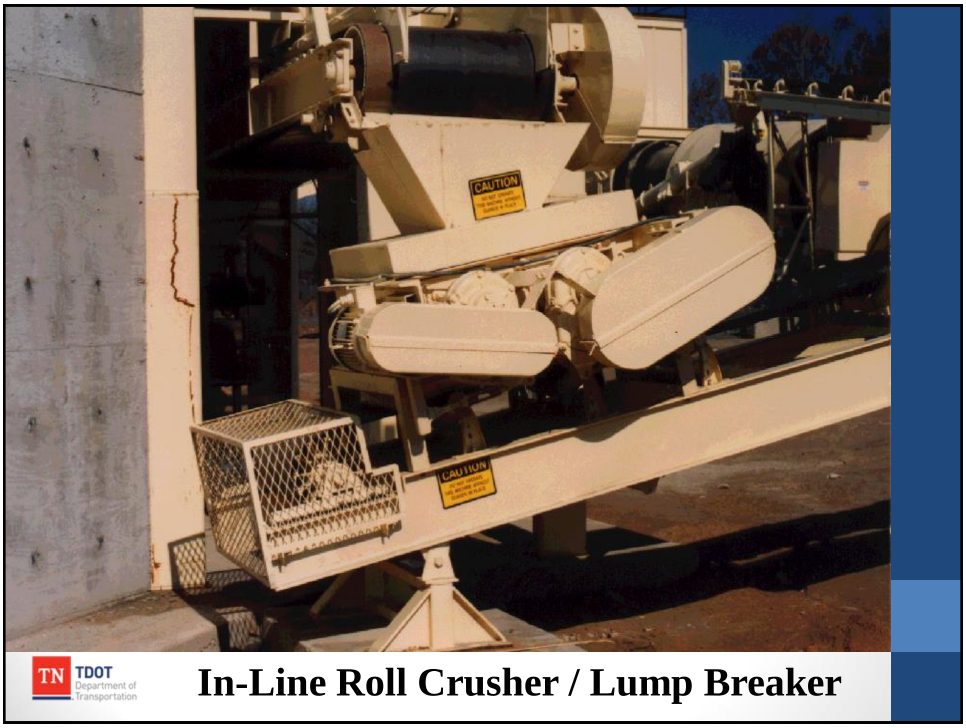
Rap Bin on a Batch Plant

Rap Bins



In-Line Roll Crusher / Lump Breaker

4

Liquid Asphalt Storage and Metering Systems

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Asphalt Storage and Metering Systems

TN TDOT Department of Transportation

What You Will Learn

- Asphalt storage tank systems.
- TDOT requirements all AC systems.
- Hot oil heat systems.
- BMPs for maintaining asphalt cement integrity.

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Section 407.04.A: Requirements for All Plants

407.04.A.6 Bituminous control unit.

"Provide means for weighing or metering the bituminous material to ensure the proper amount of material is added to the mix within the tolerance specified. Provide means for checking the quantity or rate of flow of bituminous material into the mixer."

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Synchronization: Continuous Plants

407.04.C, Continuous Mixing Plants, Part 3.

"Provide positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control may be achieved using mechanical means or any other positive method satisfactory to the Engineer."

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Synchronization: Dryer Drums

407.04.D, Dryer Drum Plants, Part 2.

"Provide satisfactory means to allow a positive interlocking control between cold aggregate feed and asphalt. Base the control setting for the asphalt flow on the dry weight of the aggregate. Provide an acceptable method for proportioning asphalt flow as variations in aggregate flow take place. Provide a metering system to measure the flow of asphalt into the drum, and locate an approved method of checking and calibrating the metering system in the control house. Provide an automatic interlock system that will shut off the asphalt flow and the burner when the aggregate flow ceases."

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Synchronization: Batch Plants

407.04.B, Batch Plants, Part 3.

- Provide a bituminous material bucket of a non-tilting type.
- The length of the discharge opening or spray bar shall be not less than 3/4 the length of the mixer, and it shall discharge directly into the mixer.
- Shall be adequately heated.
- Shall be at least 15% in excess of the weight of bituminous material required in any batch.
- Shall have a scale with divisions measuring in gallons equivalent to a weight sensitivity of 0.04% of the total batch weight.
- The meter shall be accurate within a tolerance of 0.5%.

TN TDOT Department of Transportation

Best Management Practices
Maintaining AC Temperature

- Critical to proper coating of the aggregate.
- Critical for proper placement and compaction.
- Critical for a quality paving product.
- TDOT controls AC temps through tolerances on Mixing temperatures.

TN TDOT Department of Transportation

Temperature Requirements

- 407.11.A, Hot Mix Asphalt- Heat the bituminous materials for hot mixes to the required mixing temperature specified in Table 407.11-1.

PG Binder Grade	Minimum Temp.	Maximum Temp.
PG 64-22, PG67-22	270° F	310° F
PG 70-22	290° F	330° F
PG 76-22	290° F	330° F
PG 82-22	290° F	330° F

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Temperature Requirements

407.11.B, Warm Mix Asphalt (WMA)-

"The Contractor may subject the produced mixture to reduced production and placement temperatures by adding a chemical warm mix additive meeting **921.06.B.3** or by making plant modifications as specified in **407.04.A.12.**"

TN TDOT Department of Transportation

Temperature Requirements

407.11.B, Warm Mix Asphalt-

"When using either WMA technology, the maximum mixing temperature for any grade of asphalt cement shall be no more than 300 °F."

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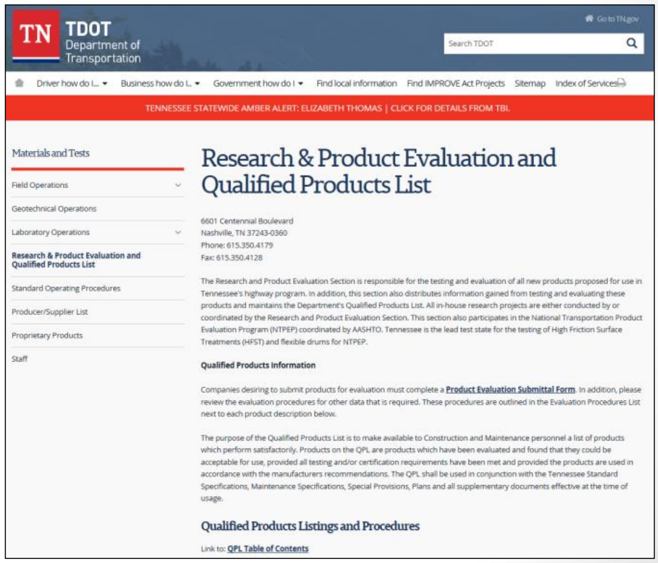
Temperature Requirements (Warm Mix Asphalt)

- QPL 39
- Link to QPL lists: https://www.tn.gov/tdot/topic/tdot-materialstests-research-product-evaluation-qualified-products



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Why Have Temperature Requirements?

- Manufacturer recommends it.
- Protects asphalt from over-cooking.
  - Blue Smoke.
  - Loss of light ends.
- Having a minimum temperature helps with compaction on the road.
  - Ensures that the mixture will stay in a condition favorable to achieve compaction.

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Requirement: AC Storage Tanks

- Samples for binder testing must be taken from the transport tanker or tank.
- Testing valves are typically found on the tanks.

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Asphalt Storage Tanks

- Tanks can be horizontal or vertical.
- Tanks typically have hot oil heating coils.
  - Some are heated electrically or with a burner.

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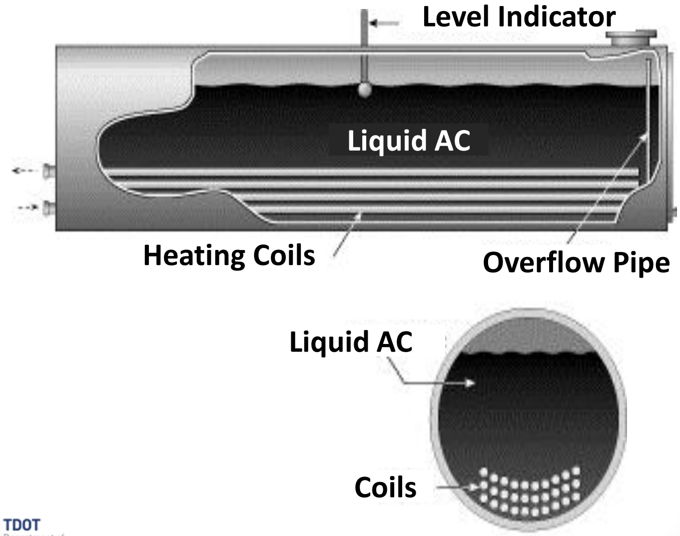
Asphalt Storage Tanks



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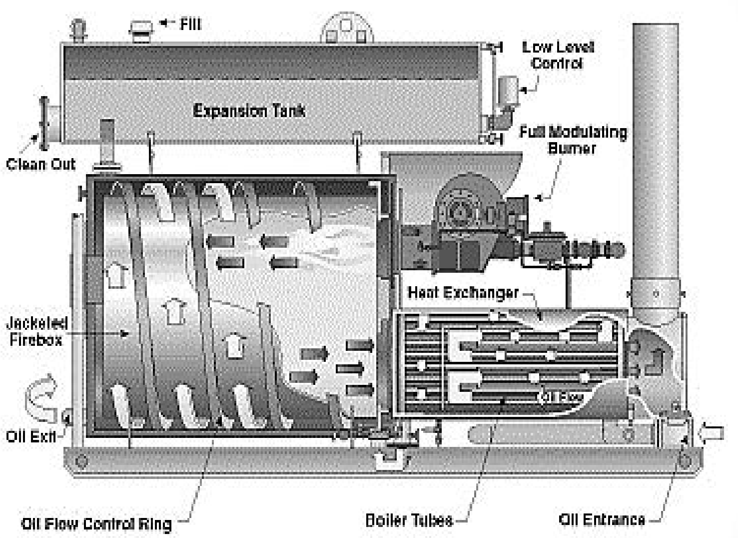
Fossil Fuel Fired Hot Oil Heater



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Fossil Fuel Fired Hot Oil Heater

Storing & Using Modified Asphalts

- Need to be kept in circulation.
- Several equipment options exist.

Natural Convective Currents
In an Asphalt Storage Tank

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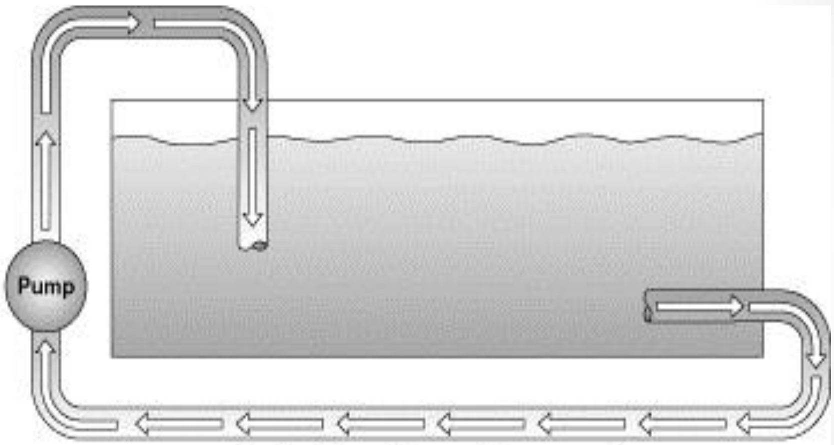
Storing & Using Modified Asphalts



Recirculating with a pump is suggested
for some modified asphalts

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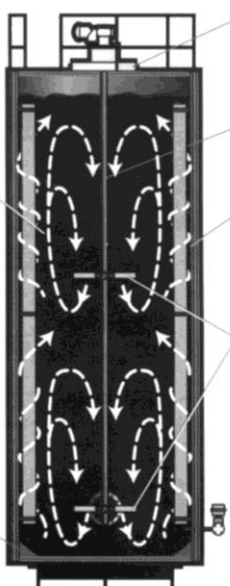
Storing & Using Modified Asphalts



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Multiple Storage Tanks

Multiple Storage Tanks

Best Management Practices: Multiple Tank Installations

- Do not mix asphalt types.
  - Affects asphalt binder properties.
- Care should be exercised when switching valves to direct asphalt storage.
  - It can potentially contaminate asphalt.
- Tanks should be pulled down or emptied before a new type binder is stored.

TN TDOT Department of Transportation

Safety Issues Asphalt Storage Tanks

- Condensation in empty tanks very dangerous. Moisture turns to steam when charging tank with hot asphalt.
- Never look inside a tank being charged with asphalt.
- CAUTION when loading, unloading, sampling.
  - Asphalt is HOT. Be aware of first aid procedures at any facility that you visit.

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Asphalt Distribution in Drum-Mix Plants

TN TDOT Department of Transportation

Asphalt Distribution

- Understanding asphalt distribution:
  - Calculating Flow Requirements.
  - Calibrating Asphalt Meter.

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Calculating AC Flow

Equation for determining the number of gallons/minute of asphalt cement that is to be delivered:

$$R = \frac{P}{100} \times T \times \frac{2000}{W} \times \frac{1}{60}$$

Where: *R* = Asphalt to be delivered, gpm.

P = Optimum Asphalt Content.

T = Production Rate, TPH.

W = Unit Weight of Asphalt (typically about 8.4 lb/gal).

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Calculating AC Flow (Example)

Determine the number of gallons/minute of asphalt cement assuming 6.0 % asphalt content at 200 TPH:

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Calculating AC Flow (Example)

Determine the number of gallons/minute of asphalt cement assuming 5.7 % asphalt content at 300 TPH:

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Calculating AC for Batch Plants

- Calculating the necessary asphalt content for a batch plant varies from the original equation.
- Batch plants make a specific amount of mixture per batch that runs through the plant.
  - R is not expressed as a rate!

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Calculating AC for Batch Plants

Equation for determining the number of gallons of asphalt cement inside of each batch:

$$\boxed{R = \frac{P}{100} \times T \times \frac{2000}{W}} \times \cancel{\frac{1}{60}}$$

Where:

- R = Asphalt Content, *Gallons.*
- P = Optimum Asphalt Content.
- T = Batch Weight, *Tons.*
- W = Unit Weight of Asphalt (typically about 8.4 lb/gal).

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Asphalt Distribution Automatic Control

- Asphalt binder flow is controlled by the plant automation.
- Automation adjusts asphalt binder flow at the asphalt pumping/metering unit.
- Manual calculations not required.

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Asphalt Distribution
Calibrating AC Meter

1. Tare empty truck or vessel and pump asphalt all the way to end of fill line, suspending line to ensure no asphalt leaks from line (CAUTION - AC HOT!).
2. Record totalizer on AC meter, or set totalizer to zero.
3. Pump asphalt into truck or vessel at rate representing normal production flow.
4. When stopping AC flow, make sure line is not allowed to drain into vessel.
5. Record gallons or tons on AC meter.
6. Weigh truck and calculate net weight in truck.

TN TDOT Department of Transportation

Asphalt Distribution
Calibrating Binder Meter

7. Convert gallons to weight if meter reads in gallons.
8. Compare registered meter weight with actual weight on truck.
9. Following manufacturers guidelines, adjust meter based on weight difference.
10. Repeat test, adjusting instrument, until two consecutive tests are within tolerance.
11. Repeat test at high flow rate, then low flow rate.
12. Adjust meter until all flow rates are within tolerance.

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Calibrating Binder Meter

- Set pump at approximately 50% flow and fill truck.
- Record binder weight/gallon at 8.54 lbs/gallon.
- Calculated weight of binder pumped is 10,402 lbs.
- Actual weight in truck is 10,800 lbs.
- Re-test and re-adjust until two consecutive tests pass.

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Best Management Practices Calibrating Binder Meters

- Larger tests rather than smaller truck tests decrease probability of error (1,000 gallon minimum typically used in industry).
- Thermocouples or RTD's used to measure temperature of binder at meter for temperature calibration should be checked against known calibrated thermometers to make sure proper binder temperature is being taken.
- Charged binder lines must not be allowed to drain at start or stop or binder quantities in tests will be off.

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Best Management Practices Calibrating Binder Meters

- Verify proper specific gravity or AC weight/gallon is entered in meter.
- Truck scales are calibrated +/- 20 pounds.
- Small binder test sample sizes should be avoided.
- 40 pound tolerance on a truck scale is 4.7 gallons of binder.

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Best Management Practices Troubleshooting AC Content

- If binder extractions are consistently high or consistently low, suspect meter recalibration or belt scale recalibration, or binder thermocouple recalibration.
- If binder extractions vary, but meter checks on calibration test, suspect flow control device problem at binder pumping skid.
- Plant automation is typically not the problem on binder content variations (typically belt scale, meter, or flow control device).

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Best Management Practices Troubleshooting AC Content

- Air leaks in binder lines can cause meters measuring gallons to count air as asphalt.
  - Extracted binder content will be low.
- Thermocouples or RTD’s measuring binder temperature for temperature compensation will cause binder content errors if not registering proper temperature (replace unit).

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Anti-Stripping Additive

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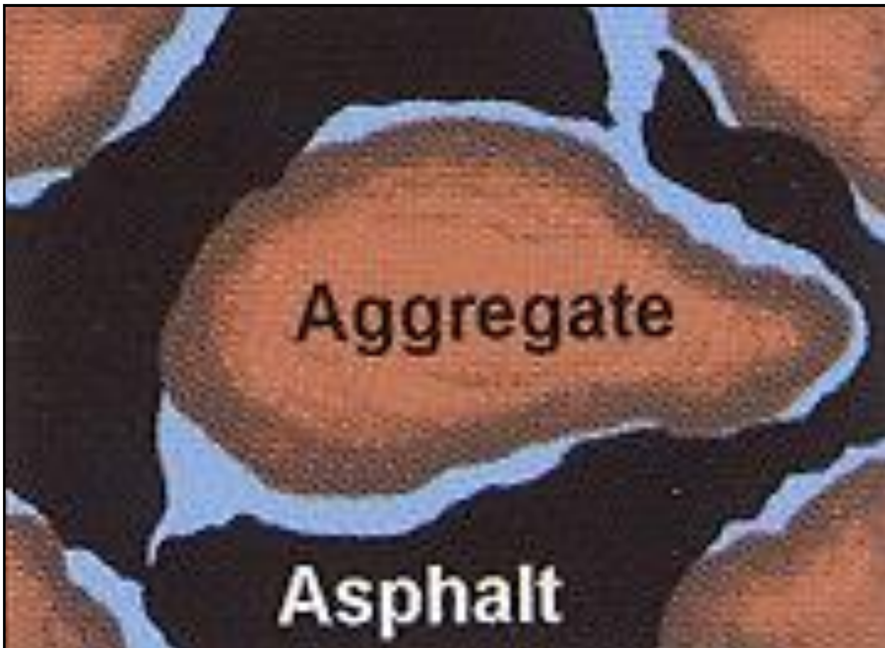

Stripping

Supplemental Spec. 921.06.B

"When using an anti-stripping additive other than hydrated lime, use a dosage rate of **0.3%**, unless either gravel is used as a coarse aggregate or test results indicate moisture susceptibility, in which case mix at a dosage rate of **0.5%**.

The Department's QPL identifies qualified antistripping products. Do not use any product unless it appears on this list."

ASA can be introduced at:

- The Asphalt Terminal
  - Contractor buys binder with ASA already added.
- The Asphalt Plant
  - Blended in-line during production.
- The Asphalt Plant
  - Blended into tanks during unloading of binder transport units.

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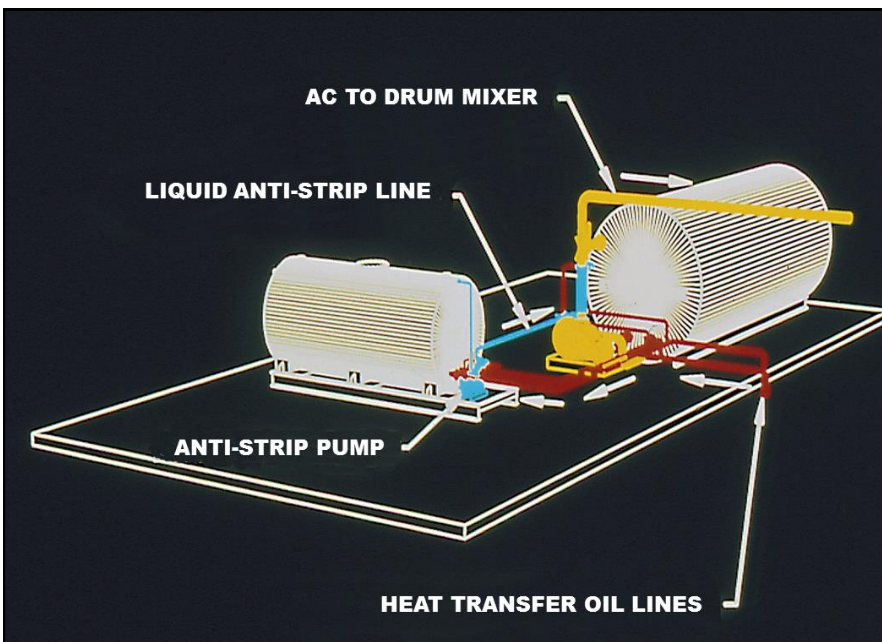

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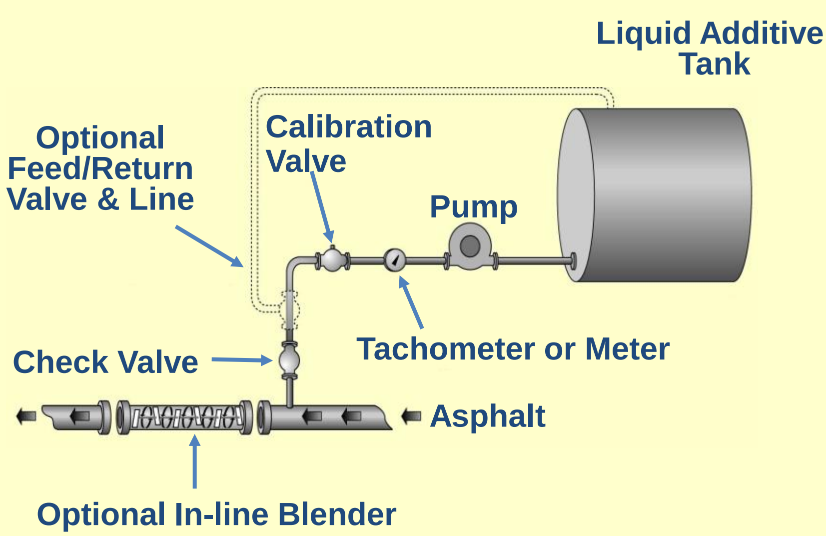
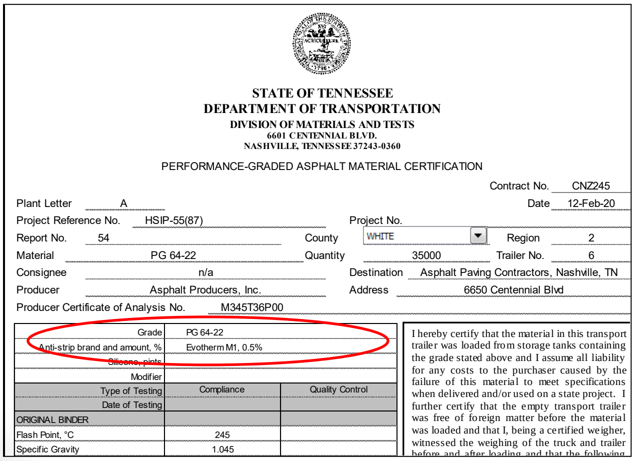
ASA Injection System (Blended during production)

Additive



Typical Asphalt Additive Tank System

Added at Asphalt Terminal



STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

PERFORMANCE-GRADED ASPHALT MATERIAL CERTIFICATION

Contract No. CNZ245
Plant Letter A
Date 12-Feb-20
Project Reference No. HSIP-55(87)
Project No.
Report No. 54
County WHITE
Region 2
Material PG 64-22
Quantity 35000
Trailer No. 6
Consignee n/a
Destination Asphalt Paving Contractors, Nashville, TN
Producer Asphalt Producers, Inc.
Address 6650 Centennial Blvd
Producer Certificate of Analysis No. M345T36P00

Grade	PG 64-22	
Anti-strip brand and amount, %	Evotherm M1, 0.5%	
Silicone, pints		
Modifier		
Type of Testing	Compliance	Quality Control
Date of Testing		
ORIGINAL BINDER		
Flash Point, °C	245	
Specific Gravity	1.045	

I hereby certify that the material in this transport trailer was loaded from storage tanks containing the grade stated above and I assume all liability for any costs to the purchaser caused by the failure of this material to meet specifications when delivered and/or used on a state project. I further certify that the empty transport trailer was free of foreign matter before the material was loaded and that I, being a certified weigher, witnessed the weighing of the truck and trailer before and after loading and that the following

Asphalt certifications that come with truckloads will indicate if ASA is included.

TN TDOT Department of Transportation

Added at Plant When Unloading

- Some plants may be equipped with systems that pump ASA into storage tanks while tanker units are being unloaded.

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Calculate ASA Needed in Gallons

- $$ASA_{TOT} = \frac{\left(HMA \times \left(\frac{AC}{100}\right) \times \left(\frac{ASA}{100}\right) \times 2{,}000\right)}{ASA_{DEN}}$$
  - ASA_{TOT} = Gallons of Anti-Strip Agent.
  - HMA = Total Tonnage of Mix produced in that day.
  - AC = Percent of Binder (from JMF).
  - ASA = Percent of Anti-Strip (from JMF).
  - ASA_{DEN} = Density of Anti-Strip Agent (8.4 lbs/gal).

TN TDOT Department of Transportation

Calculate ASA Needed in Gallons

- 2,200 tons of 411-D produced today.
- 5.8% Asphalt Content.
- 0.5% Anti-Strip Additive.
- Anti-Strip Additive weighs 8.4 lbs/gallon.

TN TDOT Department of Transportation

Calculate ASA Needed in Gallons

- $$ASA_{TOT} = \frac{\left(HMA \times \left(\frac{AC}{100}\right) \times \left(\frac{ASA}{100}\right) \times 2{,}000\right)}{ASA_{DEN}}$$

TN TDOT Department of Transportation

5

Hot Mix Asphalt Storage and Delivery

Hot Mix Asphalt

Storage and Delivery

What You Will Learn

- Operational Concepts Surge/Storage Silos
- Benefits Using Surge/Storage Silos
- Concerns Using Surge/Storage Silos
- Best Management Practices for Maximizing Storage Capability
- Best Management Practices for Silo Loadout

Storage Silos

- Many configurations:
  - Portable
  - Stationary
  - Single Silo
  - Multiple Silo
  - Over Truck Scale
  - Weigh Hoppers in Silos

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TN TDOT Department of Transportation

Storage Silos

Storage Silos

Storage Silos

- Minimize trucks required on a project.
- Increase daily productivity of batch plants.
- Silos are required for drum-mix plants.

Best Management Practices
Storage Silos

- With silos we are mostly concerned about:
  - Segregation.
  - Temperature Loss.
  - Oxidation.

TN TDOT Department of Transportation

Section 407.04 (a)
Surge and Storage Silos

- Surge and Storage Systems:
  - Surge or Storage systems may be used at the option of the Contractor provided each system is approved by the Department prior to use.
  - The surge and storage system shall be of such design that there is no appreciable difference between material being discharged from the bin or silo and material being discharged directly from the pugmill or drum.

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Storage Silos

- When using a silo, the contractor shall deliver material that is:
  - within the tolerance ranges as set forth on the Job Mix Formula.
  - without segregation.
  - without balling or hardening.

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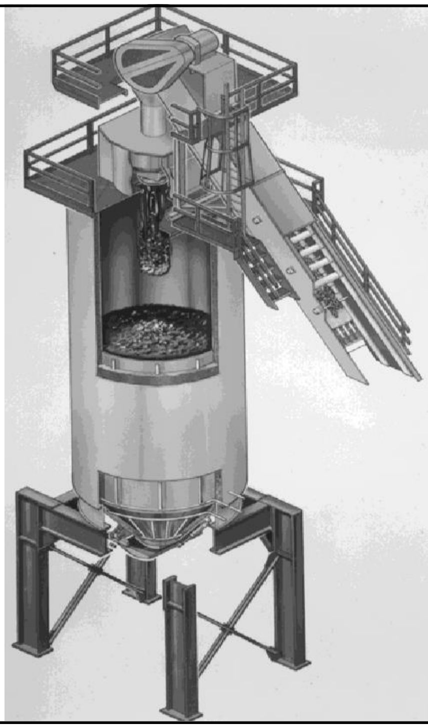
Several Design Elements Have Evolved to Address Our Concerns over Storage



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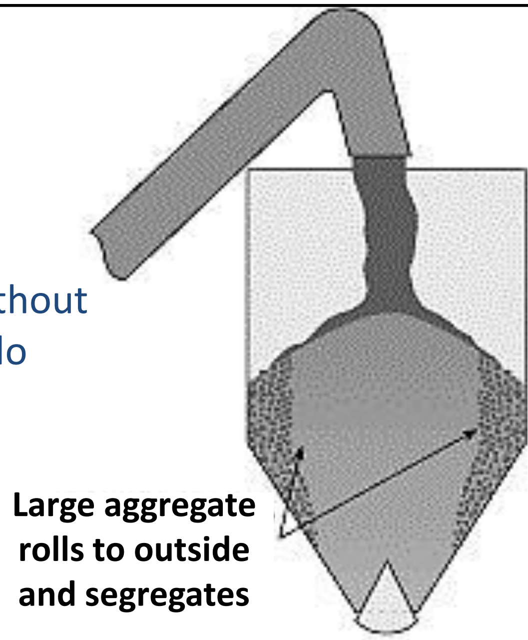
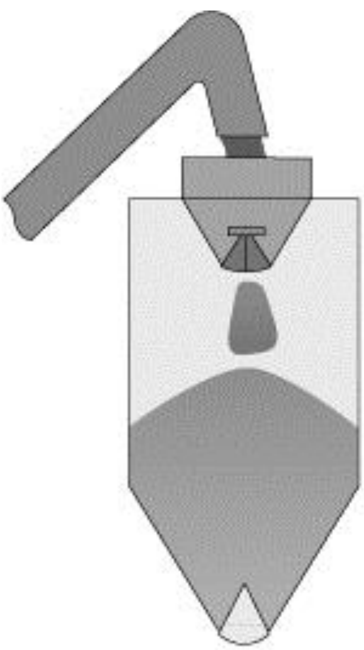
Segregation without a Batcher on Silo



Segregation without "batcher"

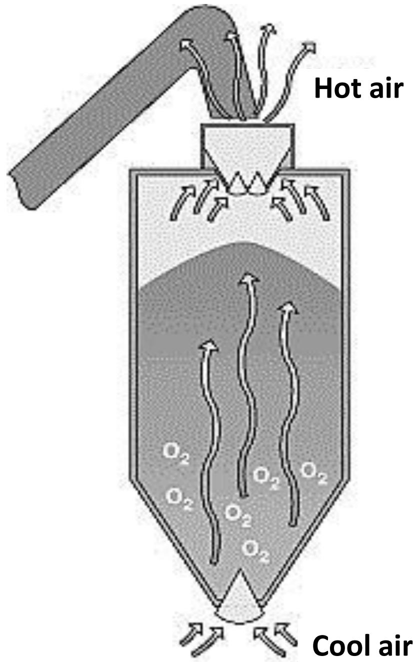
Batchers drop a large mass of material at one time to reduce segregation.



Silo batcher

Heat can escape out the batcher and draws in cool air to oxidize the mix.

Insulated batchers and heated silo gates reduce this effect



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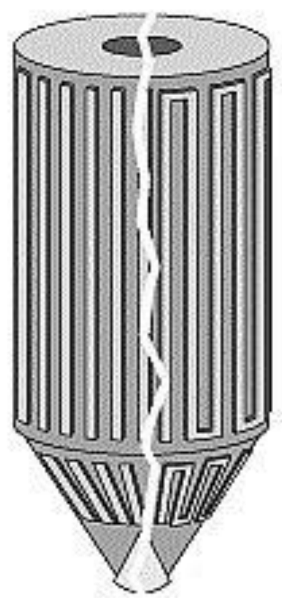
Insulation and hot oil heat helps reduce the effects of heat loss to the atmosphere.



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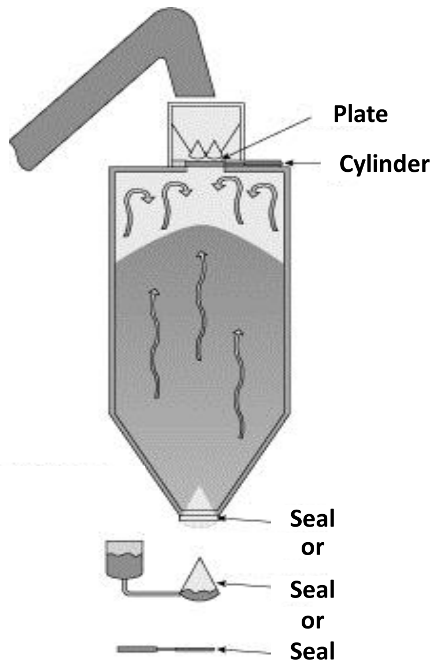
Seals on the bin top and silo gate area lengthen storage times by reducing the "Chimney Effect." Air is trapped in an insulated and sealed environment.



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Best Management Practices
Storage Silos

- To reduce the opportunity for segregation:
  - Feed all batchers in center.
  - Feed split-feed type batcher in-line with splitter.
  - Adjust timer-style batchers for full discharge (varies with production rate).
  - Adjust close timers to leave some material in batcher on closing.

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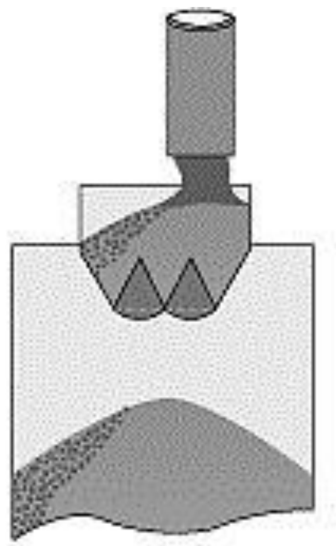
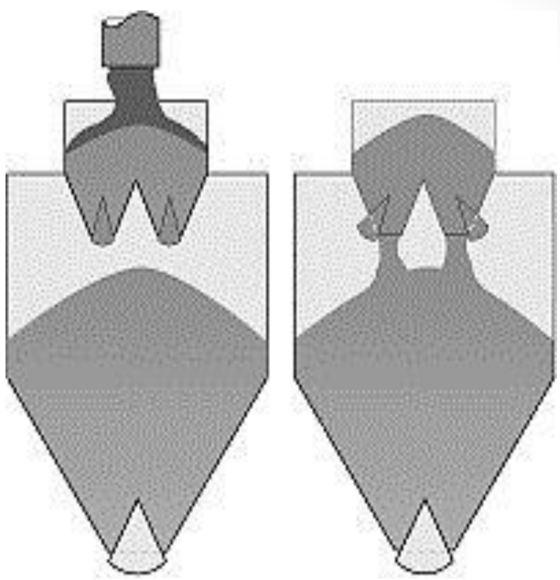


Segregation caused by not feeding batcher in center



Split feed batcher charging and discharging

Loading Truck

Best Management Practices
Silo Loadout

- Specific gate designs and loadout procedures have been developed to minimize segregation in the loading process.

Round Opening | **2 Rectangular Openings**

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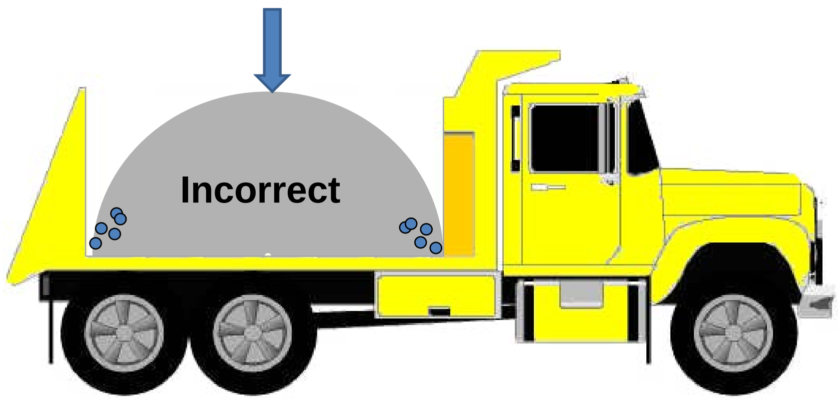
Incorrect Loading



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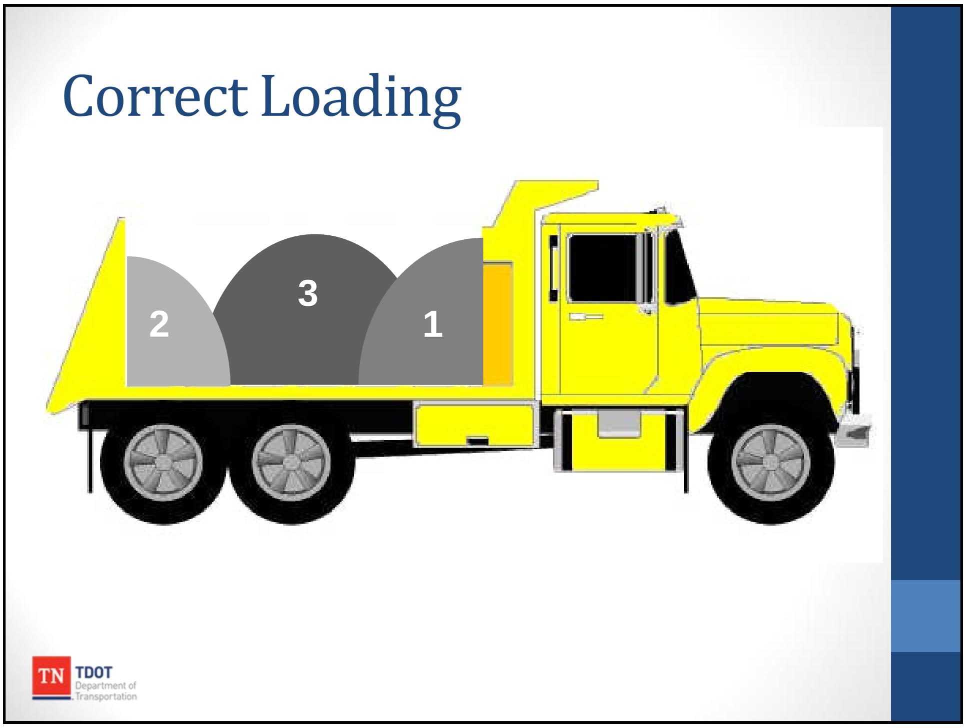
Correct Loading
2
3
1
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Transportation

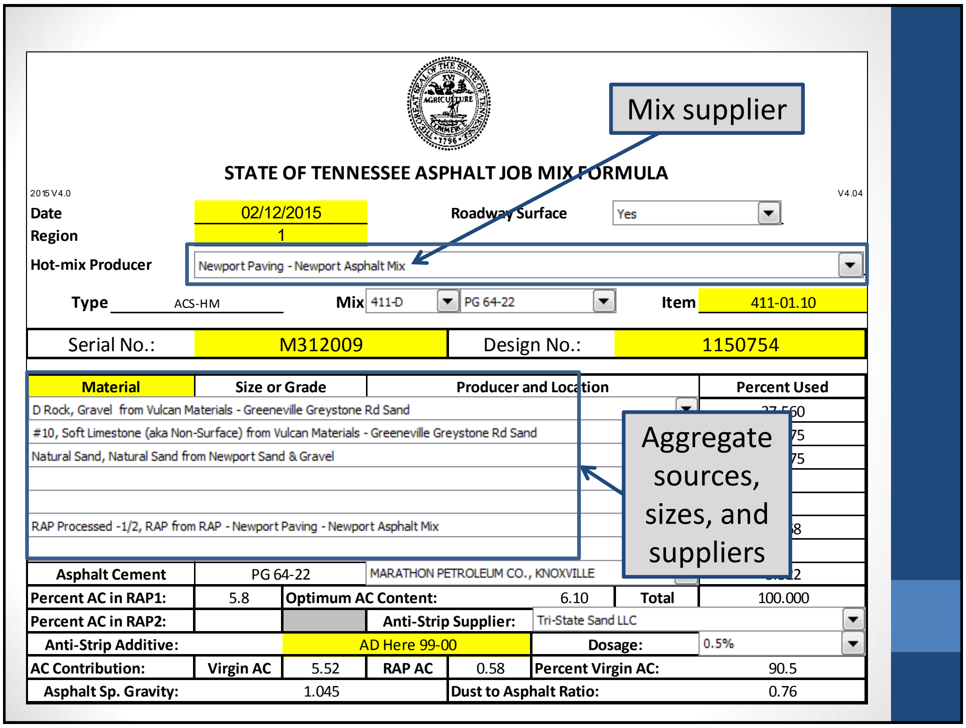
6

Job Mix Formula Overview

Overview of the Job Mix Formula (JMF)

What is a JMF?

- It is a valuable document to all inspectors.
- On this document you will find:
  - Materials being used and their source.
  - Proportions of each material.
  - What Plant is being used.
  - Type of Mix.
  - Gradations.
  - Approval of the Materials Engineer.



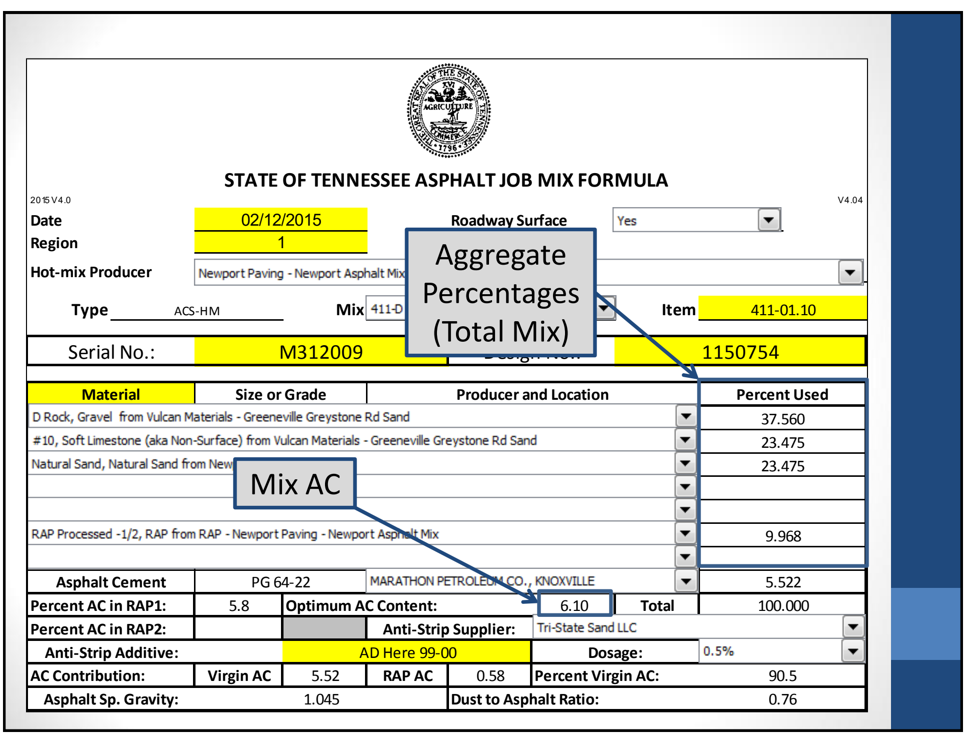
STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2015 V4.0 V4.04

Date	02/12/2015	Roadway Surface	Yes
Region	1		
Hot-mix Producer	Newport Paving - Newport Asphalt Mix		
Type	ACS-HM	Mix	411-D / PG 64-22
Item	411-01.10		
Serial No.:	M312009	Design No.:	1150754

Material	Size or Grade	Producer and Location	Percent Used
D Rock, Gravel from Vulcan Materials - Greeneville Greystone Rd Sand			37.560
#10, Soft Limestone (aka Non-Surface) from Vulcan Materials - Greeneville Greystone Rd Sand			75
Natural Sand, Natural Sand from Newport Sand & Gravel			75
RAP Processed -1/2, RAP from RAP - Newport Paving - Newport Asphalt Mix			8
Asphalt Cement	PG 64-22	MARATHON PETROLEUM CO., KNOXVILLE	2

Percent AC in RAP1:	5.8	Optimum AC Content:	6.10	Total	100.000
Percent AC in RAP2:		Anti-Strip Supplier:	Tri-State Sand LLC		
Anti-Strip Additive:	AD Here 99-00	Dosage:	0.5%		
AC Contribution:	Virgin AC 5.52	RAP AC 0.58	Percent Virgin AC:	90.5	
Asphalt Sp. Gravity:	1.045	Dust to Asphalt Ratio:	0.76		



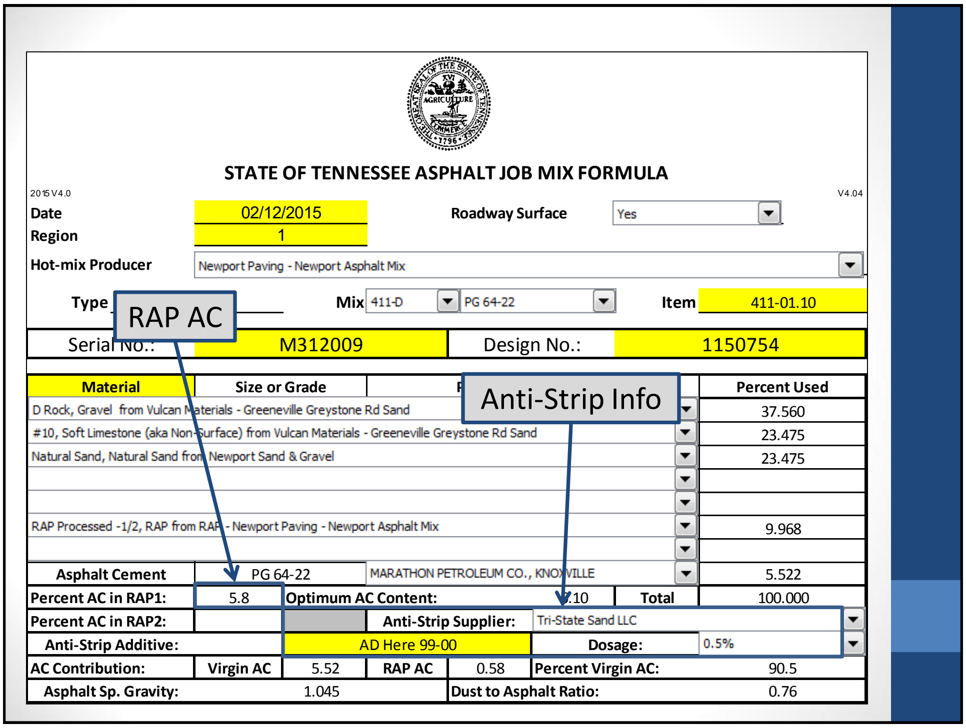
STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2015 V4.0 V4.04

Date	02/12/2015	Roadway Surface	Yes
Region	1		
Hot-mix Producer	Newport Paving - Newport Asphalt Mix		
Type	ACS-HM	Mix	411-D
Item	411-01.10		
Serial No.:	M312009	Design No.:	1150754

Material	Size or Grade	Producer and Location	Percent Used
D Rock, Gravel from Vulcan Materials - Greeneville Greystone Rd Sand			37.560
#10, Soft Limestone (aka Non-Surface) from Vulcan Materials - Greeneville Greystone Rd Sand			23.475
Natural Sand, Natural Sand from New			23.475
RAP Processed -1/2, RAP from RAP - Newport Paving - Newport Asphalt Mix			9.968
Asphalt Cement	PG 64-22	MARATHON PETROLEUM CO., KNOXVILLE	5.522

Percent AC in RAP1:	5.8	Optimum AC Content:	6.10	Total	100.000
Percent AC in RAP2:		Anti-Strip Supplier:	Tri-State Sand LLC		
Anti-Strip Additive:	AD Here 99-00	Dosage:	0.5%		
AC Contribution:	Virgin AC 5.52	RAP AC 0.58	Percent Virgin AC:	90.5	
Asphalt Sp. Gravity:	1.045	Dust to Asphalt Ratio:	0.76		



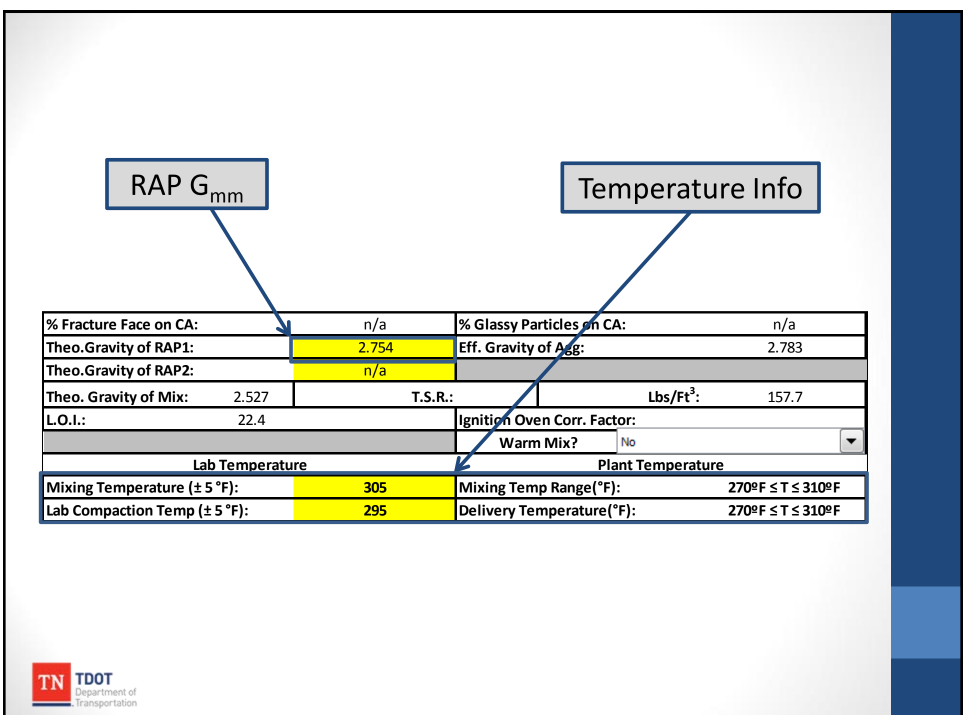
STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2015 V4.0 V4.04

Date	02/12/2015	Roadway Surface	Yes
Region	1		
Hot-mix Producer	Newport Paving - Newport Asphalt Mix		
Type		Mix 411-D / PG 64-22	Item 411-01.10
Serial No.:	M312009	Design No.:	1150754

Material	Size or Grade	Percent Used
D Rock, Gravel from Vulcan Materials - Greeneville Greystone Rd Sand		37.560
#10, Soft Limestone (aka Non-Surface) from Vulcan Materials - Greeneville Greystone Rd Sand		23.475
Natural Sand, Natural Sand from Newport Sand & Gravel		23.475
RAP Processed -1/2, RAP from RAP - Newport Paving - Newport Asphalt Mix		9.968
Asphalt Cement	PG 64-22 — MARATHON PETROLEUM CO., KNOXVILLE	5.522

Percent AC in RAP1:	5.8	Optimum AC Content:		6.10	Total	100.000	
Percent AC in RAP2:			Anti-Strip Supplier:	Tri-State Sand LLC			
Anti-Strip Additive:		AD Here 99-00	Dosage:	0.5%			
AC Contribution:	Virgin AC	5.52	RAP AC	0.58	Percent Virgin AC:	90.5	
Asphalt Sp. Gravity:	1.045		Dust to Asphalt Ratio:	0.76			



% Fracture Face on CA:	n/a	% Glassy Particles on CA:	n/a
Theo.Gravity of RAP1:	2.754	Eff. Gravity of Agg:	2.783
Theo.Gravity of RAP2:	n/a		
Theo. Gravity of Mix: 2.527	T.S.R.:	Lbs/Ft^3:	157.7
L.O.I.: 22.4		Ignition Oven Corr. Factor:	
		Warm Mix?	No
Lab Temperature		Plant Temperature	
Mixing Temperature (± 5 °F):	305	Mixing Temp Range(°F):	270ºF ≤ T ≤ 310ºF
Lab Compaction Temp (± 5 °F):	295	Delivery Temperature(°F):	270ºF ≤ T ≤ 310ºF

Aggregate Percentages

Sieve Size	Percents Used								
	D Rock	#10	Natural Sand			RAP Processed 1/2		% Req.	Design Range
	40.0	25.0	25.0			10.0		100	
2"									
1.5"									
1.25"									
1"									
3/4"									
5/8"	100	100	100			100		100	100
1/2"	89	100	100			89		95	95-100
3/8"	68	100	100			68		84	80-93
No.4	21	92	99			21		58	54-76
No.8	12	60	89			12		43	35-57
No.16									
No.30	9	23	50			9		23	17-29
No.50	7	16	16			7		11	10-18
No.100	4.5	12.0	6.1			4.5		6.8	3-10
No.200	2.7	9.6	3.5			2.7		4.6	0-6.5

Stockpile Gradations

Blend Gradation

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What if RAP is used?

- See what kind of Mix is being used.
- Refer to charts in either 307.03 or 411.03.

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Section 307
RAP in Hot Mix Asphalt
(Base and Binder Mixes)

Mix Type	Percent RAP (Non-Processed)	Percent Maximum RAP (Processed)	Percent Maximum RAP (Processed & Fractionated)	Maximum Particle Size (Inches)
307-ACRL	0	0	-	-
307-AS	0	0	15	-
307-A	15	20	35	1.50
307-B	15	30	35	1.50
307-BM	15	30	35	0.75
307-BM2	15	30	35	0.75
307-C	15	30	35	0.38
307-CW	15	30	35	0.50
307-CS	0	15	25	0.31

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(Table 307.03-3)

Section 411
RAP in Hot Mix Asphalt
(Surface Mixes)

Mix Type	Percent RAP (Non-Processed)	Percent Maximum RAP (Processed)	Percent Maximum RAP (Processed & Fractionated)	Maximum Particle Size (Inches)
411-D (PG64, PG67)	0	15	20	0.50
411-D (PG70, PG76, PG82)	0	10	15	0.50
411-E (Roadway)	0	15	20	0.50
411-E (Shoulder)	15	30	35	0.50
411-TL (PG64, PG67)	0	15	15	0.31
411-TL (PG70, PG76, PG82)	0	10	10	0.31
411-TLD (PG64, PG67)	0	15	15	0.31
411-TLD (PG70, PG76, PG82)	0	10	10	0.31

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(Table 411.03-6)

RAP On the JMF

STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2015 V4.0 | V4.04

Date	02/12/2015	**Roadway Surface**	Yes
Region	1		
Hot-mix Producer	Newport Paving - Newport Asphalt Mix		
Type ACS-HM	**Mix** 411-D	PG 64-22	**Item** 411-01.10
Serial No.:	M312009	Design No.:	1150754

Material	Size or Grade	Producer and Location	Percent Used
D Rock, Gravel from Vulcan Materials - Greeneville Greystone Rd Sand			37.560
#10, Soft Limestone (aka Non-Surface) from Vulcan Materials - Greeneville Greystone Rd Sand			23.475
Natural Sand, Natural Sand from Newport Sand & Gravel			23.475
RAP Processed -1/2, RAP from RAP - Newport Paving - Newport Asphalt Mix			9.968
Asphalt Cement	PG 64-22	MARATHON PETROLEUM CO., KNOXVILLE	5.522

Percent AC in RAP1:	5.8	**Optimum AC Content:**		6.10	**Total**	100.000
Percent AC in RAP2:			**Anti-Strip Supplier:**	Tri-State Sand LLC		
~~**Anti-Strip Additive:**~~		~~AD Here 99-00~~		~~**Dosage:**~~	~~0.5%~~	
AC Contribution:	**Virgin AC** 5.52	**RAP AC** 0.58	**Percent Virgin AC:**	90.5		
Asphalt Sp. Gravity:	1.045		**Dust to Asphalt Ratio:**	0.76		

Determine RAP Contribution

BATCH WEIGHT (LBS):	**6000**
% AC ON JMF:	**4.4**
% RAP ON JMF:	**15**
% AC IN RAP (ALSO FROM JMF):	**4.8**
% MOISTURE IN RAP:	**5.5**

- Determine Total Binder Weight, Weight of RAP Aggregate, Virgin Binder Weight, and RAP Binder Weight.

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Determine RAP Contribution

- Total Binder Wt. = $\frac{(\%\ AC,\ JMF) \times (Batch\ Weight)}{100}$

- Total Agg. Wt. = (Batch Wt.) – (Total Binder Wt.)

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Determine RAP Contribution

- Total Agg. Wt. = 5,736 lbs

BIN #	AGG. %	INDIV. WT.	ACCUM. WT.
1	37		
2	25		
3	17		
4	6		
RAP	15		

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Determine RAP Contribution

- $Total\ RAP\ Wt. = \frac{(RAP \times Total\ Agg.Wt.)}{(100 - AC_{RAP})}$

- $RAP\ Binder\ Wt. = \ (Total\ RAP - RAP\ Agg.Wt.)$

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Determine RAP Contribution

- $Virgin\ Binder\ Wt. = (Total\ Binder - RAP\ Binder)$

- $Virgin\ Binder\ (\%) = \left(\frac{Virgin\ Binder\ Wt.}{Total\ Binder\ Wt.}\right) \times 100$

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7

Sampling and Testing

Sampling and Testing Materials

2 Types of Sampling and Testing:

Quality *Assurance*

- Performed by TDOT.
- According to TDOT Materials and Tests S.O.P. 1-1 (including the Sampling and Testing Guide).
- Testing types:
  - Acceptance
  - Verification
  - Assurance

Quality *Control*

- Performed by the contractor.
- According to QC plan submitted by the contractor.
- Must align with TDOT Spec. Section 407.03.

Types of Asphalt Mixtures

- Surface Mixes:
  - 411-D, 411-E (Roadway, Shoulder), 411-TL, 411-TLD, 411-OGFC, 307-CW*
- Binder Mixes:
  - 307-B, 307-BM, 307-BM2, 307-C, 307-CS, 307-CW*
- Base Mixes:
  - 307-A, 307-AS, 307-ACRL, 313-TPB
    - *307-CW can be an intermediate layer or a surface layer in low volume applications.

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Sampling and Testing

- What materials are we going to sample for testing?
  - Aggregates
  - RAP
  - Hot Mix Asphalt
  - Binder

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Sampling and Testing

- Copies of sampling and testing requirements for any material on a TDOT project can be found:
  - TDOT M&T Standard Operating Procedures
  - SOP 1-1, "Procedures for the Sampling and Testing, and Acceptance of Materials and Products"
    - https://www.tn.gov/assets/entities/tdot/attachments/20170130_FINAL_SOP1-1.pdf

TN TDOT Department of Transportation

July 29, 2015
November 16, 2016
January 30, 2017

Tennessee Department of Transportation
Division of Materials and Tests

Procedures for the Sampling, Testing, and Acceptance of Materials and Products (SOP 1-1)

Purpose: The purpose of this document is to establish the procedures and minimum requirements for the acceptance, verification, and certification of materials and products used on Tennessee Department of Transportation (TDOT) projects and projects under the oversight of TDOT (Local Projects, Grants, etc. that include Federal Funds).

Background: Acceptance of materials, or combination of materials, may be accomplished in several different ways. Federal requirements state that each State Highway Agency shall develop a Quality Assurance Program which assures all materials, on projects in which Federal monies are used, conform to the requirements of the approved plans and specifications. In addition, these procedures assure projects using state funds will also be constructed using the highest quality materials.

Policy: All materials used on TDOT projects must be accepted prior to use. Acceptance of materials is normally by:

A. Testing during the production of a product (e.g. hot mix asphalt, Portland cement concrete, base materials),

B. By manufactures certifications, followed by random verification testing (e.g. reinforcing steel, cement, liquid asphalt) (refer to SOP 1-1, Part 4 using Random Numbers for Sampling and Testing)

C. Pre-approval and testing of a product or its components prior to being used (e.g. aggregate quality, gray iron castings, reinforced concrete pipe, corrugated metal pipe)(usually TDOT stamped), or

D. From the Qualified Products List (QPL) with certifications (e.g. sign sheeting, erosion control blankets, pavement marking materials).

The procedures set forth in the TDOT Materials and Testing Standard Operating Procedures Manual (SOP), the Sampling and Testing Schedule, the Sampling and Testing Guide, the Verification procedures, and the Independent Assurance Procedures, shall be used to document the minimum requirements for product acceptance.

NOTE: For those projects constructed under the oversight of TDOT (Local Projects, Grants, etc. that include Federal Funds) any reference in SOP 1-1 Part 1 and SOP 1-1 Part 2 that refers to TDOT Personnel being the sampled by party, is replaced by the Agency's CEI or Certified sampling and testing technician.

1

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Types of Tests:

There are three basic types of sampling and tests routinely conducted: acceptance, verification, and assurance.

Acceptance Sampling and Testing: These tests are conducted to approve or accept a product, or construction method, by generally comparing the test results to specification requirements. Most products where TDOT conducts acceptance testing are based on a lot, or frequency, during the production and/or placement of that product, to assure specification compliance. For example, hot mix asphalt is accepted by gradation, asphalt content, and in place density, etc...., Portland cement concrete is accepted by temperature, air content, slump, (and strength) at the time of placement, pavement base material is accepted based on gradation and density at the time of placement, etc..... Aggregate sources, however, are accepted for quality and gradations before the aggregate can be used in a particular application. There are products that are sampled and tested, and then accepted at the manufactures facility and then delivered to TDOT projects for use. These products must have the TDOT emblem stenciled on before being incorporated for use. These products would include: pipes (reinforced concrete and corrugated metal) and pre-stressed beams.

Verification Sampling and Testing: These tests are conducted at a much lower frequency than acceptance tests to verify/validate that products accepted by manufactures certifications are in compliance with the applicable Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction January 1, 2015 (Standard Specifications). Verification sampling and testing are also completed to assure that contractors' quality control results are acceptable.

Independent Assurance Sampling and Testing: These are tests conducted to assure that acceptance sampling and testing procedures are done in accordance with the specified procedures and to compare testing equipment.

Quality Control of Samples: These tests are conducted by Contractors in an effort to maintain standards by testing samples against specifications.

Material Certifications:

All materials that are accepted on certification must have a DT-0044 (T-2) form, completed by the Contractor, showing contract number, project number, county, item number and quantity of material being accepted. Attach the DT-0044 (T-2) form to the manufacturer's certification and forward to the Regional Materials and Tests Supervisor. The Manufacturer's certification certifies that TDOT requirements (specifications) have been met.

In many instances, the manufacturer's certification will not be project specific, i.e. it will not have the contract or project number on the certification. When this occurs, do not write the contract or project number on the certification. Instead, require the contractor or jobber to fill out a DT-0044 (T-2) form, have it notarized, and attach manufacturer's certification. Copies of certifications will be acceptable provided originals are kept on file by the contractor, supplier or manufacturer and available for inspection.

Any material that is on the Department's QPL may be accepted by a certification from the manufacturer stating that the material furnished to the project is of the same formulation and has the same physical characteristics as the material evaluated for the QPL. The

2

Sampling and Testing

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Bituminous Plant Mix Pavements	Plant Mix Asphalt Grading B, BM, BM2, C, CW, D, E, CS, TLD, & TL	Asphalt Content AASHTO T-164, Method E-II by extraction, or AASHTO T-308 by ignition oven	Project Inspector	1 test for every 1000 tons randomly	Completed mix in truck or on roadway	AASHTO T-164 Method E-II will be performed by pouring the extracted asphalt and solvent through nested No. 16 and No. 200 mesh sieves. AASHTO T 164 Method A may be used for modified asphalt or when problems are encountered filtering according to Method E-II. May not be required on production days of less than 100 tons. Ignition oven may be utilized to determine AC content and gradation.
		Aggregate Gradation AASHTO T-30 and AASHTO T-11				
		Air Voids & Volumetric Properties (T166, T209, T269)	Project Inspector or Materials and Tests	During Test Strip Construction or Mix Verification	Completed mix in truck or on roadway	Applies only to mixes requiring a design. Verification Sample required to be submitted to Regional Lab.
		LOI (Surface Mix only)	Project Inspector	One sample per day for Surface Mix only	Completed mix in truck	If daily sample fails, take 3 cores per lot placed that day to determine LOI. Penalty for failure to meet.
	Plant Mix Asphalt Grading A, A-S, A-CRL, & Asphalt Treated Permeable Base	Aggregate Gradation AASHTO T-30 and AASHTO T-11	Project Inspector	1 test for every 1000 tons randomly	Combined RAP and aggregate belt samples OR Sample completed mix in truck or on roadway. See remarks for test method info regarding this option.	If testing completed mix, perform extraction using AASHTO T-164 method E-II utilizing nested sieves (No. 16 and No. 200) AASHTO T 164 Method A may be used for modified asphalt or when problems are encountered filtering according to Method E-II. May not be required on production days of less than 100 tons. Ignition oven may be utilized to determine gradation.

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Aggregates

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Aggregates

- Check JMF for Aggregate Info, Nominal Maximum Aggregate Size, etc.
- Perform Appropriate Tests IAW TDOT and AASHTO Specs.
- How much material do we need?

STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2015 V4.0 V4.01

Date	03/12/2015	Roadway Surface	Yes
Region	3		
Hot-mix Producer	LoJac - Springfield		
Type	ACS-HM	Mix	411-OGFC / PG 76-22
Item	411-03.15&03.16		
Serial No.:	15M0089	Design No.:	3150095

Material	Size or Grade	Producer and Location	Percent Used
D Rock, Hard Limestone (Type I) from Vulcan Materials - Springfield			70.350
#7, Soft Limestone (aka Non-Surface) from Vulcan Materials - Springfield			14.070
#8, Soft Limestone (aka Non-Surface) from Vulcan Materials - Nashville Danley Plant			9.380
Asphalt Cement	PG 76-22	MARATHON PETROLEUM CO., NASHVILLE TERMINAL	6.200

Percent AC in RAP1:		Optimum AC Content: 6.20	Total 100.000
Percent AC in RAP2:		Anti-Strip Supplier:	Westvaco Polychemical Dept
Anti-Strip Additive:	Evotherm R1	Dosage:	0.3%
AC Contribution:	Virgin AC 6.20	RAP AC	Percent Virgin AC:
Asphalt Sp. Gravity:	1.03	Dust to Asphalt Ratio:	0.48
% Fracture Face on CA:	100	% Glassy Particles on CA:	n/a
Theo.Gravity of RAP1:		Eff. Gravity of Agg:	2.613
Theo.Gravity of RAP2:			
Theo. Gravity of Mix: 2.385	T.S.R.: 84.9	Lbs/Ft^3:	148.8
L.O.I.:	24.0	Ignition Oven Corr. Factor:	
		Warm Mix?	

Lab Temperature		Plant Temperature	
Mixing Temperature (± 5 °F):	320	Mixing Temp Range(°F):	290ºF ≤ T ≤ 330ºF
Lab Compaction Temp (± 5 °F):	290	Delivery Temperature(°F):	290ºF ≤ T ≤ 330ºF

Percents Used

Sieve Size			D Rock 75.0	#7 15.0	#8 10.0			% Req. 100	Design Range
2"									
1.5"									
1.25"									
1"									
3/4"			100	100	100			100	100
5/8"									
1/2"			92	93	100			93	85-100
3/8"			62	65	93			66	55-75
No.4			15	12	16			15	10-25
No.8			7	6	6			7	5-10
No.16									
No.30									
No.50									
No.100									
No.200			3.0	3.0	3.0			3.0	2-4

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AASHTO T-2/ASTM D-75 Aggregate Sampling

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AASHTO T-2/ASTM D-75

- Determine NMAS from JMF.
- See TABLE 1 in specification.
  - Determine sample size.

Aggregate Size[A]	Field Sample Mass, min, kg[B] [lb]
	Fine Aggregate
2.36 mm [No. 8]	10 [22]
4.75 mm [No. 4]	10 [22]
	Coarse Aggregate
9.5 mm [⅜ in.]	10 [22]
12.5 mm [½ in.]	15 [35]
19.0 mm [¾ in.]	25 [55]
25.0 mm [1 in.]	50 [110]
37.5 mm [1½ in.]	75 [165]
50 mm [2 in.]	100 [220]
63 mm [2½ in.]	125 [275]
75 mm [3 in.]	150 [330]
90 mm [3½ in.]	175 [385]

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AASHTO T-2/ASTM D-75

AASHTO recommends obtaining belt samples of aggregates whenever possible.

A belt-shaped template must be used.

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AASHTO T-2/ASTM D-75

Use a scoop to remove the aggregate from the portioned section.

Make sure to sweep the fine aggregate off the belt entirely.

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AASHTO T-2/ASTM D-75

Most raw materials must be sampled from a stockpile.

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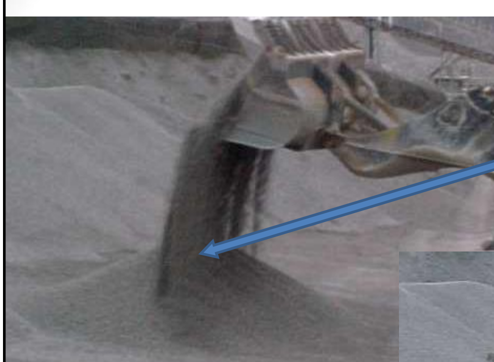
AASHTO T-2/ASTM D-75

Use power equipment whenever available.

Ensure that the material is re-blended before the loader takes a sample.

AASHTO T-2/ASTM D-75



Create a small pile adjacent to the original stockpile.

Strike off the top of the pile to create a flat surface.

AASHTO T-2/ASTM D-75

Approach the pile as 4 separate quadrants. Take 1 equal sample from each quadrant.

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AASHTO T-2/ASTM D-75

Sample from at Least 3 locations (preferably top, middle, and bottom of the pile).

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AASHTO T-2/ASTM D-75

For sampling fine aggregates, a sampling tube may be used.

When using this method, sample in 5 locations.

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Aggregate Testing

- Tests to be run:
  - Stockpile Moisture Contents.
    - TDOT Method
  - T-27 / T-11 Washed Sieve Analysis on ALL aggregates.
  - TDOT Glassy Particle Test.
    - If **<u>slag</u>** is used as a coarse aggregate.
  - TDOT Fractured Face Count.
    - If **<u>gravel</u>** is used as a coarse aggregate.

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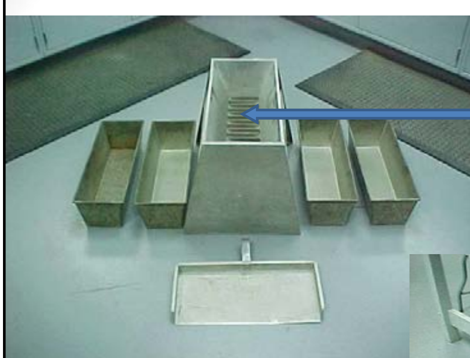
AASHTO T-248 Reducing Aggregate Samples for Testing

TN TDOT Department of Transportation

Method A: Mechanical Splitter



Openings may either be fixed or adjustable.

Their widths are dependent upon aggregate size.

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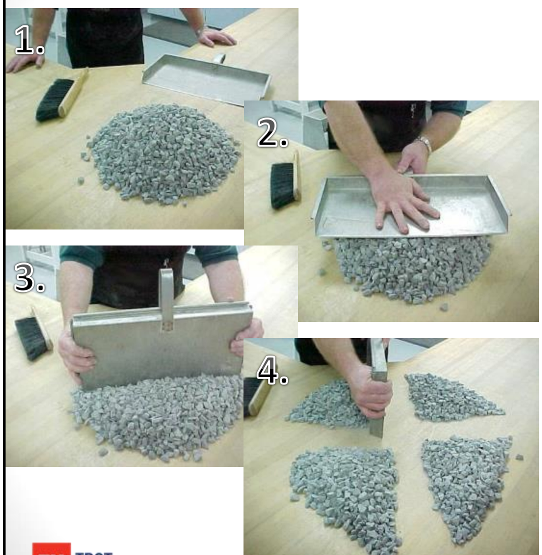
Method B: Split and Quarter



1. Start with a small stockpile of material.
2. Flatten the pile to help avoid aggregate roll down.
3. Use a straight edge to cut pile in half.
4. Halve each half with the straight edge for quarters.

TN TDOT Department of Transportation

AASHTO T-255 Moisture Content of Aggregate by Drying

TN TDOT Department of Transportation

Aggregate Moisture Content

- Sample material IAW AASHTO T-2
- Reduce Sample IAW Table 1 in AASHTO T-255
- Record Initial Weight
- Dry to a CONSTANT MASS
- Record Final Weight
- Calculate Moisture Percentage

$$Moisture\ Content = \frac{(WET - DRY)}{DRY} \times 100$$

TN TDOT Department of Transportation

Aggregate Moisture Content

- Initial (Wet) Weight: 2,140 grams
- Final (Dry) Weight: 1,940 grams

TN TDOT Department of Transportation

AASHTO T-11 Materials Finer Than #200 Sieve in Mineral Aggregate by Washing

AASHTO T-11

Weigh the oven-dried aggregate and record its mass. Add a bit of wetting agent (mild soap). Be careful not to add too much!

AASHTO T-11

Add water and stir gently.

Then carefully decant liquid over a nest of sieves.

TN TDOT Department of Transportation

AASHTO T-11

Continue washing until the liquid is reasonably clear.

Oven dry the aggregate at 230°F to a constant mass.

TN TDOT Department of Transportation

AASHTO T-27
Sieve Analysis of Fine and Coarse Aggregate

TN TDOT Department of Transportation

AASHTO T-27

After recording the mass of the oven-dried, washed aggregate, the material must be shaken though a stack of sieves.

TN TDOT Department of Transportation

AASHTO T-27

Once the material has been shaken for a sufficient period of time, each sieve must be cleaned out.

The mass of its contents recorded cumulatively.

AASHTO T-27

AASHTO T-11		
Original Dry Sample Weight (A)	**1530.0**	grams
Weight Of Sample After Wash, Dried (B)	1464.8	grams
Wash Loss (A-B)	65.2	grams

AASHTO T-27				
US Standard Sieve Sizes	**Cumulative Wt. Retained (grams)**	**Percent Retained (%)**	**Percent Passing (%)**	**JMF Design**
5/8"	30.3	2.0	98.0	100
1/2"	76.5	5.0	95.0	96
3/8"	287.8	18.8	81.2	83
No.4	615.4	40.2	59.8	59
No.8	858.4	56.1	43.9	43
No.30	1148.5	75.1	24.9	25
No.50	1330.9	87.0	13.0	16
No.100	1420.4	92.8	7.2	10.0
No.200	1458.1	95.3	4.7	6.5
PAN	1464.8	***	***	***

TDOT Test for Glassy Particles

TN TDOT Department of Transportation

Glassy Particle Weight

- TDOT Spec 903.11.a.4
  - The <u>mass</u> of glassy particles from a sample of +4 material.
- Typically done on crushed slag.
- Cannot exceed 20% glassy particles by weight.

TN TDOT Department of Transportation

Glassy Particle Weight

When slag is used as a coarse aggregate, a check for glassy particles must be performed (on a sample of the + #4 material).

IAW TDOT 903.11.1.4, the slag can not have more than 20% glassy particles as determined by mass.

TN TDOT Department of Transportation

Glassy Particles (Slag)
Subsection 903.11(a)(4)

Does mix contain slag used as coarse aggregate?

Yes
No

Crushed slag coarse aggregate shall contain no more than 20%, by weight, of glassy particles; except that where used in Grading G mix, the percent of glassy particles, by weight, shall not exceed 10%.

A representative sample containing at least 300 grams of the (+4) slag should be used.*

* DOT Policy

$$\text{\% Glassy Particles} = \frac{\text{Mass of Glassy Particles}}{\text{Total Mass of Sample Used}} \times 100\%$$

Mass of Glassy Particles g
Total Mass of Sample Used g

% Glassy Particles =

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TDOT Test for Fractured Faces

TN TDOT Department of Transportation

Fractured Face Count

- ASTM D-5821
  - A count of particles with two or more fractured faces.
- Typically done with gravels.
- Fractured faces provide structural support within asphalt mixtures.

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Fractured Face Count

When gravel is used as a coarse aggregate, some of the material is crushed, leaving one or more fractured faces. Some particles, however, will not be affected by this process.

We need to determine the percent of particles with 2 or more fractured faces by count (not by mass).

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Fractured Face Count

TN TDOT Department of Transportation

Fractured Face Count
Subsection 903.11(a)(3)

Is Crushed Gravel used as a coarse aggregate in this mix? Yes ◉ No ○

At least 70% by count, of the material retained on the 4.75 mm (No. 4) sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle.

A representative sample containing at least 200 grams should be used.

$$\% \text{ Fractured} = \frac{\text{No. of Particles Fractured}}{\text{Total No. of Particles Inspected}}$$

No. of Particles Fractured	
Total No. of Particles Inspected	

% Fractured =

TN TDOT Department of Transportation

Sampling and Testing RAP

- Obtain a proper sample IAW T-2 and T-248.
- Run a preliminary moisture content test.
- Run a preliminary extraction/gradation.
  - AASHTO T-164/T-30
- Compare results with the JMF and TDOT Specification 307.02.b.
- Subsequent testing of RAP is required for every 2,000 tons of material used in the mix.

TN TDOT Department of Transportation

AASHTO T-164 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures

TN TDOT Department of Transportation

AASHTO T-164

- This is TDOT's **STANDARD** test method for determining the AC Content of either RAP or HMA.
- As an alternate method, AASHTO T-308 (Ignition Furnace) may be used, but a comparison solvent extraction must be performed at least once per week of production.

TN TDOT Department of Transportation

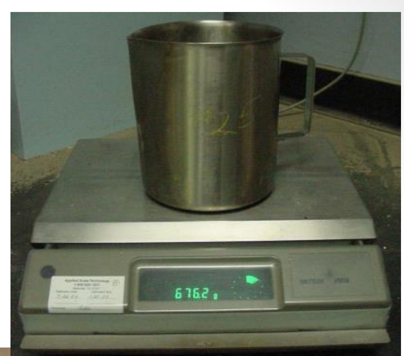
AASHTO T-164

- Extraction of asphalt material from mixtures.
- Used to determine percentage of asphalt binder.

TN TDOT Department of Transportation

AASHTO T-164

- Record the initial sample mass.
  - Mass of both the aggregate and binder together.
  - Remember to record the weight of the pitcher as well.



TN TDOT Department of Transportation

AASHTO T-164

- Place the distributor plate over the seal.
- Center the paper filter on the plate.
- Fasten the extractor collar with the spacers and wing nuts.

TN TDOT Department of Transportation

AASHTO T-164

- Add up to 200 grams of filter aid to help trap the dust within the mixture.
  - Record mass.
- Add solvent into the filter aid to make a slurry to pour on the paper
- Pour evenly over the filter paper.

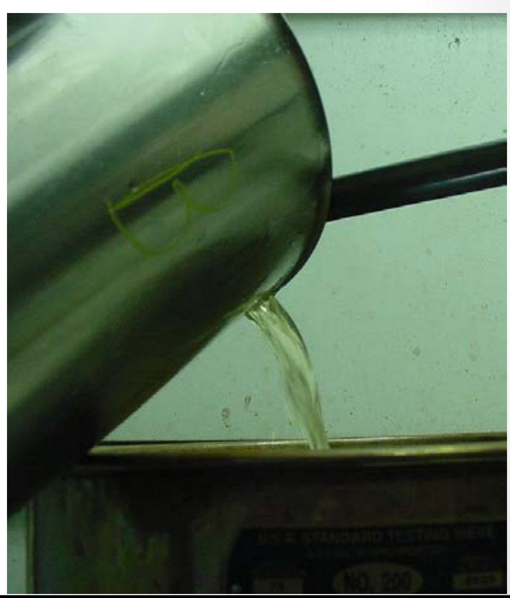
TN TDOT Department of Transportation

AASHTO T-164

- Add solvent into the pitcher containing the asphalt mixture.
- Vigorously stir contents after allowing the mix to soak a couple minutes.
- Pour extracted binder over the sieves without letting aggregate escape pitcher.

AASHTO T-164

- Continue previous step until aggregate appears clean.
- A good indicator is the solvent leaving the pitcher the same color it entered.



AASHTO T-164

- Following Steps:
  - Allow the extractor to pull the solvent through the filter material completely (should appear dry).
  - Turn off the vacuum.
  - Empty the solvent and extracted asphalt into the hazardous waste container then transport the material to the hazardous waste disposal site at your facility.

TN TDOT Department of Transportation

AASHTO T-164

- Finishing Steps:
  - Rinse the extracted aggregate with water.
  - Turn the vacuum back on and pour the water over the sieves.
  - Continue to rinse the aggregate and pour the water out until the water leaving the pitcher is clear.

TN TDOT Department of Transportation

AASHTO T-164

- Finishing Steps:
  - Add enough water to cover the aggregate and gently agitate it before pouring the aggregate out onto the sieves.
  - Use the water wash bottle to remove the small aggregate material that may be stuck inside the pitcher.

TN TDOT Department of Transportation

AASHTO T-164

- Finishing Steps:
  - Allow water to drain completely before turning the vacuum off.
  - Remove sieves and disassemble the extractor carefully.
  - Carefully place filter paper into metal pan.
  - Place sieves and pan into oven to dry material for sieve testing.

TN TDOT Department of Transportation

Dust to Asphalt Ratio (D.A.R)

- D.A.R = Percent Aggregate Passing #200 Sieve / Binder Content

- Given that 4.91% passes the #200 sieve and a binder content of 5.86%, what is the D.A.R.?

TN TDOT Department of Transportation

AASHTO T-30
The Sieve Analysis of Residual Aggregate

TN TDOT Department of Transportation

SIEVE ANALYSIS

AASHTO T-30

(1)

Sieve	Wt. Ret.	% Ret.	% Pass
1 1/2"		0.00	0.00
1 1/4"		0.00	0.00
1"		0.00	0.00
3/4"		0.00	0.00
5/8"		0.00	0.00
1/2"	100	6.03	93.97
3/8"	345.2	20.83	79.17
# 4	691.7	41.74	58.26
# 8	985.3	59.46	40.54
# 30	1164.7	70.29	29.71
# 50	1381.4	83.36	16.64
# 100	1475.8	89.06	10.94
# 200	1567.3	94.58	5.42
			D.A.R.
Total Agg. Wt. =		**1657.1**	**0.92**

(2)

Sieve	Wt. Ret.	% Ret.	% Pass
1 1/2"		0.00	0.00
1 1/4"		0.00	0.00
1"		0.00	0.00
3/4"		0.00	0.00
5/8"		0.00	0.00
1/2"		0.00	0.00
3/8"		0.00	0.00
# 4		0.00	0.00
# 8		0.00	0.00
# 30		0.00	0.00
# 50		0.00	0.00
# 100		0.00	0.00
# 200		0.00	0.00
			D.A.R.
Total Agg. Wt. =		**0**	**#DIV/0!**

Fract. Face Count

No. particles ________
No. fractured ________
% fractured ________

Glassy Particles

total wt. ________
wt. Glassy ________
% Glassy ________

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Sampling and Testing

T-30 Test Results

Sieve	% Passing	JMF
5/8"	100	100
1/2"	93.4	98
3/8"	79.2	81
No.4	58.3	64
No.8	40.5	48
No.30	29.7	34
No.50	16.6	17
No.100	10.9	13.4
No.200	5.4	7.3

The stockpile gradation tolerance for all recycled material on each sieve is listed below.

9.50 mm (3/8") sieve and larger	± 10 %
4.75 mm (No. 4) sieve	± 8 %
2.36 mm (No. 8) sieve	± 6 %
600 µm (No. 30) sieve	± 5 %
75 µm (No. 200) sieve	± 4 %

TN TDOT Department of Transportation

(TDOT 307.03.b)

Asphalt Mixtures

TN TDOT Department of Transportation

AASHTO T-168 Sampling Bituminous Paving Mixtures

TN TDOT Department of Transportation

AASHTO T-168

- Determine NMAS from JMF
- Go to TABLE 1 in spec.
- Determine sample size

TABLE 1 Guide for Estimating Quantity of Sample

Maximum Size of Aggregates[A]	Uncompacted Mixture	
	Approximate Mass min, kg [lb]	Approximate Volume L [Gal]
2.36-mm [No. 8]	10 [22]	8 [2]
4.75-mm [No. 4]	10 [22]	8 [2]
9.5-mm [⅜-in.]	16 [35]	12 [3]
12.5-mm [½-in.]	20 [45]	15 [4]
19.0-mm [¾-in.]	20 [45]	15 [4]
25.0-mm [1-in.]	24 [52]	18 [5]
37.5-mm [1½-in.]	30 [66]	22 [6]
50-mm [2-in.]	35 [75]	22 [6]

[A] The maximum size of aggregate is the largest sieve size listed in the applicable specification upon which any material is permitted to be retained.

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AASHTO T-168 (5.2.2)

Sampling from Truck Transports

TN TDOT Department of Transportation

AASHTO T-168 (5.2.2)
Sampling from Truck Transports

Avoid sampling the extreme top surface!

How many different places?

Mixture Temperatures

Mix Temperature

<u>2 Concerns:</u>

- Plant Production Temperature
- Lab Compaction Temperature

TN TDOT Department of Transportation

Mix Temperature:

Plant Production Temp. – Hot Mix

- Must adhere to TDOT Spec 407.11:

407.11 Preparing the Bituminous Material

A. Hot Mix Asphalt (HMA)

Heat the bituminous materials for hot mixes to the required mixing temperature specified in Table 407.11-1.

Table 407.11-1: Mixing Temperatures

PG Binder Grade	Minimum Temperature (°F)	Maximum Temperature (°F)
PG 64-22, PG 67-22	270	310
PG 70-22	290	330
PG 76-22	290	330
PG82-22	290	330

The temperature for Grading AS, Grading ACRL, and Grading TPB mixtures shall be between 225 and 275 °F, except when modified binders are used, and then the temperatures shall be between 250 and 310 °F. Aggregate should be coated and no visible drain down should occur in storage silos or hauling equipment.

TN TDOT Department of Transportation

Mix Temperature:

Plant Production Temp. – Warm Mix

- Must adhere to TDOT Spec 407.11, Table B:

B. Warm Mix Asphalt (WMA)

The Contractor may subject the produced mixture to reduced production and placement temperatures by adding a chemical warm mix additive meeting **921.06.B.3** or by making plant modifications as specified in **407.04.A.12.**

When using either WMA technology, the maximum mixing temperature for any grade of asphalt cement shall be no more than 300 °F. At the beginning of a day's production, the producer may produce up to five truckloads at the temperatures specified in Table 407.11-1 to pre-heat placement equipment (pavers, transfer devices) before producing WMA. Indicate the laboratory mixing and compaction temperatures on the JMF during the mix design approval process. A tolerance of ±5.0 °F for each temperature will be allowed.

During test strip construction, ensure that all plant-produced WMA exhibits the ability to meet the test requirements for tensile strength ratio (TSR), conditioned tensile strength, Marshall Stability and flow, volumetrics, and boil test, as specified for HMA in specifications **307**, **407**, and **411**. Procedures for testing shall be in accordance with that which is defined for quality control and acceptance in **407.03.D.2.h** and **407.20.B.3**, respectively.

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Mix Temperature:

Lab Compaction Temp.

Established during mix design process

Found on JMF

Mixing Temperature (± 5 °F):	320
Lab Compaction Temp (± 5 °F):	290

STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2015 V4.0 V4.01

Date 03/12/2015 Roadway Surface Yes
Region 3
Hot-mix Producer LoJac - Springfield
Type ACS-HM Mix 411-OGFC PG 76-22 Item 411-03.15&03.16

Serial No.: 15M0089 Design No.: 3150095

Material	Size or Grade	Producer and Location	Percent Used
D Rock, Hard Limestone (Type I) from Vulcan Materials - Springfield			70.350
#7, Soft Limestone (aka Non-Surface) from Vulcan Materials - Springfield			14.070
#8, Soft Limestone (aka Non-Surface) from Vulcan Materials - Nashville Danley Plant			9.380
Asphalt Cement	PG 76-22	MARATHON PETROLEUM CO., NASHVILLE TERMINAL	6.200

Percent AC in RAP1: Optimum AC Content: 6.20 Total 100.000
Percent AC in RAP2: Anti-Strip Supplier: Westvaco Polychemical Dept
Anti-Strip Additive: Evotherm R1 Dosage: 0.3%
AC Contribution: Virgin AC 6.20 RAP AC Percent Virgin AC:
Asphalt Sp. Gravity: 1.03 Dust to Asphalt Ratio: 0.48

% Fracture Face on CA: 100 % Glassy Particles on CA: n/a
Theo.Gravity of RAP1: Eff. Gravity of Agg: 2.613
Theo.Gravity of RAP2:
Theo. Gravity of Mix: 2.385 T.S.R.: 84.9 Lbs/Ft^3: 148.8
L.O.I.: 24.0 Ignition Oven Corr. Factor:
Warm Mix?

Lab Temperature		Plant Temperature	
Mixing Temperature (± 5 °F):	320	Mixing Temp Range(°F):	290ºF ≤ T ≤ 330ºF
Lab Compaction Temp (± 5 °F):	290	Delivery Temperature(°F):	290ºF ≤ T ≤ 330ºF

Sieve Size	Percents Used							% Req.	Design
			D Rock	#7	#8			100	Range
			75.0	15.0	10.0				
2"									
[illegible]									
[illegible]									
[illegible]									
[illegible]			100	100	100			100	100
[illegible]									
1/2"			92	93	100			93	85-100
3/8"			62	65	93			66	55-75
No.4			15	12	16			15	10-25
No.8			7	6	6			7	5-10
No.16									
No.30									
No.50									
No.100									
No.200			3.0	3.0	3.0			3.0	2-4

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Ten Minute Boil Test

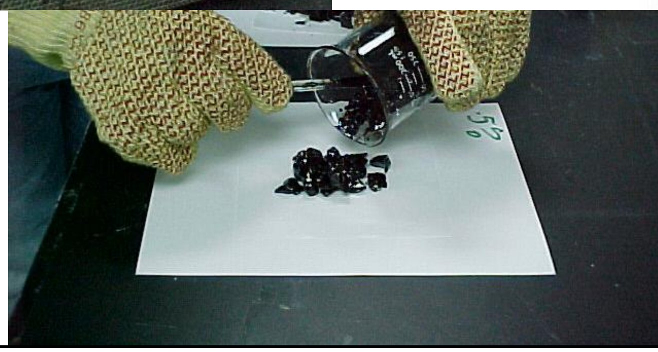
Ten Minute Boil Test (Stripping)

Field Test

The completed mix will be tested for stripping at the asphalt plant as follows. From a sample of the completed mix, visually select a minimum of 50 grams of the **plus No. 4** (4.75 millimeters) material and place immediately in boiling water. Continue to boil for 10 minutes, pour off water and place coated aggregate on a paper towel. The coated aggregate shall not show any evidence of stripping as determined by a visual inspection.

- **Test performed by project inspector**

10 Minute Boil Test



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Not Stripping

Stripping

TN TDOT Department of Transportation

Moisture Content of Asphalt Mixtures

TN TDOT Department of Transportation

Moisture Test

- Mixes with RAP only
- Sampled from BEHIND THE PAVER
- Test performed WEEKLY by CONTRACTOR
- Maximum moisture content of 0.1%
- Test performed IAW AASHTO T-329

TN TDOT Department of Transportation

AASHTO T-209 Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

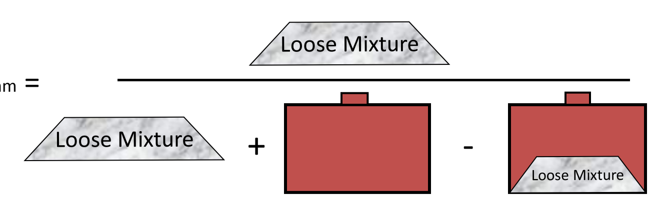
TN TDOT Department of Transportation

Maximum Specific Gravity of Compacted Mixture

AASHTO T- 209

G_{mm} = Rice Gravity = Maximum Gravity = Theoretical Gravity

G_{mm} =



TN TDOT Department of Transportation

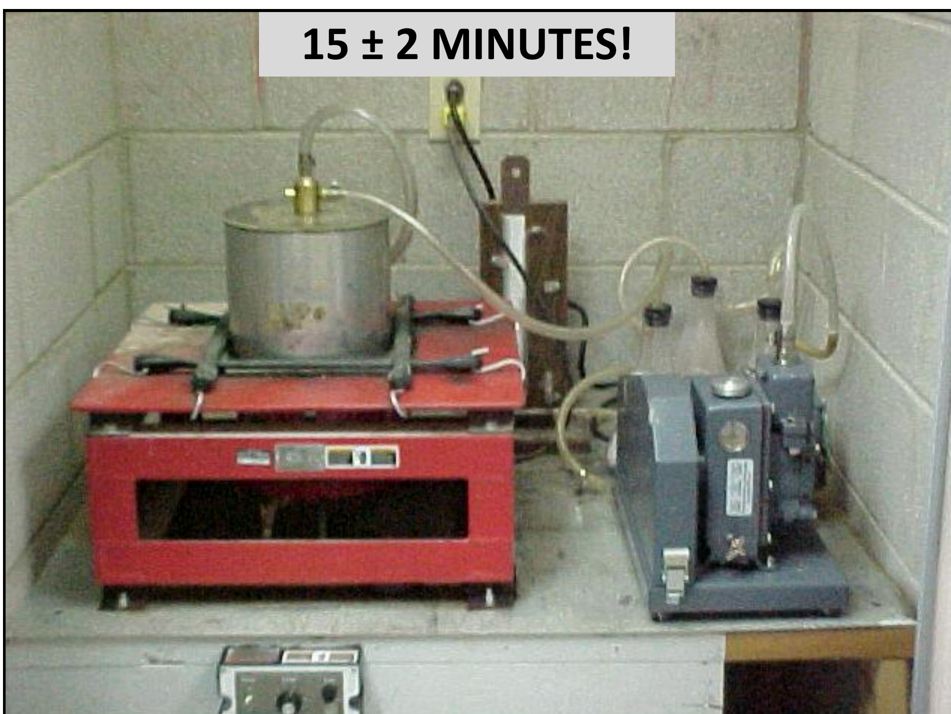
Loose mix is allowed to cool to room temperature.

The mix will also have to be crumbled into small particles. What is the largest conglomerate particle that can remain?

The mix is placed into a calibrated volumetric flask and the dry mass is determined.

The mix is then covered (by about an inch) with water that is 77° F (25° C)

TN TDOT Department of Transportation



Slowly bleed the vacuum off using the required valve. Then fill the flask with 77° water.

After letting the flask sit for 10 minutes, record the water temperature and place the lid on the flask. Top off the water level, dry the outside of the flask, and record the mass.

Maximum Specific Gravity of Compacted Mixture AASHTO T-209 Calculations

CALCULATION OF MAXIMUM SPECIFIC GRAVITY:

WT. DRY SAMPLE (A)	1604.0
WT. FLASK FILLED WITH WATER (D)	7399.0
WT. FLASK FILLED WITH WATER & DRY SAMPLE (E)	8347.2

$$Gmm = \frac{A}{A + D - E} =$$

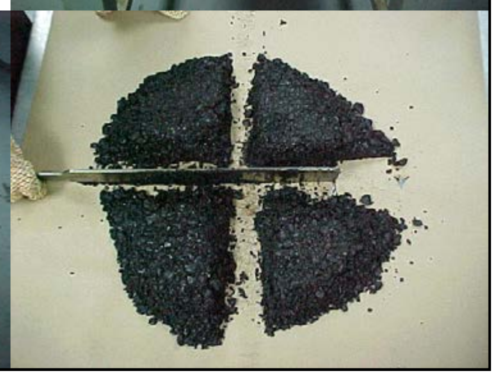
TN TDOT Department of Transportation

AASHTO T-245 Part 1: Compacting Marshall Specimens

TN TDOT Department of Transportation

Reduce sampled mix to appropriate specimen sizes (about 1200g) by splitting and quartering.

How many specimens do we need to compact?



Assemble the preheated specimen molds and place a protection disc in the bottom.

At what temperature should the molds be kept preheated?

Load or "charge" the mold in one lift and spade the mix with a flat-blade spatula.

How many times should the mix be spaded?
Do not forget to add the top specimen disc!

TN TDOT Department of Transportation

Compact mixture with 75 compaction blows per side.

TN TDOT Department of Transportation

Once compaction is complete, remove the protection papers and carefully extrude the specimen from the mold. Then, the pills must be allowed to cool to room temperature prior to further testing.

TN TDOT Department of Transportation

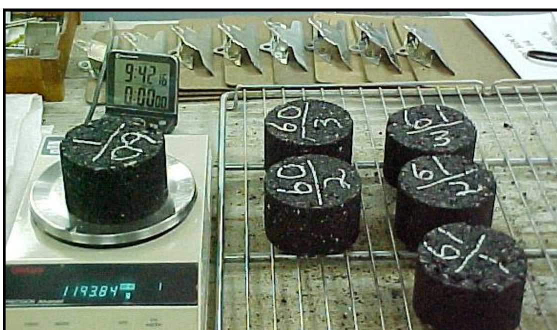
AASHTO T-166
Bulk Specific Gravity Using SSD Method

TN TDOT Department of Transportation

AASHTO T-166

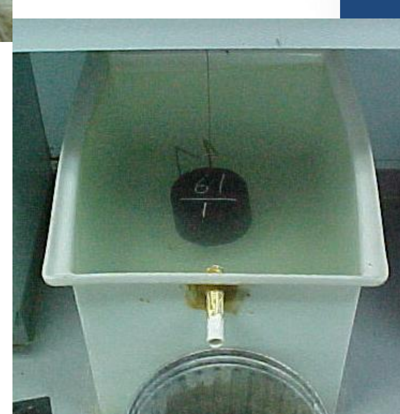
- Used to determine the bulk specific gravity of a compacted specimen (G_{mb})
- Can be performed on either a lab or field compacted specimen (core)
- Three weights needed:
  - Dry Weight
  - Saturated Surface-Dry Weight (SSD)
  - Weight Submerged in Water

TN TDOT Department of Transportation



Record the mass of the specimen.

Place the specimen in a basket suspended in water under a balance for 4 ± 1 minutes.



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Blot lightly with a damp towel to remove excess exterior moisture.

Re-weigh the specimen and record its SSD mass.

TN TDOT Department of Transportation

AASHTO T-166 Calculations

$$\text{Bulk Specific Gravity } (G_{mb}) = \frac{\text{Dry Weight}}{\text{SSD Weight} - \text{Weight in Water}}$$

Dry Wt: 1,156 grams

SSD Wt: 1,161 grams

Wt. in Water: 665 grams

TN TDOT Department of Transportation

AASHTO T-269
Calculating Air Voids

TN TDOT Department of Transportation

Calculating Air Voids (AASHTO T-269)

% Air Voids (V_a) = 100 x (1 – (A/B))

A = bulk specific gravity of the pill (Gmb)

B = maximum specific gravity of the mix (Gmm)

TN TDOT Department of Transportation

AASHTO T-245 Part 2: Marshall Flow and Stability

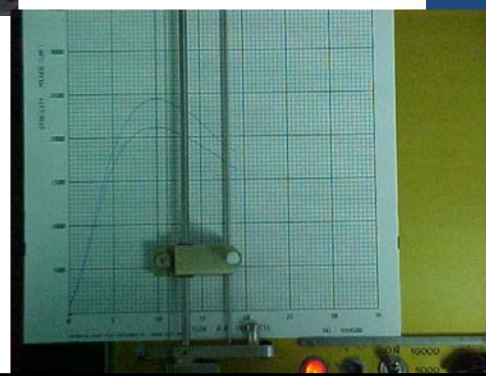
TN TDOT Department of Transportation

Prior to testing in a Stability/Flow device, the pills must be conditioned at 140° F (60°C).

How long must they remain in the water bath?

Once taken out of the conditioning bath, the specimen must be tested within 30 seconds. Why?

The stability/flow test data is recorded on a special graph chart. Multiple specimens can be shown on the same chart.



TN TDOT Department of Transportation

AASHTO T-308 Asphalt Content by Furnace Ignition

TN TDOT Department of Transportation

AASHTO T-308

- TDOT's ***STANDARD*** test method for determining the AC Content of either RAP or HMA is T-164-EII, extractions.
- As an alternate method, AASHTO T-308 (Ignition Furnace) may be used, but a comparison solvent extraction must be performed at least once per week of production.

TN TDOT Department of Transportation

AASHTO T-308

TN TDOT Department of Transportation

AASHTO T-308

- Furnace must be calibrated to each different mix.
- Use the furnace must be backed up weekly with a solvent extraction.
- Test is to be run at 538 ° C unless infrared furnace is used.
- Watch for broken aggregate.

TN TDOT Department of Transportation

Begin by determining the correct sample size for the HMA being tested (T-308 TABLE 1).

Split the sample evenly between the two sample baskets.

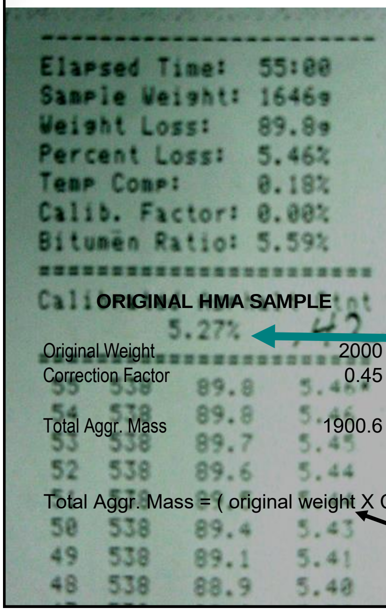
Spread the material into a thin, even layer to ensure complete ignition of the binder.

Stack baskets and lock cover into place.

Place the basket/sample assembly into the furnace. Be careful not to let the assembly touch any part of the furnace wall.

Enter the sample mass, the testing temperature, and the pre-determined correction factor. Furnace will stop test when AC content is determined.

AASHTO T-308
Calculations



(Before Burnout)	
Total Wt. Sample & Basket	5000.0
Basket Wt.	3000.0
Wt. of Sample	2000.0
(After Burnout)	
Total Wt. Sample & Basket	4891.6
Basket Wt.	3000.0
Wt. of Sample	1891.6
Design A. C.	5.4
A. C. Content from N.C.A.T.tape	5.27
A.C. Content Deviation	**-0.13**

ORIGINAL HMA SAMPLE

Original Weight	2000
Correction Factor	0.45
Total Aggr. Mass	1900.6

Total Aggr. Mass = (original weight X Correction Factor / 100) + Recovered Agg. Wt.

Test Print-out

ASTM D-4867 Tensile Strength Ratio (TSR) Test

TN TDOT Department of Transportation

ASTM D-4867

- Test run during verification on surface and binder mixes.
- Requires the compaction of six specimens using plant produced mix.
- Specimens are compacted to achieve 7% air voids.
- Use the same compactive effort from the original design.

TN TDOT Department of Transportation

ASTM D-4867

Determine the Gmb of the six compacted specimens.

Go ahead and calculate the % air voids verify they are in the acceptable range of 6.0 – 8.0 %

We must also measure and record the thickness or height of each specimen.

TN TDOT Department of Transportation

ASTM D-4867

Calculate Gmb
and Air Voids.

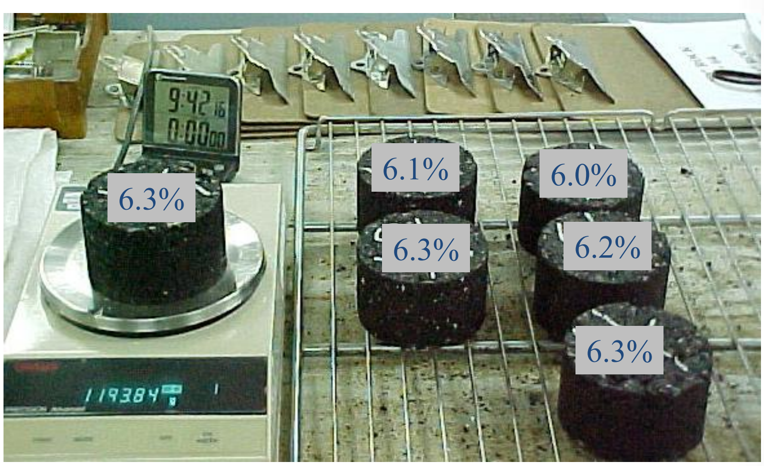
$$\text{Bulk Specific Gravity } (G_{mb}) = \frac{\text{Dry Weight}}{\text{SSD Weight} - \text{Weight in Water}}$$

$$\text{\% Air Voids (Va)} = 100 \times (1 - \text{Gmb/Gmm})$$

TN TDOT Department of Transportation

We need to get this info for <u>all 6</u> TSR pills.

ASTM D-4867



Let us choose three to be our "wet" pills and the other three will be "dry" (unconditioned).

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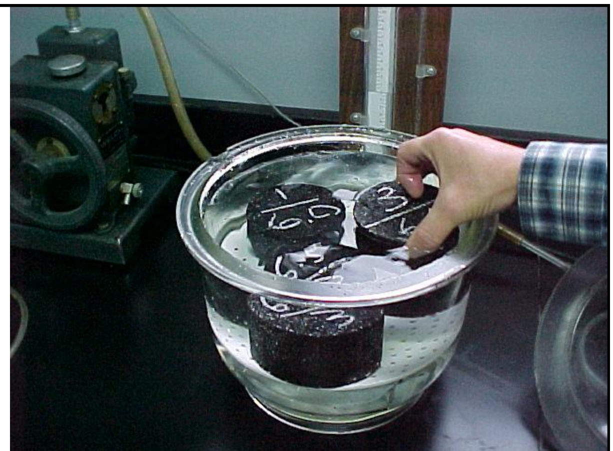
We are now ready to saturate the subset in a container of water by using a vacuum to "pull" water into the specimens for just a few seconds.

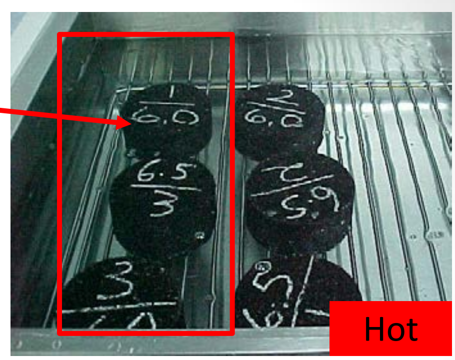


The acceptable saturation range is from 55% to 80 % of the volume of air voids for each specimen.

If the saturation is less than 55 %, then the vacuum must be reapplied. What if it is greater than 80 %?

TN TDOT Department of Transportation

The conditioned (wet) subset is placed in a 140°F water bath for 24 hours.



Meanwhile, the unconditioned (dry) subset sits on a shelf.

TN TDOT Department of Transportation

At the end of the conditioning period, both subsets are brought back to 77°F for 30 minutes.

Finally, all 6 specimens are tested for tensile strength. (*Note the different breaking head)*

ASTM D-4867

- The Tensile Strength Ratio (TSR) is the ratio of conditioned (wet) strength to unconditioned (dry).

$$\boxed{TSR(\%) = (S_{tm} / S_{td}) \times 100}$$

S_{tm} = Average conditioned (wet) strength, psi

S_{td} = Average unconditioned (dry) strength, psi

TN TDOT Department of Transportation

ASTM D-4867

- EXAMPLE: For a set of TSR pills, the average conditioned (wet) strength is 181.2 psi. The average conditioned (dry) strength is 195.9 psi. What is the TSR?

$$TSR = (S_{tm} / S_{td}) \times 100$$

TN TDOT Department of Transportation

ASTM D-4867

- TDOT Specifications for TSR (407.03.E.1)

Table 407.03-4: Criteria for Stripping and Moisture Susceptibility

Asphalt Cement	Minimum Tensile Strength	Minimum TSR
Polymer Modified	100 psi	80%
Non-Polymer Modified	80 psi	80%

TN TDOT Department of Transportation

Loss On Ignition (L.O.I)

- Performed on SURFACE MIXTURES ONLY
  i.e., 411D, 411OGFC, 411TL, 411TLD
- Performed IAW TDOT Spec. 407.03.E
- Results Compared to Value Listed on JMF
- **L.O.I. IS A PAY FACTOR!**

TN TDOT Department of Transportation

L. O. I.

Test for Percent loss on ignition of the Mineral Aggregate in a Asphalt Paving Mixture.

Obtain a representative aggregate sample and weigh approximately **600** grams into an assayer's fire clay crucible which has been ignited to constant weight. The crucible must have a cover to prevent pop-out of aggregate while heating. The covered crucible and its contents is then ignited in a muffle furnace at 1742° F **(950° C)** to constant weight (minimum of **8 hours**). The crucible and contents are cooled to room temperature and weighed.

If the aggregate sample has been obtained by extraction with a vacuum extractor, the weights before and after ignition must be corrected for filter aid.

TN TDOT Department of Transportation

Record the mass of each container while empty, then fill them with the aggregate.

Next, record the mass of all of the containers filled with the aggregate.

Place lids on all of the containers, and insert them into the furnace.

Place a piece of ceramic media on top of the lids to hold them in place.

TN TDOT Department of Transportation

How long do we burn the aggregate?

Notice how white the aggregate now appears.

Finally, again record the mass of all of the containers filled with the ignited aggregate.

1 **Determining Weight of Sample**

Note : Minimum Sample Size = 600 Grams

(A) Weight of Agg. From Burnout Oven		**900.0**
Weight of Sample Container (Crucible)	+	**1100.0**
Total Wt. Of Agg. + Sample Container	=	

2 **Determining Weight Loss**

Wt. of Container + Test Sample (Before Ignition)	
Wt. of Container + Test Sample (After Ignition)	
(B) Weight Loss	

3 **Calculating L.O.I. :**

L.O.I. = (B) Divided by (A) x 100

Inspector ____________

Title ____________

Remarks : No Filter Aid Used . Sample taken from Burnout oven

TN TDOT Department of Transportation

L. O. I.

(Calculations)

- Form found in workbook.

- Now we need to calculate our L.O.I. pay factor.

L. O. I. Pay Factor Calculations

Case 1:

JMF L.O.I. Value: **10.0%** Difference: **1.1%**

Mix L.O.I. Value: **11.1%** Percent Pay: **100%**

Case 2:

JMF L.O.I. Value: **10.0%** Difference: **3.2%**

Mix L.O.I. Value: **13.2%** Percent Pay: **94%**

(% pay = 100 - (1.2 x 5)

Case 1:

JMF L.O.I. Value: **10.0%** Difference: **7.2%**

Mix L.O.I. Value: **17.2%** Percent Pay: **0% !!!**

MILL IT UP !!!!!!!

Sampling and Testing

Sampling and Testing

- What tests do Plant Technicians do daily?
- Where could we find out what is required?
  - SOP 1-1

June 9, 2009
June 4, 2010
November 28, 2011
February 25, 2014
REVISED: July 29, 2015

Tennessee Department of Transportation
Division of Materials and Tests

Procedures for the Sampling and Testing, and Acceptance of Materials and Products (SOP 1-1)

Purpose: The purpose of this document is to establish the procedures and minimum requirements for the acceptance, verification, and certification of materials and products used on Tennessee Department of Transportation (TDOT) projects and projects under the oversight of TDOT (Local Projects, Grants, etc. that include Federal Funds).

Background: Acceptance of materials, or combination of materials, may be accomplished in several

TN TDOT Department of Transportation

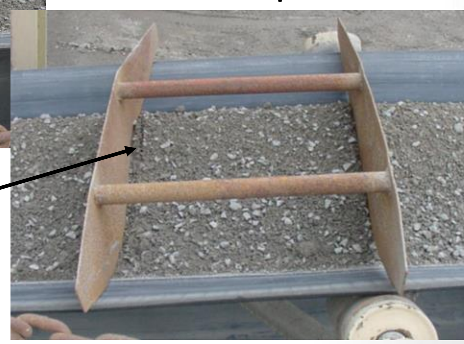
Sampling and Testing

- Note the different set of required tests for A, AS, ACRL, TPB.
- Gradation only. “No extraction required”
- Bin sample for Batch Plant.
- Belt sample for Dryer-Drum Plant.
- Mat Thickness Cores Cut by Contractor
  - 313 Treated Permeable Base Only

TN TDOT Department of Transportation

Sampling and Testing

AASHTO recommends obtaining belt samples of aggregates whenever possible.



A belt-shaped template must be used.

TN TDOT Department of Transportation

Sampling and Testing

- Verification Samples for Liquid Binder:
  - Obtained by Contractor in presence of Inspector.
  - Obtained at start up once a week thereafter.

TN TDOT Department of Transportation

Sampling and Testing

SOP 1-1, Part 1, Paragraph 37:

"All samples taken at asphalt plants <u>shall be taken from the sampling valve on storage tanks and not from transport units</u>. Samples taken from projects utilizing liquid anti-stripping additives (ASA) should either contain ASA or be accompanied by an ASA sample. Before taking the verification sample, <u>sufficient liquid asphalt (1 gallon minimum) shall be discarded to flush the sampling pipe of possible contaminants</u>. The sample size shall be a minimum of 1 quart.

TN TDOT Department of Transportation

Sampling and Testing (Liquid Binder)

<u>ALL</u> samples submitted to TDOT must be accompanied by Form DT-0044.

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

CONTRACTOR MATERIAL CERTIFICATION
AND/OR
SAMPLING AND TESTING RECORD

☐ Original Sample ☐ Check Sample

Project Reference No. ______ County ______ Region ______
Project No. ______ Contract No. ______
Contractor ______ Heat No. ______ Size ______
Date Sampled ______ Date Received at Lab ______
Identification ______ Date Reported ______
Submitted by ______ Sampled by ______
Sampled from ______ Amount Represented ______
Producer ______ Location ______
Manufacturer ______ Location ______
Lab Serial No. ______ Report No. ______

ITEM NUMBER	DESCRIPTION, FIELD USE AND/OR LAB USE	QUANTITY
	INCIDENTAL ITEMS:	

Original to: Headquarters Materials and Tests
Copies to: Regional Materials and Tests; Others upon request

______ Contractor's Personnel Signature

THE CONTRACTOR MUST FILL OUT THIS PORTION PROVIDED <u>THE MATERIAL IS PROPERLY CERTIFIED BUT IS NOT PROJECT IDENTIFIED. A NOTARIZED SIGNATURE IS REQUIRED.</u>

I hereby certify that the above referenced material to be incorporated into this project is represented by the attached manufacturer's certification.

Contractor/Employee Signature ______ Company ______
Sworn to and subscribed before me this ______ day of ______, 20 ______
WITNESSED BY: ______ **Notary Public** My commission expires on ______

<u>T.D.O.T. Use Only</u>
This materials accepted by certification and visual inspection.
Accepted By: ______ Project Inspector **OR** ______ Project Supervisor
Reviewed By: ______ Regional Materials and Tests

This material ☐ meets ☐ does not meet the requirements of the specification for ______
Tested by ______ Approved ______ Engr. Of Materials and Tests

Form DT-0044 (Rev. 10-02)

TN TDOT Department of Transportation

Sampling and Testing (Liquid Binder)

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

SAMPLE

CONTRACTOR MATERIAL CERTIFICATION
AND/OR
SAMPLING AND TESTING RECORD

☑ Original Sample ☐ Check Sample

Project Reference No.	STP-M-1234(5)	County	MONTGOMERY Region 3
Project No.	12345-6789-10	Contract No.	1234
Contractor	Bob Jones	Heat No.	Size
Date Sampled	12-Jan-03	Date Received at Lab	13-Jan-03
Identification		Date Reported	14-Jan-03
Submitted by	John Smith	Sampled by	Bill Smith
Sampled from	Tank	Amount Represented	200 gals.
Producer	John Smith Co.	Location	Clarksville
Manufacturer		Location	
Lab Serial No.	A123	Report No.	34-234

ITEM NUMBER	DESCRIPTION, FIELD USE AND/OR LAB USE	QUANTITY

PERFORMANCE GRADE: 76-22	TDOT Specification	TEST DATA			
Avg 7-day max temp 76 °C / 1-day Min temp -22 °C		Terminal	Spec. (Pass/Fail)	TDOT	Spec. (Pass/Fail)
ORIGINAL BINDER					
Flash Point, °C (min)	**230**	230	Pass	230	Pass
Rotational Viscosity @ 135 °C, Pa-s (max)	**3.000**	3.000	Pass	3.000	Pass
Dynamic Shear Rheometer, kPa (min)	**1.0000**	1.0000	Pass	1.0000	Pass
Phase Angle, degrees	**76.0**	76.0	Pass	69.0	Pass
ROLLING THIN FILM OVEN					
Mass Loss, % (max)	**1.00**	1.00	Pass	1.00	Pass
Dynamic Shear Rheometer, kPa (min)	**2.2000**	2.2000	Pass	2.2000	Pass
Phase Angle, degrees	**76.0**	76	Pass	69.0	Pass
PRESSURE AGING VESSEL					
Dynamic Shear Rheometer, kPa (min)	**5000**	5000	Pass	5000	Pass
m-value (min)	**0.300**	0.299	Run DT	0.299	Run DT
Stiffness, Mpa (max)	**300**	300	Pass	301	Run DT
Direct Tension, % (min)	**1.00**	1.00	Pass	1.00	Pass
OTHER TESTS					
Elastic Recovery, kPa (min)	**57.000**	53.000	Fail	53.000	Fail
Softening Point, °C (min)	**58**	40	Fail	40	Fail

Bob Jones
Contractor's Personnel Signature

THE CONTRACTOR MUST FILL OUT THIS PORTION PROVIDED THE MATERIAL [illegible]LY CERTIFIED BUT IS NOT PROJECT IDENTIFIED. A NOTARIZED SIGNATURE IS REQUIRED.
I hereby certify that the above referenced material to be incorporated into this project is [illegible] by the attached manufacturer's certification.

Contractor/Employee Signature Billy Bob Company B.B. Construction Co.
Sworn to and subscribed before me this 20th day of January 20 03
WITNESSED BY: Jim Williams My commission expires on 23-Dec-05
Notary Public

JIM WILLIAMS MONTGOMERY COUNTY, TENN. NOTARY PUBLIC AT LARGE

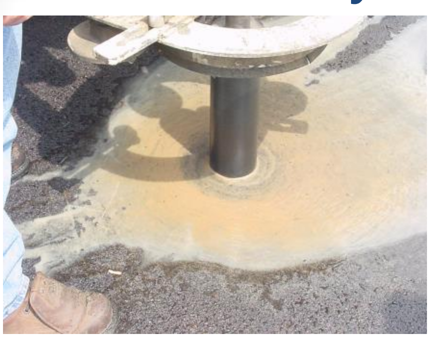
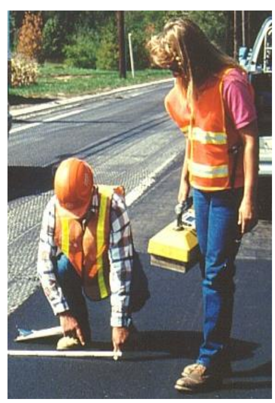
T.D.O.T. Use Only
This materials accepted by certification and visual inspection.
Accepted By: ____________ Project Inspector OR John Smith Project Supervisor
Reviewed By: ____________ Regional Materials and Tests

This material ☑ meets ☐ does not meets the requirements of the specification for PG 76-22
Tested by ____________ Approved ____________ Engr. Of Materials and Tests

Form DT-0044 (Rev. 10-02)

TN TDOT Department of Transportation

Field Density


- Performed by <u>TDOT Project Roadway Inspector</u>
- Nuclear Gauge used for testing.
- Gauge correction must be established with cores cut from test strip.

TN TDOT Department of Transportation

CALIBRATING NUCLEAR DENSITY GAUGE WITH ASPHALT CORES

Ref. No. 0 County MADISON Region 4 Date ______
Project No. 0 Contr. No. 0 Type Mix 307-BM2 w/PG 64-22
Gauge No. ______ Standard Count ______ Control Strip No. ______

Typical test pattern for end section combining all rollers

1 ☑ 7 ☑
2 ☑ 8 ☑
3 ☑ 9 ☑
4 ☑ 10 ☑
5 ☑ 11 ☑
6 ☑ 12 ☑

Min. Size
9' x 400'
10' x 360'
11' x 330'
12' x 300

		(1)	(A)	(C)	(B)	Theoretical Density =				lbs/cu.ft.
Site No.	**Gauge Reading**	**Density lbs/cu.ft.**	**Core Wt. (Dry)**	**Core Wt. (Wet)**	**(Blot Dry**	**Core * Sp. Gr.**	**Density lbs./cu.ft.**	**% Density**	**Cores Depth**	**% H_2O ** Absorbed**
1						0.000	0.00	#DIV/0!		0.00%
2						0.000	0.00	#DIV/0!		0.00%
3						0.000	0.00	#DIV/0!		0.00%
4						0.000	0.00	#DIV/0!		0.00%
5						0.000	0.00	#DIV/0!		0.00%
6						0.000	0.00	#DIV/0!		0.00%
7						0.000	0.00	#DIV/0!		0.00%
8						0.000	0.00	#DIV/0!		0.00%
9						0.000	0.00	#DIV/0!		0.00%
10						0.000	0.00	#DIV/0!		0.00%
	Avg. =	**#DIV/0!**	lbs/cu.ft.		Avg. =	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		

NOTE: Nuclear Density Gauge Correction = + or - **#DIV/0!** lbs./cu.ft.
(core - gauge)

$$\text{* Core Sp. Gr.} = \frac{\text{(Wt. Dry)}}{\text{(Blot Dry)- (Wt. Water)}}$$

Example: wt. dry =699grams
water =385grams
blot dry =710grams

$$\text{Core Sp. Gr.} = \frac{699}{710 - 385}$$

Sp. Gr. = 2.15

$$\text{** Percent Water Absorbed by Volume} = \frac{B - A}{B - C} \times 100$$

A= mass in grams of sample in air
B= mass in grams of SSD specimen in air
C= mass in grams of sample in water

TN TDOT Department of Transportation

Insp. ______
Title ______

Density

Lab/Core Density

- Performed on test strip cores in Lab.
- Test run by <u>TDOT Plant Inspector</u>
- AASHTO T-166

8

Daily Plant Reports

Daily Plant Reports and Random Number Sampling

The Basics

- Both types of Plants have their own Daily Plant Reports
  - Drum Plant: DT-1399
  - Batch Plant: DT-0267
- Forms on the website:
  - https://www.tn.gov/tdot/article/transportation-materials-tests-division-field-operations-forms

Batch Plants

TN TDOT Department of Transportation

Fill in the info that comes from the JMF and info that comes from the Control House (tonnage)

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

DAILY REPORT OF ASPHALT PLANT INSPECTION
BATCH PLANT

Item No. 411.01.07
State Rt. 121-122 Date 27-Aug-03
Report No. 3 Region 3
Reference No. SP County Lincoln
Project No. 12345-6789-10 Prime Contractor Lincoln Asphalt
Air Tem. Min. Max. Grading 411-E w/ RAP Contract No. 12345
Make of Plant & Loc.: Barber - Fayetteville, TN Subcontractor
Tonnes (Tons): RAP 120.56 Virgin AC 39.89 Mineral Aggregate 712.24 Total Mix 872.69
Stripping Test OK Dust Coating +4.75 mm (No. 4) Material Silicone Used No
Fractured Face Count % Glassy Particles by Weight Moisture if Recycle
Anti-Stripping Yes Brand Portland Percent Used 0.3 L (Gal) Used 23.9

Material	Producer	Batch Weight Bin No.	Batch Weight kg (lbs.)	Batch Weight Percent	Mix Temperature	
A.C.	Ergon, Nashville, TN	5				
C.A.	Lincoln Asphalt, Fayetteville, TN	4	1128.0	18.0		
Med C.A.	Rogers Group, Fayetteville, TN	3	564.0	9.4		
Screenings	Rogers Group, Fayetteville, TN	2	1128.0	18.8		
Sand	Cumberland Mountain Sand, Hillsboro, TN	1	2820.0	47.0		
Filler (Bins)		A.C.	3.6	6.0		
Anti-Strip	Pavebond Lite	Total	6000.0	100.0		

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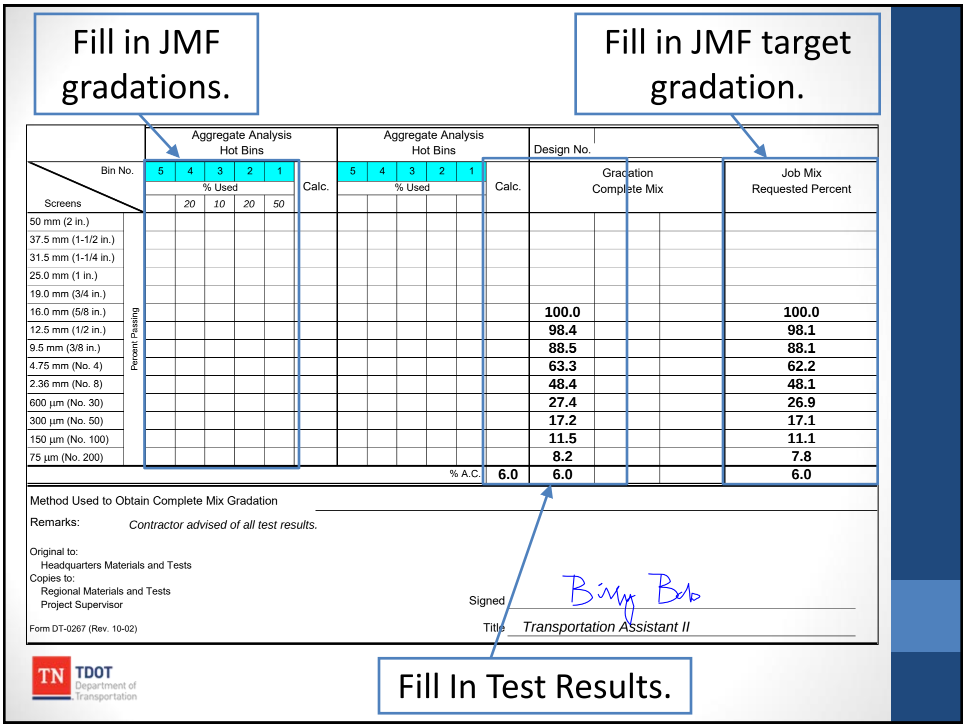


Screens	Aggregate Analysis Hot Bins						Aggregate Analysis Hot Bins						Design No.	
Bin No.	5	4	3	2	1	Calc.	5	4	3	2	1	Calc.	Gradation Complete Mix	Job Mix Requested Percent
% Used		20	10	20	50									
50 mm (2 in.)														
37.5 mm (1-1/2 in.)														
31.5 mm (1-1/4 in.)														
25.0 mm (1 in.)														
19.0 mm (3/4 in.)														
16.0 mm (5/8 in.)													100.0	100.0
12.5 mm (1/2 in.)													98.4	98.1
9.5 mm (3/8 in.)													88.5	88.1
4.75 mm (No. 4)													63.3	62.2
2.36 mm (No. 8)													48.4	48.1
600 µm (No. 30)													27.4	26.9
300 µm (No. 50)													17.2	17.1
150 µm (No. 100)													11.5	11.1
75 µm (No. 200)													8.2	7.8
											% A.C.	6.0	6.0	6.0

Percent Passing

Method Used to Obtain Complete Mix Gradation

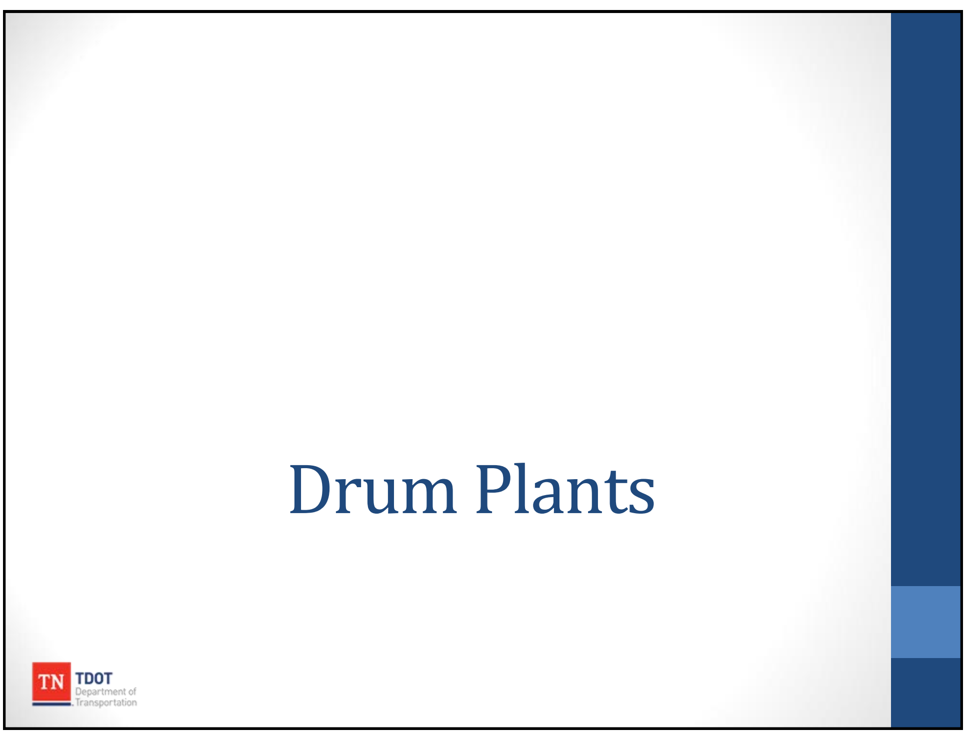
Remarks: *Contractor advised of all test results.*

Original to:
Headquarters Materials and Tests
Copies to:
Regional Materials and Tests
Project Supervisor

Form DT-0267 (Rev. 10-02)

Signed Billy Bob

Title *Transportation Assistant II*



Fill in the info that comes from the JMF and info that comes from the Control House (tonnage)

STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
6601 CENTENNIAL BLVD.
NASHVILLE, TENNESSEE 37243-0360

DAILY REPORT OF ASPHALT PLANT INSPECTION
DRUM PLANT

Item No. 411.02.01
State Rt. 100
Report No. 3
Reference No. SP
Project No. 12345-6789-10
Date 26-Aug-03
Region 3
County WILLIAMSON
Prime Contractor APAC
Air Tem. Min. 69 Max. 88 Grading 411-D Contract No.
Make of Plant & Loc.: ASTEC, Franklin, TN Subcontractor
Tonnes (Tons): RAP 120.56 Virgin AC 39.89 Mineral Aggregate 712.24 Total Mix 872.69
Stripping Test Good Dust Coating +4.75 mm (No. 4) Material 0.24 Silicone Used: ☑ Yes ☐ No
Fractured Face Count % Glassy Particles by Weight Moisture if Recycle
Anti-Stripping Brand Percent Used L (Gal) Used

Percentage A.C. and Cold Feed Bins %	Material		Producer	Mix Temperature	
5.3	A.C. Pen	70-22	Ergon, Nashville, TN		
47.35	C.A. Bin No.	1	Vulcan, Dickson, TN		
14.21	Med C.A. Bin No.	2	Vulcan, Franklin, TN		
9.47	Screenings Bin No.	3	Vulcan, Nashville, TN		
23.68	Sand Bin No.	4	Vulcan, Nashville, TN		
	Filler				
	Total				

Fill in test results.

Fill in info from JMF.

Sample No. / Screens	Aggregate Analysis Combined Agg. Feed To Drum (Percent Passing)	Gradation Complete Mix	Job Mix Requested %	Min. Agg. Load Cell Weights
50 mm (2 in.)				Total Tonnes (Tons) Mix, Dry:
37.5 mm (1-1/2 in.)				% Diff./Truck Wts:
31.5 mm (1-1/4 in.)				
25.0 mm (1 in.)				
19.0 mm (3/4 in.)				
16.0 mm (5/8 in.)		100	100	
12.5 mm (1/2 in.)		96.4	94.9	Asphalt Calculations
9.5 mm (3/8 in.)		84.7	81.4	A.C. Meter, L(gal):
4.75 mm (No. 4)		57.3	54.2	kg/L (lbs/gal) A.C.:
2.36 mm (No. 8)		43.2	41.9	
600 µm (No. 30)		26.4	25.2	A.C. Wasted, Tonnes (tons):
300 µm (No. 50)		10.9	10	Actual % A.C.:
150 µm (No. 100)		6.1	5.5	
75 µm (No. 200)		4.7	4.2	
	% A.C.	5.53		

Design No.

Method Used to Obtain Complete Mix Gradation

Remarks:

Original to:
Headquarters Materials and Tests
Copies to:
Regional Materials and Tests
Project Supervisor
Form DT-1399 (Rev. 10-02)

Signed John Smith

Title *Transportation Technician II*

Random Numbers

Random Numbers

- How often are we supposed to sample/test asphalt at the plant for Acceptance?
- Every 1,000 tons (407.20.B.1 <u>and</u> SOP 1-1)
- When during that 1,000 tons should I take my sample?
  - Which truck is that?

Random Numbers

- Standard Operating Procedures indicate samples taken for plant acceptance should be done so randomly.
- Random number tables are also provided.
- Electronic random number generators (cell phone apps, calculators, EXCEL, etc.) are also acceptable.

TN TDOT Department of Transportation

Random Number Example

- We are taking our first sample of the day for acceptance.
- Time to select a random number…

TN TDOT Department of Transportation

	A		B		C		D		E	
1	0.678	0.694	0.141	0.441	0.836	0.182	0.274	0.829	0.365	0.881
	0.023	0.158	0.948	0.763	0.555	0.741	0.157	0.869	0.811	0.789
	0.504	0.635	0.730	0.899	0.719	0.357	0.284	0.140	0.644	0.082
	0.704	0.941	0.361	0.863	0.882	0.404	0.704	0.933	0.667	0.571
	0.830	0.617	0.154	0.081	0.109	0.741	0.503	0.974	0.301	0.911
2	0.247	0.737	0.402	0.169	0.871	0.830	0.069	0.276	0.998	0.499
	0.710	0.346	0.012	0.836	0.233	0.885	0.077	0.341	0.607	0.719
	0.205	0.290	0.040	0.804	0.638	0.987	0.353	0.539	0.208	0.676
	0.980	0.629	0.424	0.081	0.002	0.761	0.185	0.940	0.997	0.568
	0.360	0.766	0.117	0.032	0.588	0.049	0.407	0.388	0.535	0.464
3	0.120	0.852	0.163	0.852	0.201	0.487	0.713	0.696	0.914	0.080
	0.413	0.327	0.839	0.949	0.724	0.728	0.508	0.471	0.327	0.850
	0.955	0.924	0.285	0.028	0.299	0.064	0.953	0.791	0.437	0.745
	0.131	0.616	**0.223**	0.213	0.027	0.024	0.484	0.030	0.533	0.552
	0.037	0.500	0.803	0.546	0.093	0.401	0.750	0.189	0.417	0.078
4	0.096	0.483	0.713	0.576	0.935	0.281	0.506	0.994	0.014	0.491
	0.818	0.855	0.950	0.195	0.142	0.392	0.380	0.786	0.063	0.423
	0.689	0.685	0.742	0.863	0.906	0.966	0.617	0.375	0.908	0.685
	0.443	0.857	0.239	0.770	0.181	0.241	0.982	0.373	0.150	0.316
	0.020	0.898	0.158	0.365	0.497	0.139	0.864	0.937	0.392	0.026
5	0.245	0.510	0.670	0.082	0.483	0.403	0.524	0.338	0.387	0.406
	0.658	0.596	0.690	0.737	0.899	0.567	0.655	0.231	0.508	0.374
	0.107	0.682	0.077	0.763	0.593	0.877	0.094	0.929	0.268	0.973
	0.057	0.478	0.230	0.623	0.339	0.942	0.239	0.839	0.074	0.854
	0.312	0.193	0.428	0.947	0.185	0.197	0.642	0.537	0.590	0.876
	A		B		C		D		E	

Random Number Example

- Our random number is 0.223.
- That means we want to sample approximately how far into our sub-lot of 1,000 tons?
- Assume each truck holds 20 tons.

TN TDOT Department of Transportation

Random Numbers

- A random number may indicate sampling later in the lot, such as 950 tons in a 1,000 ton lot.
- If this happens, set aside a contingency sample in case there are issues with the plant or other events causing production to cease before the intended sample can be collected.
- If no shut-downs or delays occur, discard the contingency sample.

TN TDOT Department of Transportation

9

Course Review

Handout 1

Scale / Cold Feed Calculations

PART A:

Instructions: Calculate the percentage of error for each cold feed belt scale and determine if the results meet TDOT specifications.

Cold feed #1

Amount placed in truck: 14.66 (applied weight)

Amount Indicated by Readout: 14.62 (scale weight)

Percent Error: ____________

In Tolerance? ____________

Cold feed #2

Amount placed in truck: 13.21 (applied weight)

Amount Indicated by Readout: 13.01 (scale weight)

Percent Error: ____________

In Tolerance? ____________

Cold feed #3

Amount placed in truck: 15.14 (applied weight)

Amount Indicated by Readout: 15.08 (scale weight)

Percent Error: ____________

In Tolerance? ____________

Cold feed #4

Amount placed in truck: 16.21 (applied weight)

Amount Indicated by Readout: 14.49 (scale weight)

Percent Error: ____________

In Tolerance? ____________

Cold feed #5

Amount placed in truck:	13.28	(applied weight)
Amount Indicated by Readout:	14.62	(scale weight)
Percent Error:		
In Tolerance?		

Cold feed #6

Amount placed in truck:	12.79	(applied weight)
Amount Indicated by Readout:	12.75	(scale weight)
Percent Error:		
In Tolerance?		

Cold feed #7

Amount placed in truck:	15.84	(applied weight)
Amount Indicated by Readout:	15.9	(scale weight)
Percent Error:		
In Tolerance?		

Cold feed #8

Amount placed in truck:	11.06	(applied weight)
Amount Indicated by Readout:	11	(scale weight)
Percent Error:		
In Tolerance?		

Handout 1

Scale / Cold Feed Calculations

PART B:

Instructions:

Using the aggregate rate vs. belt speed chart provided, determine the appropriate belt speed for each of the desired production levels.

Production Rate # 1 250 tph AC Content: 4.20%

Agg. Proportions (%)		Total Agg %	Agg. TPH	Belt Speed	
Bin 1	20%	______	______	______	ft/min
Bin 2	37%	______	______	______	ft/min
Bin 3	22%	______	______	______	ft/min
Bin 4	21%	______	______	______	ft/min

Production Rate # 2 200 tph AC Content: 5.80%

Agg. Proportions		Total Agg %	Agg. TPH	Belt Speed	
Bin 1	20%	______	______	______	ft/min
Bin 2	25%	______	______	______	ft/min
Bin 3	40%	______	______	______	ft/min
Bin 4	15%	______	______	______	ft/min

Production Rate # 3 280 tph AC Content: 6.20%

Agg. Proportions		Total Agg %	Agg. TPH	Belt Speed	
Bin 1	25%	______	______	______	ft/min
Bin 2	30%	______	______	______	ft/min
Bin 3	20%	______	______	______	ft/min
Bin 4	25%	______	______	______	ft/min

Production Rate # 4 180 tph AC Content: 3.60%

Agg. Proportions		Total Agg %	Agg. TPH	Belt Speed	
Bin 1	18%	________	________	________	ft/min
Bin 2	37%	________	________	________	ft/min
Bin 3	27%	________	________	________	ft/min
Bin 4	18%	________	________	________	ft/min

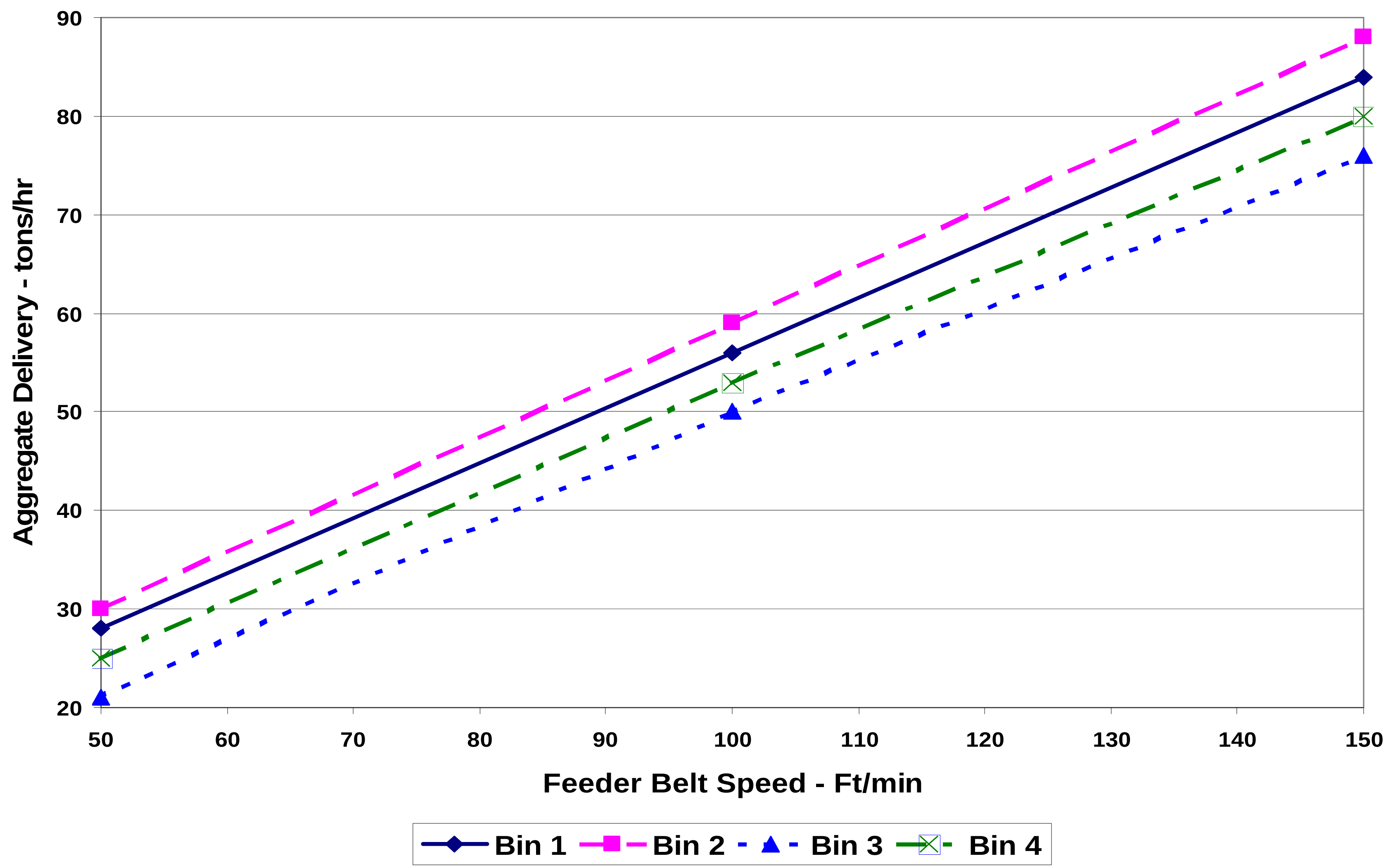
Production Rate # 5 325 tph AC Content: 5.60%

Agg. Proportions		Total Agg %	Agg. TPH	Belt Speed	
Bin 1	26%	________	________	________	ft/min
Bin 2	27%	________	________	________	ft/min
Bin 3	25%	________	________	________	ft/min
Bin 4	22%	________	________	________	ft/min

Production Rate # 6 175 tph AC Content: 6.20%

Agg. Proportions		Total Agg %	Agg. TPH	Belt Speed	
Bin 1	25%	________	________	________	ft/min
Bin 2	25%	________	________	________	ft/min
Bin 3	25%	________	________	________	ft/min
Bin 4	25%	________	________	________	ft/min

Calibration Graph for Cold Feed



Handout 2

Asphalt Meter & Anti-Stripping Additive Calculations

PART A:

Instructions: Caluculate the Flow rate for each problem. Assume the weight of asphalt to be 8.4 lbs/gallon

#1

Plant is producing 450 Tons/Hour at 6.2% Asphalt Content FLOW = _________ gpm

#2

Plant is producing 200 Tons/Hour at 4.2% Asphalt Content FLOW = _________ gpm

#3

Plant is producing 200 Tons/Hour at 4.2% Asphalt Content FLOW = _________ gpm
*This Mix has 20% RAP and only 70% Virgin Asphalt

Handout 2

Asphalt Meter & Anti-Stripping Additive Calculations

PART B:

Instructions: Caluculate the Total amount of Anti-Strip Additive used in gallons for each day.
Assume the weight of ASA to be 8.4 lbs/gallon.

Day One

2,500 Tons of 307 BM2 produced.
4.1% Asphalt Content
0.3% Anti-Strip Used

ASA = __________ Gallons

Day Two

700 Tons of 411 D Produced
6.1% Asphalt Content
0.5% Anti-Strip Used

ASA = __________ Gallons

Day Three

2,000 Tons of 307A produced
3.2% Asphalt Content
0.5% Anti-Strip
*This Mix has 15% RAP and only 78% Virgin Asphalt

ASA = __________ Gallons

Sampling and Testing Homework In-Class Handout
AASHTO T-164/T-30, T-166/T-245, Fractured Face Count

Instructions:

Complete the worksheet and answer the following questions:

a) What is the average calculated AC content? ____________________

b) What is the percent of fractured faces? ____________________

c) What is the average dust to asphalt ratio? ____________________

d) Does this test meet AASHTO specifications? If not, why? ____________________

____

____

e) What is the average stability for the AM test? ____________________

f) What is the average bulk specific gravity for the AM test? ____________________

g) What are the average air voids for the PM test? ____________________

Type Mix **307-BM2 PG 67-22** **Proj. No.**

Date **12/11/17** **Inspector**

	(Test 1)	(Test 2)
Weight of Filter Aid Used	100.0	100.0
Weight of Filter Paper	11.5	11.3
Weight of Mix Sample + Container	2201.4	2213.2
Wt. Of Container	- 545.4	550.1
(1) Wt. Of Mix sample		

After Extracting A . C .

	(Test 1)	(Test 2)
Wt. Of Filter Aid + Filter Paper + (-200) Mtl	221.6	230.2
Wt. Of Filter Aid + Filter Paper	-	
(2) Wt. Of (-200) Mtl.		
Weight of Extracted Aggregate + Pan	1795.2	1820.0
Wt. Of Pan	- 343.0	372.4
(3) Wt. Of Extracted Aggregate		
(4) Total Wt. Of Aggregate = (2) + (3) =		
(5) Wt. Of Extracted Asphalt = (1) - (4) =		

$$\% \text{ A. C.} = \frac{\text{Weight of Extracted Asphalt}}{\text{Weight of Mix Sample}} \times 100 =$$

SIEVE ANALYSIS

AASHTO T-30

(Test 1)

Sieve	Wt. Ret.	% Ret.	% Pass
1 1/2"	-		
1 1/4"	0		
1"	-		
3/4"	109		
5/8"	-		
1/2"	-		
3/8"	521		
# 4	796		
# 8	1006		
# 30	1291		
# 50	1376		
# 100	1398		
# 200	1431		
			D.A.R.
Total Agg. Wt. =			

(Test 2)

Sieve	Wt. Ret.	% Ret.	% Pass
1 1/2"	-		
1 1/4"	0		
1"	-		
3/4"	112		
5/8"	-		
1/2"	-		
3/8"	524		
# 4	801		
# 8	1009		
# 30	1295		
# 50	1382		
# 100	1401		
# 200	1435		
			D.A.R.
Total Agg. Wt. =			

Fract. Face Count

No. particles	172
No. fractured	164
% fractured	

Glassy Particles

total wt.	
wt. Glassy	

MARSHALL MIX DESIGN

Rev. 2-1-2000

Date	12/11/17	**Cont. No.**		**Contractor**	
Type Mix	307-BM2 PG 67-22	**County**		**No. Hammer Blows**	75
Proj. No.		**Region**		**sp.gr. a.c.**	1.032

Sample No.	**% AC**	**% Agg.**	**Weight Marshall In Air**	**S S D**	**Grams Specimen In Water**	**Volume Marshall Specimen**	**Bulk Sp.Gr. Marshall Specimen**	**Theo. Gravity Mix**	**Effective Gravity Aggs.**	**% Voids Total Mix**	**% Voids Min. Agg. (VMA)**	**% Voids Filled With AC**	**Unit Wt. (PCF)**	**Stability Lbs.**	**Flow (.01")**
	A	B	C	D	E	F	G	H	I	J	K	L	M	O	P
1	5.66		1193.5	1194.9	689.1			2.450						2450	14.6
2	**Test 1**		1197.4	1199.3	691.4									2300	15.9
3			1196.1	1198.0	690.8									2350	15.8
						Average							Average		
1															
2															
3															
1															
2															
3															
1															
2															
3															
1	5.81		1191.3	1193.2	685.7			2.450						2450	16.1
2	**Test 2**		1190.4	1191.2	684.1									2375	15.4
3			1189.9	1192.0	686.2									2500	14.9
						Average							Average		

*Theo. Grav. Mix (H) As Determined By AASHTO T--209

Agg. loss on ignition (loi)		Recommended AC content	
Agg. fractured face count	95.3	Theoretical Gravity	2.450
Agg. glassy particles		Dust to asphalt ratio (dar)	
Agg. absorption		Amount & type of anti-strip	
Agg. bulk Sp. Gr.		Mix tensile strength ratio (tsr)	
Agg. apparent Sp. Gr.			
Grams for 2.5" specimen		Approved	

Efff. Gr. Aggs. = B / (100 / H - A / Sp. gr. AC)

Theo. Grav. (at any ac content) = 100 / (A /Sp. Gr. AC + B / I)

Sampling and Testing Homework In-Class Handout
AASHTO T-164/T-30, T-166/T-245, Fractured Face Count

Instructions:

Complete the worksheet and answer the following questions:

a) What is the calculated AC content? ____________________

b) What is the % passing the # 4 seive? ____________________

c) What is the dust to asphalt ratio? ____________________

d) Does this test meet AASHTO specifications? If not, why? __________

____

____

e) What is the % fractured faces? ____________________

f) What is the average bulk specific gravity for the AM test? ____________________

g) What are the average air voids for the PM test? ____________________

EXTRACTION SAMPLE

Type Mix **411-D PG 64-22** **Proj. No.** ____________

Date **12/11/17** **Inspector** ____________

	(1)	(2)
Weight of Filter Aid Used	100.0	100.0
Weight of Filter Paper	11.3	11.1
Weight of Mix Sample + Container	2204.4	2207.6
Wt. Of Container	- 525.0	521.0
(1) Wt. Of Mix sample		
After Extracting A . C .		
Wt. Of Filter Aid + Filter Paper + (-200) Mtl	224.4	226.1
Wt. Of Filter Aid + Filter Paper	-	
(2) Wt. Of (-200) Mtl.		
Weight of Extracted Aggregate + Pan	1802.4	1815.7
Wt. Of Pan	- 345.4	355.0
(3) Wt. Of Extracted Aggregate		
(4) Total Wt. Of Aggregate = (2) + (3) =		
(5) Wt. Of Extracted Asphalt = (1) - (4) =		
% A. C. = Weight of Extracted Asphalt / Weight of Mix Sample x 100 =		

SIEVE ANALYSIS

AASHTO T-30

(1)

Sieve	Wt. Ret.	% Ret.	% Pass
1 1/2"	-		
1 1/4"	-		
1"	-		
3/4"	-		
5/8"	0		
1/2"	24.6		
3/8"	251.4		
# 4	621.3		
# 8	826.4		
# 30	1144.6		
# 50	1265.4		
# 100	1414.7		
# 200	1454.9		
			D.A.R.
Total Agg. Wt. =		**1500.4**	**0.94**

(2)

Sieve	Wt. Ret.	% Ret.	% Pass
1 1/2"	-		
1 1/4"	-		
1"	-		
3/4"	-		
5/8"	0		
1/2"	27.8		
3/8"	255.8		
# 4	630.5		
# 8	834.4		
# 30	1153.9		
# 50	1272.6		
# 100	1428.2		
# 200	1458.8		
			D.A.R.
Total Agg. Wt. =			

Fract. Face Count

No. particles 218

No. fractured 147

% fractured ______

Glassy Particles

total wt. ______

wt. Glassy ______

______

MARSHALL MIX DESIGN

Rev. 2-1-2000

Date	12/11/17	**Cont. No.**		**Contractor**	
Type Mix	411-D w/PG 64-22	**County**		**No. Hammer Blows**	75
Proj. No.		**Region**		**sp.gr. a.c.**	1.032

Sample No.	% AC	% Agg.	Weight Marshall In Air	S S D	Grams Specimen In Water	Volume Marshall Specimen	Bulk Sp.Gr. Marshall Specimen	Theo. Gravity Mix	Effective Gravity Aggs.	% Voids Total Mix	% Voids Min. Agg. (VMA)	% Voids Filled With AC	Unit Wt. (PCF)	Stability Lbs.	Flow (.01")
	A	B	C	D	E	F	G	H	I	J	K	L	M	O	P
1	6.24		1189.2	1191.6	683.5			2.445						2175	13.7
2	**A.M.**		1188.5	1190.4	682.9									2150	13.8
3	**Sample**		1190.1	1192.3	683.9									2200	14.2
						Average							Average		
1															
2															
3															
						Average							Average		
1															
2															
3															
						Average							Average		
1															
2															
3															
						Average							Average		
1	5.92		1191.3	1193.2	682.4			2.435						2345	14.8
2	**P.M.**		1190.4	1191.2	680.4									2275	13.9
3	**Sample**		1189.9	1192.0	681									2175	15.2
						Average							Average		

*Theo. Grav. Mix (H) As Determined By AASHTO T--209

Agg. loss on ignition (loi) ______
Agg. fractured face count ______
Agg. glassy particles ______
Agg. absorption ______
Agg. bulk Sp. Gr. ______
Agg. apparent Sp. Gr. ______
Grams for 2.5" specimen

Recommended AC content ______
Theoretical Gravity 2.445
Dust to asphalt ratio (dar) ______
Amount & type of anti-strip ______
Mix tensile strength ratio (tsr) ______
Approved

Efff. Gr. Aggs. = B / (100 / H - A / Sp. gr. AC)

Theo. Grav. (at any ac content) = 100 / (A /Sp. Gr. AC + B / I)

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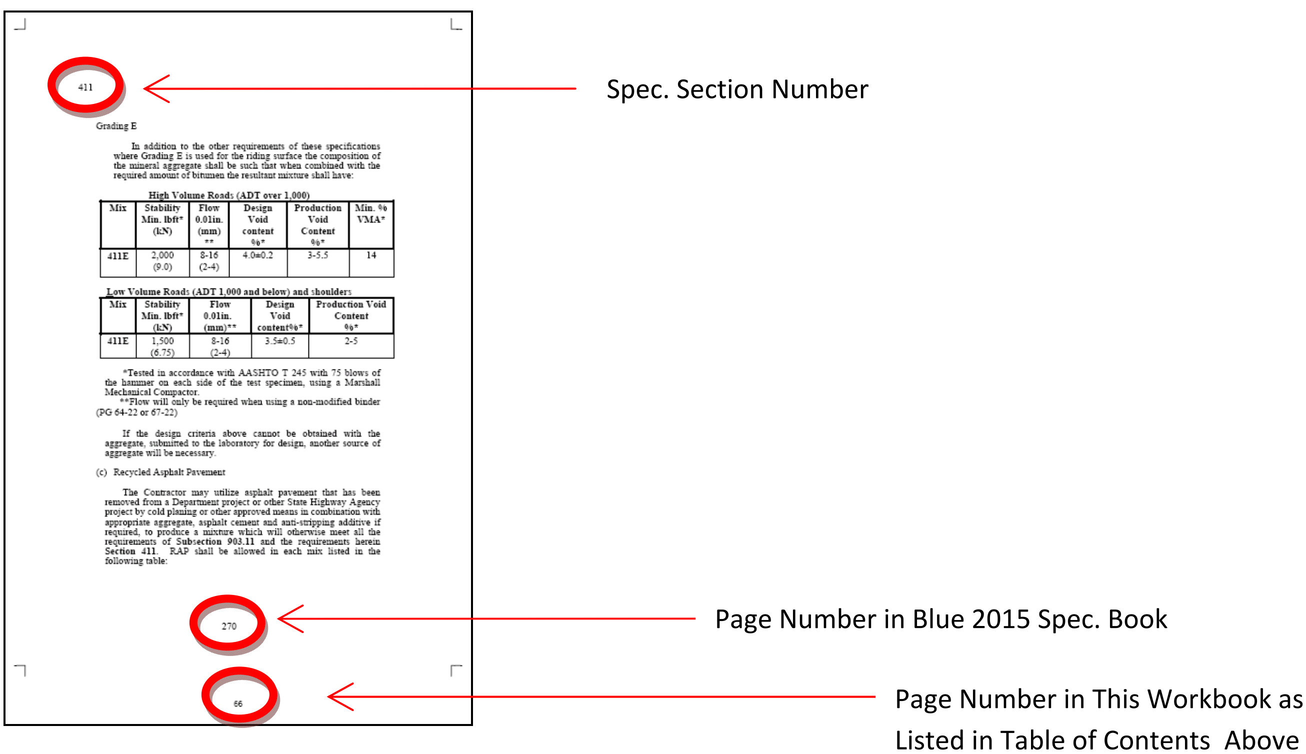
Specifications

SPECIFICATIONS AND SUPPLEMENTALS

TABLE OF CONTENTS

Specifications:



SECTION 106 – CONTROL OF MATERIALS

106.01 Quality of Materials

Only use materials in the Work that conform to all of the Contract quality requirements. Control and incorporate materials to produce completed construction that conforms to and is fully acceptable under the terms of the Contract.

Where reference is made in the Contract to certain manufacturers' materials or products, it is not the intent to preclude the use of others, but rather to establish minimum acceptable design standards. The Contractor may substitute material and products of other manufacturers provided they are equal to or better than the minimum design standards and are approved by the Department.

106.02 Material Information

When the Department has readily available test reports on materials from local sources near the Project, it will furnish copies to the Contractor covering each source for which a specific request is made. In furnishing such reports, the Department will not be responsible for materials failing to conform to the test reports either as to quality or quantity.

106.03 Local Material Sources

If the Contractor desires preliminary tests of local materials, it shall deliver samples of the materials to the Laboratory. The Department will test such samples, up to a reasonable number, and in such time as the work load in the Laboratory may permit. Acceptable test results on preliminary samples will not guarantee acceptance of materials from the same source later.

106.04 Sampling and Testing, or Inspection

Incorporate into the Work only those materials that have been sampled and tested, inspected, and approved by the Engineer. Untested or unaccepted materials used in the Work without the Engineer's written permission shall be removed and replaced at no cost to the Department. Unless otherwise specified, sampling and testing, or inspection will be conducted by qualified representatives in accordance with the most current published national standard specifications, AASHTO or ASTM methods on the date of the Advertisement. Furnish all materials for samples at no cost to the Department. The Department will perform sampling and testing, or inspection, at its expense unless otherwise specified. If the Department does not elect to sample and test or inspect at the source, it will sample and test, or inspect, materials after delivery to the site or to the batching plant. Furnish all facilities, and provide all reasonable assistance to secure and transport samples, and move materials being inspected.

The Departmental procedures will provide sampling and testing frequencies for the acceptance, quality control, independent assurance, verification, or certification for materials and products.

The Engineer may accept certain materials or products and assemblies based on Certificate of Compliance signed by the manufacturer or its authorized representative, stating that such materials, products, and assemblies fully comply with the requirements of the Contract. For each lot of such materials or assemblies delivered to the Work, provide a Certificate of Compliance that clearly identifies the lot. Provide all necessary paperwork with certification submittals as specified in Departmental Procedures.

Furnish a notarized Certificate of Compliance for a non-bid item, not permanently incorporated in the Work, but that must meet a designated specification upon delivery of the material to the Project and prior to its being used.

The Department may sample and test materials, products, or assemblies accepted on the basis of Certificate of Compliance at any time, and may reject such materials and assemblies if found to be in non-conformance with the Contract.

106.05 Source or Plant Inspection

The Contractor is entirely responsible for securing satisfactory material. However, if the volume of any given material, the progress of construction, and other considerations of interest to the Department so justify, the Department may inspect materials at the source of supply. The Department will undertake such inspection only when the Engineer is assured of the fullest cooperation and assistance of the Contractor and of the material producer involved. Provide required copies of all orders, shipping information, and other pertinent papers.

Provide the representatives of the Department with free and safe access at all times to parts of the site or plant concerning the manufacture and production of material for the Project. If the Contractor is not the owner of the place where fabrication, preparation, or manufacture is in progress, the plant owner is deemed to be the agent of the Contractor with respect to the obligation assumed hereunder.

106.06 Field Laboratory

Furnish Type A or Type B laboratory(s) or both, as required to be used exclusively for testing purposes. Provide suitable field laboratories or inspection offices at batch plants and sources or plants at which off-site inspection is provided by the Department under **106.05**. Locate the laboratory(s) as directed by the Engineer. Install, equip, and make building(s) ready for use before the Contractor's operations require field testing. When a concrete batch plant is located near a Type B Laboratory used for testing at an asphalt plant, the Engineer may approve joint use provided there is ample time and equipment to perform all necessary testing for both operations.

All Contractor and producer laboratories must be inspected and qualified in accordance with TDOT procedures before the Contractor can perform any work.

A. Type A

Provide a Type A Laboratory consisting of a building, room, or dedicated area having at least 120 square feet of floor area with a minimum width of 8 feet and a minimum height of 7 feet. Provide laboratory space that is floored, roofed, sealed inside, weather-tight, and furnished with electricity. Furnish the space with adequate work benches, cabinets, and drawers. Provide suitable heat and air conditioning, and equip the laboratory with a laboratory oven capable of maintaining a temperature of 230 °F ± 9 °F. Provide lights, electrical outlets, and adequate ventilation for the tests being performed.

When the determination of aggregate gradation is required, furnish the following equipment:

1. Scales of appropriate capacity and design to weigh the required samples. Scales are to be sensitive to within 0.2% of the sample to be weighed. Provide standard weights for scale calibration.

2. Screens of appropriate size and mesh to separate the samples into the required series of sizes. Woven wire cloth shall conform to AASHTO M 92. Screens for running gradations of coarse aggregates shall have a minimum area of 2.33 square feet.

3. A mechanical shaker approved by the Engineer and suitable for running both coarse and fine aggregate.

4. Facilities to perform wash tests according to AASHTO T 11 that include an adequate and suitable water supply.

B. Type B

In addition to meeting all of the requirements for a Type A Laboratory, a Type B Laboratory shall be equipped with the following:

1. Laboratory space with a minimum of 300 square feet.

2. Two vacuum extractors, each having a minimum bowl capacity of 100 troy ounces meeting the requirements of ASTM D2172, or one vacuum extractor and one ignition

furnace meeting the requirements of AASHTO T308. Supply an adequate amount of an approved solvent from the Department's Qualified Products List and provide for storage and disposal of the waste solvent in accordance with the regulations promulgated under the Tennessee Hazardous Waste Management Act.

To ensure adequate ventilation, house the extractor and drying equipment in an enclosed hood. Equip the hood with an exhaust fan vented to the outside and mounted at the appropriate location in order to remove the vapors of the solvent. Where the extractor is installed outside the laboratory, only vent the drying equipment as outlined above.

3. Supply apparatus meeting the requirements of AASHTO T 166, Section 3.1 and 3.2 for determining the bulk specific gravity of compacted asphalt mix. When required by the Contract, supply an apparatus meeting the requirements of AASHTO T 209, Section 3.1 through 3.5 for determining the maximum specific gravity of an asphalt mix.

4. Supply a minimum of two suitable thermometers with an approximate temperature range of 50 to 400 °F.

5. Provide a furnace capable of performing loss on ignition tests for a minimum 10-troy ounce sample.

6. When required as specified in **407.03**, provide equipment needed to perform Marshall Tests according to AASHTO T 245. The compactor shall be a Marshall Mechanical type with rotating mold(s) and slanted foot hammers that produce a modified kneading action.

Unless otherwise specified in the Contract, the Department will not pay for Field Laboratories as a separate item but will consider it incidental to the applicable contract items.

106.07 Notice of Source or Arrival of Materials

Purchase all materials sufficiently in advance of incorporating into the Work to allow the Engineer to conduct sampling and testing, or inspection. Provide the Department, in writing, the name and location of suppliers that will furnish materials for the Project. When the Department does not elect to perform materials sampling and testing, or inspection at the source, advise the Engineer in writing within 24 hours after materials requiring sampling for testing, or inspection, are delivered to the site of the Work.

106.08 Handling and Storage of Materials

Transport all materials in tight, clean vehicles, and prevent contamination, segregation, or other damage to the materials when in route to the job site or the batching plant, and when moved from point to point at later stages.

Store materials to preserve their quality and fitness for use. When considered necessary, store materials in weatherproof buildings, place them on wooden platforms or other hard, clean surfaces but not on the ground, and cover them when directed. Locate stored materials to facilitate prompt inspection. Do not use private property for storage purposes without written permission of the owner or lessee. If using portions of the right-of-way for storage of materials or erection of batching plants, obtain the specific approval of the Engineer.

106.09 Resampling and Testing, or Reinspection

At the option of the Engineer, the Department may resample and test all materials or re-inspect at any time after delivery to the site, or to any batching plant. If such materials are found to be unacceptable, the Department will reject the materials.

106.10 Defective Material

Do not deliver to the site materials found to be unacceptable or rejected elsewhere. Remove rejected materials from the site or processing batch plant at no cost to the Department.

SECTION 307 – BITUMINOUS PLANT MIX BASE (HOT MIX)

DESCRIPTION

307.01 Description

This work consists of constructing one or more base course layers of aggregate and asphalt, prepared in a hot bituminous mixing plant and spread and compacted on a prepared subgrade, granular sub-base, or base.

MATERIALS

307.02 Materials

Provide materials as specified in:

Aggregate for Mixture,
  Grading A, ACRL, AS, B, BM, BM2, C, CS, or CW **903.06**
Asphalt Cement, Grade PG 64-22, 70-22, 76-22, 82-22........ **904.01**
Chemical Additive **921.06.B**

The specific grading of aggregate to be used will be specified in the Contract or shown on the Plans. The Engineer will accept mineral aggregate, bituminous material, and the plant mix in accordance with **407.02**.

307.03 Composition of Mixtures

A. General

The bituminous base and/or leveling course shall be composed of aggregate and bituminous materials. The hot plant mixes shall comply with the applicable requirements of **407.03**.

Combine the specified mineral aggregate and asphalt cement in proportions that will meet the design composition limits specified in Table 307.03-1.

Table 307.03-1: Mixture Composition

Mixtures	Proportions of Total Mixture, Percent by Weight	
	Combined Mineral Aggregate, %	**Asphalt Cement, % (1)**
Grading AS and ACRL	96.3 - 97.7	2.3 - 3.7
Grading A	95.8 - 96.7	3.3 - 4.2
Grading B, BM and BM2	93.8 - 95.8	4.2 - 6.2
Grading C and CW	93.8 - 95.8	4.2 - 6.2
Grading CS	92.3 - 94.7	5.3 - 7.7

(1) If the effective combined specific gravity of the aggregate exceeds 2.80, the Engineer may adjust the proportions specified.

In addition, combine the materials with the required amount of bitumen to meet the design properties specified in Table 307.03-2, except that on low volume roads (ADT 1,000 or below), the minimum stability shall be 1,500 pound-feet and the VMA and dust-asphalt ratio will be waived for 307-B, 307-BM, 307-BM2 and 307-C mixes.

Table 307.03-2: Mixture Design Properties

Mix [(1)]	Stability (minimum) lbf [(2)]	Design Void Content % [(2)]	Production Void Content, % [(2)]	VMA (minimum) % [(2)]	Dust-Asphalt Ratio [(3)]
307-B	2,000	4.0±0.2	3-5.5	11.5	0.6-1.5
307-BM	2,000	4.0±0.2	3-5.5	13.5	0.6-1.5
307-BM2	2,000	4.0±0.2	3-5.5	13.5	0.6-1.5
307-C	2,000	4.0±0.2	3-5.5	13.0	0.6-1.5
307-CS	2,000	3.0±0.5	1-5	---	---
307-CW	1,500	4.0±0.2	3-5	13.0	0.6-1.5

(1) To identify critical mixes and make appropriate adjustments, the mix design shall meet these design properties for the bitumen content range of Optimum Asphalt Cement ±0.25%.

(2) Tested according to AASHTO T 245 with 75 blows with the hammer on each end of the test specimen, using a Marshall Mechanical Compactor.

(3) The dust-asphalt ratio is the percent of the total aggregate sample that passes the No. 200 sieve, as determined by AASHTO T 11, divided by the percent asphalt in the total mix.

If the materials proposed for use do not meet the design criteria specified in Table 307.03-2, find other suitable sources of materials. If the material at the asphalt plant will not combine within the tolerances of the Job Mix Formula (JMF), provide a new design.

B. Recycled Asphalt Pavement and Recycled Asphalt Shingles

1. **Recycled Asphalt Pavement (RAP).** The Contractor may use asphaltic concrete removed from a Department project or other State Highway Agency project by an approved method and stored in a Department approved stockpile. RAP combined with the appropriate aggregate, asphalt cement, and anti-strip additive when required shall produce a mixture that meets **903.06** and this Section **307**. The Contractor may incorporate RAP in the mixes specified in Table 307.03-3.

Table 307.03-3: Mixtures Using RAP

Mix Type	% RAP (Non-processed)[(1)]	Maximum % RAP (Processed)[(2)]	Maximum % RAP Processed & Fractionated [(3)]	Maximum Particle Size (inches)
307-ACRL	0	00	-	-
307-AS	0	00	-	-
307-A	15	20	35	1-1/2
307-B	15	30	35	1-1/2
307-BM	15	30	35	3/4
307-BM2	15	30	35	3/4
307-C	15	30	35	3/8
307-CW	15	30	35	1/2
307-CS	0	15	25	5/16

(1) "Non-processed" refers to RAP that has not been crushed and screened or otherwise sized prior to its use.

(2) "Processed" refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed in Table 307.03-3 prior to entering the dryer drum.

(3) "Fractionated" refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

All mixes shall contain at least 65% virgin asphalt.

The Contractor shall obtain a representative sample from the recycled material stockpile, and shall establish a gradation and asphalt cement content. The Contractor shall determine the gradation and asphalt content of the recycled material at the beginning of a project and every 2,000 tons thereafter. The stockpile asphalt cement content for all recycled material shall not vary by more than 0.8%. The stockpile gradation tolerance for all recycled material on each sieve is specified in Table 307.03-4.

Table 307.03-4: Stockpile Gradation Tolerance

Sieve Size	Tolerance
3/8 inch and larger	± 10%
No. 4	± 8%
No. 8	± 6%
No. 30	± 5%
No. 200	± 4%

The Engineer will accept the mixture for aggregate gradation and asphalt content in accordance with **407.20.B**.

Provide a special mix design with asphalt content in the range of 5 to 7% where 307-C Mix is used as a surface on the shoulder.

Perform sampling and testing of the planings as well as new materials for bid purposes, and for the submission of the Job Mix Formula (JMF) as specified in **407.03**. Submit all additives to the Engineer for approval at the same time other materials are submitted for design verification.

After mixing, verify the moisture content of the total mix is no more than 0.1% as determined by oven drying. Provisions for lowering the temperature because of boiling or foaming shall not apply.

2. **Recycled Asphalt Shingles (RAS).** RAS may be included to a maximum of 5% of the total weight of mixture. The percentage of RAS used will be considered part of the maximum allowable RAP percentage. The ratio of added new asphalt binder to total asphalt binder shall be 65% or greater <u>for all 307 mixes</u>. Either the mix producer or the RAS supplier shall obtain a representative sample from the recycled material stockpile and establish a gradation and asphalt cement content as required. Determine shingle asphalt binder content according to AASHTO T 164 Method A, with a minimum sample size of 500 grams. Determine the gradation and asphalt content of the recycled material at the beginning of the

Project and every 2,000 tons of recycled material used thereafter. The stockpile asphalt cement content for all recycled material shall not vary by more than 0.8%. All RAS material shall be processed to a minimum 100% passing the 3/8 inch sieve and a minimum 90% passing the No. 4 sieve.

To conduct the gradation testing, air dry a 500 to 700-gram sample of processed shingle material, dry sieve over the 3/8-inch and No. 4 sieves, and weigh. For mix design purposes, the Contractor may use the aggregate gradation specified in Table 307.03-5 as a standard gradation instead of determining the shingle gradation according to AASHTO T 30.

Table 307.03-5: Standard Gradation (for Mix Design Purposes)

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	97
No. 8	95
No. 16	80
No. 30	60
No. 50	50
No. 100	40
No. 200	30

An aggregate bulk specific gravity (G_{sb}) of 2.650 may be used instead of determining the shingle aggregate G_{sb} according to AASHTO T 84. In addition, the effective binder available for mixing with additional aggregates shall be considered as 75% of the total binder content as determined by AASHTO T 164 and shall be the value listed as the RAS binder content on the JMF.

Scrap asphalt shingle shall not contain extraneous waste materials. Extraneous materials including, but not limited to, asbestos, metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastics, shall not exceed 0.5% by weight as determined on material retained on the No. 4 sieve. To conduct deleterious material testing, take a representative 500 to 700-gram sample of processed shingle material, place over the No. 4 sieve, and pick and weigh all extraneous waste material retained on the No. 4 sieve. Base the percent of extraneous material on the total sample weight.

RAS shall contain less than the maximum percentage of asbestos fibers based on testing procedures established by the Department, or State or Federal environmental regulatory agencies. Analyze a minimum of one sample of processed asphalt roofing material for every 500 tons of material processed for the presence of asbestos.

Before a JMF for a particular design is approved, submit the following, along with the materials and information specified in **407.03**:

a. Certification by the processor of the shingle scrap describing the shingle scrap content and source.

b. A 1000-gram sample of the processed RAS material for inspection (new designs only).

Stockpile RAS separate from other salvage material. Do not blend RAS material in a stockpile with other salvage material. Do not blend Manufacture Waste Scrap Shingles (MWSS) and Tear-Off Scrap Shingles (TOSS). In addition, do not blend virgin sand material with the processed shingles, to minimize agglomeration of the shingle material.

All RAS supplied to a Department project shall come from a certified shingle processor/supplier approved by the Division of Materials and Tests.

C. Anti-Strip Additive

Check asphaltic concrete mixtures (Grading A, AS, ACRL, B, BM, BM2, C, CS, and CW) for stripping by the following methods:

1. The Ten Minute Boil test for dosage rate and the Root-Tunnecliff procedure (ASTM D4867) for moisture susceptibility.

   Do not use the Root-Tunnecliff procedure (ASTM D4867) with the following mixtures: Grading A, AS, ACRL, and B.

2. For mixtures not requiring design, the Ten Minute Boil test for dosage rate and moisture susceptibility.

If test results indicate moisture susceptibility, mix an approved anti-strip agent with the asphalt cement at the dosage recommended by the respective test and as specified in **921.06.B**.

EQUIPMENT

307.04 Equipment

Provide equipment as specified in **407.04** through **407.08**.

If using recycled mix, modify the asphalt plant as approved by the Engineer to accommodate the addition of asphalt planings. If using a batch plant to produce recycled mix, heat the aggregate to a temperature that will transfer sufficient heat to the cold planings to produce a mix of uniform temperature within the specified range.

CONSTRUCTION REQUIREMENTS

307.05 General

Conform to the construction requirements specified in **407.09**, and **407.11** through **407.17**.

307.06 Preparing the Subgrade, Sub-base, or Surface

The Plans will indicate whether the plant-mixed base is to be constructed on a treated or untreated subgrade or sub-base, on a granular base, or on an existing surface. Ensure that the surface upon which the plant mix base is to be constructed meets **205**, **207**, **302**, **303**, **304**, or **309**, whichever is applicable. If shown on the Plans, condition the surface as specified in **407.10**. Condition existing mineral aggregate base as specified in **310**. Construct prime coat or tack coat, when shown on the Plans, as specified in **402** or **403**, respectively.

Only place bituminous plant-mix base mixture on a surface that is dry and free of loose particles and other undesirable materials.

307.07 Thickness and Surface Requirement

Control thickness during the spreading operation by frequently measuring the freshly spread mixture to establish a relationship between the uncompacted mixture and the completed course. Thickness or spread rate in pounds per square yards shall be within reasonably close conformity with that shown on the Plans. Each course shall have a thickness after compaction of not more than 4 inches, unless otherwise approved by the Engineer.

The surface of the base shall meet the requirements specified in **407.18**, and when tested in accordance with **407.18**, the deviation of the surfaces from the testing edge of the straightedge shall not exceed the amounts specified in Table 307.07-1.

Table 307.07-1: Maximum Surface Deviation

Mixture	Maximum Deviation (inches)
Grading A, ACRL, and AS	1/2
Grading B, BM, BM2, C, CS, and CW	3/8

COMPENSATION

307.08 Method of Measurement

The Department will measure Mineral Aggregate, including Mineral Filler when required, and Asphalt Cement for Bituminous Plant Mix Base and other related items in accordance with **407.19**.

307.09 Basis of Payment

The Department will pay for accepted quantities at the contract prices in accordance with **407.20**.

For bidding purposes, use the asphalt cement content specified in Table 307.09-1 for the designated mix.

Table 307.09-1: Asphalt Cement Content

Mix Type	Asphalt Content
307 A	4.0%
307 AS	3.5%
307 ACRL	3.5%
307 B	4.3%
307 BM	5.0%
307 BM2	5.0%
307 C	5.0%
307 CW	6.0%
307 CS	6.5%

If the Engineer sets an asphalt content other than that specified in Table 307.09-1, the Department will calculate a price adjustment, based on the asphalt content set by the Engineer and the Monthly Bituminous Index for the specific grade asphalt on the mix design, in accordance with **407.20**.

SECTION 313 – TREATED PERMEABLE BASE

DESCRIPTION

313.01 Description

This work consists of constructing treated permeable base, composed of either a mixture of aggregate, Portland cement, and water, or a mixture of aggregate with asphalt binder, on a prepared sub-base. The Contractor may use either cement treated or asphalt treated permeable base.

MATERIALS

313.02 Materials

Provide materials as specified in:

Portland Cement, Type I **901.01**
Aggregate for Portland Cement Treated Mixture **903.03**
Aggregate for Bituminous Treated Mixture **903.06**
Asphalt Cement, Grade PG 64-22, 70-22, 76-22, 82-22 .... **904.01**
Liquid Membrane – Forming Compounds **913.05**
Water **921.01**

313.03 Composition of Mixtures

A. Portland Cement Treated Permeable Base

In accordance with **604**, submit a concrete mix design, meeting the requirements specified in Table 313.03-1, to the Engineer for approval.

Table 313.03-1: Mix Design Properties

Property	Value
Water-Cement Ratio	0.43 (approximately)
Portland Cement Content	$\geq$ 282 lbs/yd^3
Compressive Strength at 7 days (AASHTO T 22)	$\geq$ 500 psi

B. Bituminous Treated Permeable Base

Asphalt treated permeable base shall be Bituminous Plant Mix Base (Hot Mix) as specified in **307** and **407**. Use liquid asphalt at the rate of 3% by weight of the total mixture. Asphalt content shall be such that all aggregate is visibly coated. Submit a mix design to the Engineer for approval as specified in **407.03**.

EQUIPMENT

313.04 Equipment

To construct Portland cement treated base, provide equipment meeting **501.04.A** and **501.04.B**.

To construct bituminous treated base, provide equipment meeting **407.04** through **407.08**.

The spreading equipment shall meet either **501.04.D.11** or **407.06**.

CONSTRUCTION REQUIREMENTS

313.05 Construction Requirements

Construct cement treated permeable base and asphalt treated permeable base as specified in **309** and **307** respectively, unless otherwise specified below.

A. Cement Treated Permeable Base

1. **Consolidation and Finishing.** Immediately after placing the cement treated permeable base, compact the mixture using a steel wheel roller weighing not less than 6 tons. Continue rolling until maximum densification is achieved; immediately cease rolling if aggregate breakage occurs. Do not use vibratory rollers. Instead of using a steel wheel roller, the Contractor may place the cement treated permeable base with a high-density screed with dual tamping bars.

2. **Curing.** Immediately after spreading and compacting operations, cover the entire surface and exposed edges of the cement treated permeable base with transparent or white polyethylene sheeting as specified in **501.18**, or a white pigmented wax base curing compound meeting AASHTO M 148.

   Use polyethylene sheeting having a thickness of at least 4 mils, and hold the sheeting in place for a minimum of 7 days using a method approved by the Engineer. Before placing the sheeting, thoroughly wet the surface of the cement treated permeable base.

   Place wax-based curing compound at a rate of 0.04 to 0.05 gallons per square yard.

B. Asphalt or Cement Treated Permeable Base

From the time of placement until placement of the following pavement layer, protect the treated permeable base from severe weather conditions, particularly freezing rain, snow, and icing, and from contamination by dust, dirt, mud, or other fine grained material. Remove and replace, at no additional cost to the Department, all portion(s) of the treated permeable base that become contaminated to the extent that drainage is reduced or inhibited.

Do not allow traffic on the treated permeable base, with the exception of equipment required to place the following layer of pavement, provided that it enters and exits as near as possible to the paving operation. Repair damage to the treated permeable base caused by the Contractor’s equipment at no additional cost to the Department.

313.06 Limitations

If using asphalt treated permeable base, adhere to the limitations specified in **407.09**. Do not place any treated permeable base that cannot be covered by the next course of pavement within the same construction season.

313.07 Surface Requirements

The Department will test the finished surface of the treated permeable base with a 12-foot straightedge in both transverse and longitudinal directions. The finished surface shall be uniform and shall not vary by more than 1/2 inch from the lower edge of the straightedge. If the tested surface varies by more than 1/2 inch, adjust the surface to a new grade, as established by the Engineer, as follows:

1. Fill the low areas with Portland cement concrete during the concrete paving operation, or

2. Apply emulsified asphalt, RS-2, at a rate not to exceed 0.2 gallons per square yard, as determined by the Engineer, over the specified low areas, and fill the low areas with No. 8 mineral aggregate. Seat the size No. 8 mineral aggregate with a pneumatic tire roller.

313.08 Tolerance in Pavement Thickness

Place treated permeable base to the thickness designated on the Plans. Before beginning any further work, take core samples from the treated permeable base, at locations established by the Engineer, in accordance with **501.24** for verification of base thickness. Take core samples at locations determined and witnessed by a Department representative, and document on the appropriate form.

The Department will make adjustments to the contract unit price in accordance with **501.26** if the base thickness is determined by the Engineer to be deficient.

COMPENSATION

313.09 Method of Measurement

The Department will measure treated permeable base by the square yards complete in place for the width and thickness specified.

313.10 Basis of Payment

The Department will pay for accepted quantities at the contract prices as follows:

Item	*Pay Unit*
Treated Permeable Base	Square Yard

The Department will adjust payment in accordance with **501.26.B** for all base found to be deficient in thickness by more than 1/4 inch. The Department will not make additional payment over the contract unit price for base that has an average thickness in excess of that shown on the Plans.

If the Department orders any increase or decrease in the cement content of the Cement Treated Base from the approved mix design, the measurement and payment for this change will be computed in accordance with **501.25** and **501.26**.

The Department will consider the cost of taking cores for verification of pavement thickness to be included in the contract unit price of treated permeable base.

The Department will not allow additional compensation for leveling of the treated permeable base except on ramps that contain 4,500 square yards or less of Portland cement concrete pavement. The Department will measure and pay for additional concrete used on these ramps in accordance with **501.25** and **501.26**.

SECTION 407 – BITUMINOUS PLANT MIX PAVEMENTS (GENERAL)

DESCRIPTION

407.01 Description

This Section 407 is applicable to all types of bituminous pavements of the asphalt plant mix type as described in **307**, **313**, and **411**. Deviations from these general requirements will be indicated in the specific requirements for each pavement type.

This work consists of constructing one or more courses of bituminous mixture on a prepared foundation in accordance with this Section **407** and the specific requirements of the pavement type under contract.

MATERIALS

407.02 Materials

Provide materials as specified in:

Aggregates	**903**
Mineral Filler	**903.16**
Bituminous Materials	**904**
Chemical Additive	**921.06.B**

Separate aggregate into coarse and fine aggregate stockpiles. If stockpiling of coarse aggregate causes segregation, separate into coarse and medium coarse stockpiles.

Store each size and type of aggregate in a separate pile, bin, or stall. Maintain the storage yard in an orderly condition, clearing a walkway between stockpiles that are not separated by partitions. Make the stockpiles readily accessible for sampling.

The Engineer will conditionally accept the mineral aggregate for quality in the stockpile at the producer's site. The Engineer may conditionally accept the bituminous material at the asphalt terminal. The Engineer will accept for aggregate gradation and asphalt cement content from hot bin samples or sample(s) taken from the completed mix at the asphalt plant after it has been loaded onto the trucks for transport to the Project.

If anti-stripping additive, other than hydrated lime, meeting **921.06.B.1** is required, use approved in-line blending equipment, as specified in **407.04.A.6**, to add it at the mixing plant or inject it at the asphalt terminal.

If the resurfacing plans call for a Performance Grade (PG) asphalt mix with properties greater than that of PG 64-22 and this is the only asphalt grade on the Project, the Contractor may use either the asphalt grade shown on the Plans or an asphalt grade equal to or better than PG 64-22 for driveways and business entrances unless otherwise directed by the Engineer. The Department will pay for this material at the same unit price as bid for the asphalt or asphalt mix. Mark the material tickets "**FOR DRIVEWAYS AND BUSINESS ENTRANCES ONLY**" at the point of delivery.

If using a warm mix asphalt additive meeting **921.06.B.3**, use approved blending equipment to add it at the mixing plant, or deliver it premixed with the asphalt cement.

For 411-OGFC mixtures, include a stabilizing additive listed on the Department's Qualified Products List (QPL). Do not use fiber pellets. Slag wool fiber or cellulose fiber shall be blown into the asphalt plant measured by a flow meter or sensing device that is accurate to within ±10% of the amount required. For batch plants, add fibers in to the pugmill or weigh hopper. For drum plants, place the fiber line 1 foot upstream of the asphalt binder line so that the fibers are captured by the asphalt binder before being exposed to high-velocity gases in the drum. The minimum additive for a slag wool fiber shall be 0.4% and the minimum for a cellulose fiber shall be 0.3% of the total mix. The addition of a stabilizing additive material (fiber) shall be included in the cost of the asphalt cement.

407.03 Composition of Mixtures

A. General

Develop a bituminous mixture composed of aggregate (coarse, fine, or mixtures thereof), mineral filler if required, anti-strip additive if required, and bituminous material. Ensure that the aggregate fractions are sized, uniformly graded, and combined in such proportions so that the resulting mixture will meet the grading and physical properties of the approved Job Mix Formula (JMF).

B. Gradation and Bituminous Material Requirement

The requested aggregate gradation and bituminous material percentages shown on the JMF shall be within the design ranges specified in **903**, **307**, and **411**, respectively. Establish a recommended asphalt cement content for all mixes, with the final optimum asphalt cement content to be determined by the Engineer.

C. Job Mix Formula (JMF)

1. **General.** At least 14 working days before the scheduled start of production of any asphaltic paving mixture, submit a proposed Job Mix Formula (JMF) and Laboratory Design in electronic form,

where applicable, prepared in accordance with the Marshall Method of Mix Design (Asphalt Institute, MS-2), as modified by the Department, or by Gyratory Compaction (AASHTO T 312). Regardless of which method is used, prepare trial blends with at least four different asphalt contents (at least two above the optimum and two below the optimum).

When using the Marshall method of compaction, compact the specimens to 75 blows per side. When using the gyratory method of compaction, compact specimens to 65 gyrations.

All 411-OGFC design procedures shall follow the most current version of National Asphalt Pavement Association (NAPA) Publication IS-115, "Design, Construction and Maintenance of Open-Graded Friction Courses" except where modified herein. Design the OGFC using a Marshall compaction hammer at 50 blows or a standard gyratory compactor at 50 gyrations.

Provide the following information with JMF submittals:

a. The specific project on which the mixture will be used.

b. The source and description of all materials to be used in the mix.

c. The gradations and approximate proportions of the raw materials as intended to be combined in the paving mixture.

d. A single percentage of the combined mineral aggregate passing each specified sieve. Plot the combined aggregate gradation on a gradation chart with sieve sizes raised to the 0.45 power to ensure a well graded mix.

e. The Loss on Ignition (L.O.I.) results on the combined aggregate of the mixture used as a wearing course.

f. The Bulk Specific Gravity, Apparent Specific Gravity, and absorption on the combined mineral aggregate in the paving mixture (AASHTO T 84 and T 85)

g. The fractured face count and glassy particle count of the plus No. 4 material, if applicable.

h. A single percentage of asphalt by weight of total mix intended to be incorporated in the completed mixture.

i. The dosage rate and source of anti-stripping additive, if required, meeting the requirements of **921.06.B.1**, to be added to the asphalt.

j. The maximum specific gravity of the asphalt mixture (AASHTO T 209).

k. A single temperature at which the mixture is intended to be discharged from the plant.

l. Evidence that the completed mixture will conform to all physical requirements specified in **903.06** and **307.03.A** or **903.11** and **411.03.B**; however, for mixes designed according to AASHTO T 312, the stability and flow requirements will be waived and the resistance to rutting requirements for surface mixtures must be met.

m. The tensile strength ratio (TSR) indicating the stripping and moisture susceptibility characteristics of the mix.

n. To identify critical mixes and make appropriate adjustments, the mix design shall meet the required design properties for stability, flow, voids in mineral aggregate (VMA), and production void content as specified in **307.03** and **411.03** at the bitumen content range of Optimum Asphalt Cement ±0.25%.

Establish the laboratory mix and compaction temperatures for the JMF in accordance with Table 407.03-1.

Table 407.03-1: Laboratory Mix and Compaction Temperatures

PG Binder Grade	Lab Mix Temperature (°F)	Lab Compaction Temperature (°F)
64-22, 67-22	Per temp./visc. chart	Per temp./visc. chart
70-22	320 – 345	295 – 320
76-22	320 – 345	305 – 330
82-22	320 – 345	305 – 335

Perform any additional laboratory testing of the mix using the laboratory mix and compaction temperatures listed on the approved JMF, with a tolerance of ± 5 °F for each temperature.

A Certified Laboratory Technician shall prepare and sign the Laboratory Design. To be certified, the technician shall have completed the Marshall Method of Mix Design School conducted by the Department, including the written and lab performance testing.

2. **Revision of Job Mix Formula.** The approved JMF shall remain in effect until the Engineer authorizes a change in writing. The Contractor, at any time after construction has started, may request that the JMF be revised, provided evidence is shown that the revision is necessary and the revised aggregate gradation will meet all applicable gradation requirements.

   Submit a revised JMF if, during the test strip construction and mix design/production verification procedure, changes are made to the mixture to comply with the specified criteria.

   Provide a new design for any change in source of materials.

   Submit all requests for design mix adjustments, redesigns, and new design mixes in writing to the Engineer for approval.

3. **Resistance to Plastic Flow.** Include, with the submitted JMF, test data showing that the material as produced will meet **307.03.A** or **411.03.B** when tested according to AASHTO T 245. Determine the bulk specific gravity of the laboratory compacted bituminous mixture (Marshall specimens) according to AASHTO T 166.

Mixes designed according to AASHTO T 312 are exempt from AASHTO T 245.

For surface mixtures used on roads with greater than 5,000 ADT, designed with the gyratory compactor (AASHTO T 312), include sufficient raw materials (aggregate and asphalt cement) with the submitted JMF so that the Central Laboratory may conduct rut testing in accordance with AASHTO T 340. The maximum allowable rut depth shall be 0.35 inches for roads with greater than or equal to 10,000 ADT and 0.40 inches for roads with 5,000 to 10,000 ADT.

Base the percent voids in the total mix on the maximum specific gravity of the bituminous mixture (Rice Gravity) according to AASHTO T 209. Calculate the voids in mineral aggregate (VMA) using the effective specific gravity of the aggregates.

D. Contractor's Quality Control

1. **General.** Assume responsibility for the quality of construction and materials incorporated in the Work. Provide and maintain a quality control system that will provide reasonable assurance that all materials conform to specification requirements.

   Conduct all quality control sampling and testing according to the approved Quality Control Plan and the Department's Policies on Sampling and Testing Procedures and Sampling of Asphalt Mixes for Verification of Laboratory Design. The requirements for the Contractor's quality control sampling and testing will remain in effect until final Project acceptance.

2. **Contractor Quality Control System.** Develop, implement, and maintain a quality control system that will provide reasonable assurance that all materials and products submitted to the Department for acceptance conform to the specified requirements.

   a. **Quality Control Technician.** Ensure that a Quality Control Technician, who is currently certified by the Department as a Certified Asphalt Plant Technician, is present at the asphalt plant during mix production. If the Department finds that the Quality Control Technician cannot perform as required by the position, the Department will revoke the certification and require replacement with a certified technician.

b. Documentation. Document all quality control procedures, inspections, and tests and make this information available for review by the Department throughout the life of the Contract. Maintain adequate records of all inspections and tests. The records shall indicate the nature and number of tests performed, the number and type of deficiencies found, and the nature of corrective action taken as appropriate.

The Contractor's documentation procedures will be subject to the review and approval of the Department before the start of the work and to compliance checks during progress of the work. Provide copies of all charts and records documenting quality control tests and inspections to the Engineer on a daily basis.

c. Charts and Forms. Record all conforming and nonconforming inspections and test results on approved forms and charts, and keep these records current and complete. Maintain test results at the Contractor's plant site laboratory and make such records available to the Engineer at all times during the performance of the work. Chart test results for the various materials and mixtures on forms that meet the Engineer's requirements. Provide an example of each proposed chart and form to the Engineer. Supply all charts and forms to be used to record results.

d. Corrective Actions. Promptly correct all errors, equipment malfunctions, process changes, or other assignable causes that have resulted or could result in the submission of materials, products, and completed construction that do not conform to the specifications.

If the Engineer finds that the Contractor is not controlling its process and is making no effort to take corrective actions, the Engineer will require that plant operations be ceased until the Contractor can demonstrate that it can and will control the process.

e. Laboratories with Measuring and Testing Equipment. Provide a fully equipped laboratory at the production site as specified in **106.06**. This facility may be permanent or portable. Furnish the laboratory with the necessary testing equipment and supplies for performing Contractor Quality

Control sampling and testing as well as Department Acceptance sampling and testing. To assure accuracy, the Department will check the testing equipment periodically according to the Department's Procedure for Qualified Laboratories.

f. **Sampling and Testing.** Sampling and testing methods and procedures to determine quality conformance of the materials and products shall be in accordance with **106.04**. Address in the Quality Control Plan the taking of samples for material characteristics and the plotting of the test results on control charts.

g. **Alternative Procedures.** The Engineer may approve the use of alternative sampling methods, procedures, and inspection equipment if such procedures and equipment provide, as a minimum, the quality assurance required by the Contract. Before applying such alternative procedures, describe them in a written proposal and demonstrate, for the Engineer's approval, that their effectiveness is equal to or better than the Contract requirements.

h. **Mix Design/Production Verification.** After the JMF has been approved, provide material that conforms to the approved JMF within the acceptance range specified in Table **407.20-2**. Consider the process to be out of control and cease plant operations if test results from a lot fall below the 90% pay factor limit for the values specified in Table **407.20-2**. The Contractor may resume plant operations upon demonstrating that it can and will control the process.

Sample and test asphaltic concrete base and surface mixes throughout production to verify that the mix being produced is within the criteria specified in Table 407.03-2. Also record such information on control charts. Note that this requirement applies only to mixes designed according to the Marshall Method of Mix Design.

With the exception of any individual mix of 1,000 tons or less, meet the requirements specified in Table 407.03-2 for all interstate projects, any project with a current Average Daily Traffic (ADT) exceeding 12,000, and any project utilizing modified asphalt cements.

Table 407.03-2: Mix Design Requirements

Property	Value
Maximum Theoretical Gravity	± 0.025 of Mix Design Value
Voids in Total Mix	As noted for production in **307.03** and **411.03**
Voids in Mineral Aggregate	Minimum as noted in **307.03** and **411.03**
Marshall Stability	Minimum as noted in **307.03** and **411.03**
Dust/Asphalt Ratio	As noted in **307.03** and **411.03**

The asphalt pavement mix design/production verification procedure shall consist of the following:

(1) Submit mix designs to the Engineer for approval before mix production. Once approved, produce sufficient mix to construct a test strip as specified in **407.15.C**.

(2) Perform maximum theoretical gravity and gradation tests from material produced for constructing the test strip. A Quality Control Technician, who is currently certified by the Department as a Certified Asphalt Mix Design Technician, shall perform these tests under the Engineer's observation.

(3) Place no more than 500 tons of mix until the verification testing, with the exception of TSR, is complete. Without complete test results, the Contractor, at its risk, may continue to produce and place mixture in excess of the first 500 tons; however, all mixture will be subject to price adjustment or removal at the discretion of the Engineer if the test results do not comply with the specifications.

If the test results for the produced mix are within the limits required for production, as specified in Table 407.03-2, and mix density requirements are met, the Contractor may proceed.

If not, prepare a revised design before start up and submit to another evaluation process for the revised design. Place no more than 100 tons of mix during this trial. Repeat this process until an acceptable mix can be produced. All test strip and mixture design/production verification material will be subject to applicable price adjustments or removal at no cost to the Department. If the tensile strength ratio (TSR) results are not in compliance with the specifications, immediately stop production until mixture adjusts are made.

(4) During construction, perform verification testing, for each half-day's production, for mix quality control. Use a random numbers table to determine when to collect samples for testing.

(a) When the test results are outside the allowable criteria, immediately obtain a subsequent sample and test it for compliance.

(b) If the subsequent test results are within allowable limits, the Contractor may continue mix production.

(c) If the subsequent test results are outside allowable limits, do not resume mix production until it can be demonstrated to the Engineer that adequate corrective action has been taken. The Contractor may then produce sufficient mix, not to exceed 100 tons, to provide a representative sample for determining stability, voids in the total mix, and the dust/asphalt ratio. Do not continue with mix production until test results indicate compliance with Table 407.03-2 and the specified density.

3. Quality Control Plan. At the beginning of each paving season, submit in writing the proposed Quality Control Plan for the Engineer's approval. Include in this plan the sampling, testing, and inspection activities, and the anticipated frequencies of each, which the Contractor will follow to maintain process control. This Quality Control Plan shall apply to all Department contracts for the calendar year. If a change is made to the Quality Control Plan during the year, communicate such changes to the Regional Materials Supervisor. Refer to the recommended series of sampling, testing, and inspecting activities shown in Table 407.03-3.

Table 407.03-3: Recommended Items for a Contractor Quality Control Plan

A. All Types of Plants

1. Stockpiles
   a) Determine gradation of all incoming aggregates.
   b) Inspect stockpiles for separation, contamination, segregation, etc.
   c) Conduct a fractured face count when gravel is used as coarse aggregate.
   d) Determine the percent of glassy particles in slag coarse aggregate.
   e) Determine gradation and asphalt content of reclaimed asphalt pavement when used as a component material.

2. Cold Bins
   a) Calibrate the cold gate settings.
   b) Observe operation of cold feed for uniformity.
   c) Ensure that bins have proper dividers to prevent materials from spilling over into adjacent bins.

3. Dryer
   a) Observe pyrometer for aggregate temperature control.
   b) Observe efficiency of the burner.
   c) Determine the percent dust coating on plus 4 material.
   d) Check dried aggregate for contamination due to incomplete combustion of fuel.

4. Hot Bins
   a) Determine gradation of aggregates in each bin.
   b) Determine theoretical combined grading.

5. Bituminous Mixture
   a) Determine percent bitumen.
   b) Determine mix gradation.
   c) Check mix temperature.
   d) Determine percent moisture in mix when reclaimed

asphalt pavement is a component material. e) Determine Loss-On-Ignition (LOI) of aggregates in mix where applicable. f) Check the mix for uncoated aggregate. g) Ensure that handling procedures do not contribute to segregation of the mix.
B. Batch Plants 1. Batch Weights – Determine percent used and weight to be pulled from each bin to assure compliance with the JMF. 2. Check mixing time (both dry and wet). 3. Check operations of weigh bucket and scales. 4. Document accuracy of all weighing and metering devices for: a) Asphalt cement b) Aggregate c) Anti-strip additive
C. Drum Mixer Plant 1. Calibrate the cold feed and prepare a calibration chart for each cold gate. 2. Develop information for the synchronization of the aggregate feed and the bituminous material feed. 3. Determine moisture content of aggregate being fed into dryer. 4. Determine the percent dust coating on dried plus 4 material. 5. Check dried aggregate for incomplete combustion of fuel. 6. Document accuracy of all weighing and metering devices for: a) Asphalt cement b) Aggregate c) Anti-strip additive

Consider the activities identified in Table 407.03-3 to be normal activities necessary to control the production of asphalt concrete at an acceptable quality level. However, note that depending on the type of process or materials, some of the activities listed may not be necessary, and in other cases, additional activities may be required. The frequency of these activities will also vary with the process and the materials. When the process varies from the defined process average and variability targets, increase the frequency of these activities as necessary to restore proper conditions.

Plot and keep up-to-date control charts for all Quality Control Sampling and Testing. Provide control charts for the following:

(a) Extracted asphalt content

(b) Mix gradation

(c) Dust to asphalt ratio

(d) Maximum theoretical gravity (when required)

(e) Voids in total mix (when required)

(f) Stability (when required)

Post all current control charts in the asphalt lab where they can be seen.

The Contractor is responsible for formulating all design mixes with the exception of plant mix seal coat mixes. No lab design is required for **307** Grading A, AS, and ACRL mixes. However, establish the anti-strip additive dosage rate and verify compatibility of mixture materials by the ten minute boil test as specified in **407.03.E.2**. Submit all Contractor-furnished design mixes to the Department for approval prior to their use. Provide process control of all materials during handling, blending, mixing, and placing operations.

If reclaimed asphalt pavement (RAP) is approved for use as a component material in a hot bituminous mixture, the Contractor's Quality Control Plan shall include determination of the gradation and asphalt content of the RAP material at a minimum frequency of 1 stockpile sample per 2,000 tons used in the mixture.

E. Testing Procedures

Conduct the Tensile Strength Ratio (TSR), Stripping, and Loss on Ignition (LOI) testing in accordance with the following:

1. **Tensile Strength Ratio.** Perform testing for stripping and moisture susceptibility of the mixture according to ASTM D 4867, Standard Test Method for Effect of Moisture on Asphalt-Concrete Paving Mixtures (Root-Tunnecliff Procedure).

   Specimen tested for stripping and moisture susceptibility according to Root-Tunnecliff Procedures shall meet the criteria specified in Table 407.03-4.

Table 407.03-4: Criteria for Stripping and Moisture Susceptibility

Asphalt Cement	Minimum Tensile Strength	Minimum TSR
Polymer Modified	100 psi	80%
Non-Polymer Modified	80 psi	80%

2. **Ten Minute Boil Test (Stripping)**

   a. **Field Test.** Test the completed mix for stripping at the asphalt plant as follows:

      (1) From a sample of the completed mix, visually select a minimum of 50 grams of the plus No. 4 material and place immediately in boiling water.

      (2) Continue to boil for 10 minutes, pour off water, and place coated aggregate on a paper towel.

      (3) Perform a visual inspection to verify that the coated aggregate shows no evidence of stripping.

   b. **Laboratory Test.** Determine the dosage rate for anti-stripping additive in the laboratory as follows:

(1) Wash and surface dry 50 grams of the mineral aggregate passing the 1/2-inch sieve and retained on the No. 4 sieve.

(2) Thoroughly coat the selected aggregate with the blend by stirring the mixture heated to 250° F.

(3) Immediately place the material in boiling water.

(4) Continue to boil for 10 minutes, pour off water, and place coated aggregate on a paper towel.

(5) Perform a visual inspection to verify that the coated aggregate shows no evidence of stripping.

3. **Test for Percent Loss on Ignition (LOI) of the Mineral Aggregate in an Asphalt Paving Mixture.**. Conduct Loss on Ignition Testing as follows:

   a. Obtain a representative aggregate sample and weigh approximately 600 grams into an assayer's fire clay crucible that has been ignited to constant weight. Place a cover on the crucible to prevent pop-out of aggregate while heating.

   b. Ignite the covered crucible and its contents in a muffle furnace at 1742° F to constant weight (minimum of 8 hours).

   c. Cool the crucible and contents to room temperature and weigh.

   If the aggregate sample is obtained by extraction with a vacuum extractor, correct the weights before and after ignition for filter aid using the following equation:

$$\text{Percent loss on ignition} = \frac{(\text{A} - \text{B}) \times 100}{\text{A}}$$

   Where:

   A = weight of sample before ignition (corrected for filter aid)
   B = weight of sample after ignition (corrected for filter aid)

EQUIPMENT

407.04 Bituminous Mixing Plant

Provide sufficient storage space for each size aggregate. Keep the different sizes separated until they have been delivered to the cold elevator or belt feeding the dryer. Maintain the storage yard in a neat and orderly condition and ensure that the separate stockpiles are readily accessible for sampling.

Plants used to prepare bituminous mixture shall meet all requirements specified in **407.04.A**. In addition, batch mixing plants shall meet **407.04.B**, continuous mixing plants shall meet **407.04.C**, and dryer-drum mixing plants shall meet **407.04.D**.

A. Requirements for All Plants

Mixing plants shall be of sufficient capacity and so coordinated to adequately handle the proposed bituminous construction.

1. **Equipment for Preparing Bituminous Material.** Provide tanks that are equipped to heat and hold bituminous material at the required temperatures. The circulating system for the bituminous material shall be designed to ensure proper and continuous circulation during the operating period. Make provisions for measuring and sampling the storage tanks' contents.

2. **Feeders for Dryer.** For each size aggregate, provide separate feeders that can deliver the aggregates onto the belt going to the dryer in proper proportions. Use mechanical feeders with separate adjustable gates to feed each size aggregate onto the belt.

   Provide adequate means to ensure a constant and uniform flow of material from each bin. Equip bins containing fine aggregate with vibrators if necessary.

   Do not blend or mix different aggregates, or different sizes of the same aggregates, with clam shells, bulldozers, high lifts, or similar equipment.

   Feed the aggregate into the dryer so as to obtain a uniform production and uniform temperature.

3. **Dryer.** The plant shall include a dryer or dryers that are capable of:

   a. agitating the aggregate continuously during the heating and drying process;

   b. heating and drying all aggregates to the temperature required, and

   c. supplying the mixing unit continuously at its operating capacity.

   Ensure that dryers are constructed and operated so that aggregates will not be contaminated with unburned fuel.

4. **Screens.** Provide plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the mixer's full capacity.

   The Contractor may allow a consistent carry-over, not to exceed 20%, on any screen. If any bin contains more than 20% of material that is undersized for that bin, empty the bin and correct the cause of this condition.

   Provide approved scalping screens on all dryer-drum mixing plants; additional screens will not be required.

5. **Bins.** Provide storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Arrange bins to ensure separate and adequate storage of appropriate fractions of the mineral aggregates. For each bin, provide overflow pipes of the size and at the location needed to prevent material from backing up into other compartments or bins. Provide each compartment with an outlet gate constructed so that, when closed, no leakage occurs. The gates shall be cut off quickly and completely. The bins shall be constructed to provide adequate and convenient approved facilities for obtaining representative samples of aggregate from the full flow of each compartment. These bins are not required in an approved Dryer-Drum Mixing Plant. When using mineral filler, provide separate dry storage and equip the plant to uniformly and accurately feed the filler into the mixer.

6. **Bituminous Control Unit and Anti-Stripping Additive (ASA) Systems.** Provide means for weighing or metering the bituminous material to ensure the proper amount of material is added to the mix within the tolerance specified. Provide means for checking the quantity or rate of flow of bituminous material into the mixer.

   Where required, use approved in-line blending equipment to add anti-stripping additive, other than hydrated lime, meeting **921.06.B**. Provide a storage tank for the ASA that can maintain a constant temperature without overheating the additive. Store the additive according to the manufacturer's recommendations and at a temperature of 150 ºF or less. The in-line blending equipment on drum plants shall have a totalizing "flow meter" capable of measuring the actual flow rate within the production range of 0.00 to 1.00 gallons per minute at increments of 0.05 gallons. Batch plants shall have a totalizing flow meter that displays the total gallons of material dispensed. The dispenser and/or pumps shall be capable of adding the heat stable ASA within a tolerance of 10% of the specified rate.

7. **Thermometric Equipment.** Fix an armored thermometer, capable of reading an adequate temperature range, in the bituminous feed line at a suitable location near the charging valve at the mixer unit.

   At the discharge chute of the dryer, also place an approved thermometric instrument that can register automatically or indicate the temperature of the heated aggregates. With the Engineer's approval, the Contractor may place the thermometric instrument within the fines bin.

   Equip the plant with an approved automatic recording and regulating apparatus to control the temperature of the aggregates.

8. **Dust Collector.** Equip the plant with a dust collector constructed to uniformly waste or return to the dried aggregate all or any part of the material collected. Handle collected baghouse fines intended for recirculation into the mix as if it were mineral filler or feed by another suitable method approved by the Engineer. Provide means to calibrate and adjust the dust fed from a baghouse.

9. **Safety Requirements.** Provide adequate and safe stairways to the mixer platform and sampling points. Place guarded ladders to other plant units at all points requiring access to plant operations. Provide access to the top of truck bodies by a platform or other suitable device to allow the Engineer to obtain samples and mixture temperature data. Provide a hoist or pulley system to raise scale calibration equipment, sampling equipment, and other similar equipment from the ground to the mixer platform and return. Guard and protect all gears, pulleys, chains, sprockets, and other dangerous moving parts. Provide ample and unobstructed space on the mixing platform. Maintain a clear and unobstructed passage at all times in and around the truck loading area. Keep this area free of drippings from the mixing platform.

10. **Field Laboratory.** Provide a Type B field laboratory as specified in **106.06**.

11. **Surge and Storage Systems.** The Contractor may use surge and storage systems if the Department approves each system before use, and if the systems are designed to limit differences between material discharged from the bin or silo and material discharged directly from the plant.

    Equip the surge bins and storage silos with low and high mix level indicators. Place the low level indicator at a location on the bin or silo that has been predetermined to prevent segregation of the mix.

    Arrange the conveyor system used with the surge bins or storage silos so that samples of the mix or dry material may be conveniently taken.

    Ensure that storage silos are closed, insulated, and heated so as to prevent localized heating. The storage silo shall be capable of being sealed to prevent oxidation of the mixture. Equip surge bins with a rain cover capable of preventing water from entering the mix in the bin.

    The Engineer will base approval of a surge or storage system on inspection and tests that indicate that the system is capable of conveying, retaining, and delivering the bituminous mixture:

    a. Within the tolerance ranges as set forth on the JMF;

b. Without segregation; and

c. Without balling or hardening.

The Engineer may withdraw approval of a surge or storage system if tests, inspections, or both indicate that the system is having a detrimental effect on the bituminous mixture.

The Engineer will reject bituminous mix found to be damaged in any way by the use of a surge or storage system.

Mount, under the loading hopper, platform truck scales that meet the requirements of **109** and that are capable of recording tare and gross weights.

12. **Warm Mix Asphalt Process Equipment.** The Contractor may modify plants to reduce production and placement temperatures as specified in **407.11.B**. Obtain the Department's approval before making plant modifications for warm mix asphalt production temperatures. Modifications shall not impair the plant's ability to maintain temperature control or mixture proportions.

    Ensure that modifications made to the plant to reduce mixing temperatures meet the requirements listed for warm mix asphalt additives in the Department's Qualified Products List (QPL).

B. Requirements for Batching Plants

1. **Plant Scales.** Provide dial scales for weighing of all aggregates and mineral filler, in the suspended weigh box. Dial scales shall be of a standard make and of sufficient size to allow the numerals on the dial to be read at a distance of 25 feet. The dials shall be of the compounding type having a full complement of index pointers. The value of the graduation of scales shall be as specified in Table 407.04-1.

Table 407.04-1: Graduation of Scales

Aggregate Amount (pounds)	Scale Graduation
< 5,000	≤ 5 pounds
5,000 to 10,000	≤ 10 pounds
> 10,000	≤ 0.1% scale capacity

Do not use pointers that give excessive parallax errors. Locate dial scales to be in plain view of the operator at all times. When bituminous material is measured by weight, equip the asphalt weigh bucket with a separate dial scale with a minimum graduation not greater than 2 pounds. All dial scales shall be accurate within a tolerance of 0.5%. Eliminate vibration by setting the scales on a separate foundation, if required. Provide each installation of scales with ten standard 50-pound weights meeting the requirements of the U.S. Bureau of Standards for calibrating and testing weighing equipment. Inspect scales as often as the Engineer deems necessary to ensure their continued accuracy.

Provide an approved automatic printer system that will print the weights of the material delivered, when the system is used in conjunction with an approved automatic batching and mixing control system. Provide a weigh ticket for each load as evidence of such weights.

2. **Weigh Box or Hopper.** Provide means for accurately weighing each size of aggregate and mineral filler in a weigh box or hopper suspended on scales. The weigh box or hopper shall be of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material can leak into the mixer while a batch is being weighed.

3. **Bituminous Control.** Provide a bituminous material bucket of a non-tilting type. The length of the discharge opening or spray bar shall be not less than 3/4 the length of the mixer, and it shall discharge directly into the mixer. The bituminous material bucket, its discharge valve or valves, and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drainable and all connections shall be so constructed that they will not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be at least 15% in excess of

the weight of bituminous material required in any batch. Provide the plant with an adequately heated, quick-acting, non-drip, charging valve located directly over the bituminous material bucket. If the bituminous material is metered, the indicator dial shall have a capacity of at least 15% in excess of the quantity of bituminous material used in a batch. The meter indicator dial shall have a scale with divisions measuring in gallons equivalent to a weight sensitivity of 0.04% of the total batch weight. The meter shall be accurate within a tolerance of 0.5%. The controls shall be capable of being locked at any dial setting and automatically resetting to that reading after the addition of bituminous material to each batch. The dial shall be in full view of the mixer operator. Automatically control the flow of bituminous material so that it will begin when the dry-mixing period is over. All of the bituminous material required for one batch shall be discharged in not more than 15 seconds after the flow has started. The size and spacing of the spray bar openings shall provide a uniform application of bituminous material the full length of the mixer. Provide the section of the bituminous line between the charging valve and the spray bar with a valve, and provide the spray bar with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

4. **Mixer.** Provide an approved twin pugmill type mixer, steam or hot oil jacketed, that is capable of producing a uniform mixture within the job mix tolerances and that is constructed to prevent leakage of its contents. Equip the mixer with a sufficient number of paddles or blades set in the "run around" order, and operate at such speed as to produce a properly and uniformly mixed batch. The depth of the material in the pugmill shall not be above the tips of the paddles. If not enclosed, equip the mixer box with a dust hood to prevent loss of dust.

   The clearance of blades from all fixed and moving parts shall not exceed 1 inch unless the maximum diameter of the aggregate in the mix exceeds 1-1/4 inches, in which case the clearance shall not exceed 1-1/2 inches.

5. **Control of Mixing Time.** Equip the mixer with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weigh box gate after the charging of the mixer until the closing of the mixer gate, at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry-mixing

period and shall lock the mixer gate throughout the dry and wet-mixing periods. The dry-mixing period is defined as the time interval between the opening of the weigh box gate and the start of introduction of bituminous material. The wet-mixing period is the time interval between the start of introduction of bituminous material and the opening of the mixer gate. The control of the timing shall be flexible and capable of being set at intervals of 5 seconds or less throughout a total cycle of up to 3 minutes. As a part of the timing device, install a mechanical batch counter that is designed to register only batches that have been mixed for the full time interval. Set the time intervals in the presence of and at the direction of the Engineer, who will then lock the case covering the timing device until a change is needed in the timing periods.

6. **Operator's Platform Observation House.** Equip the plant with a scale observer's house, mounted on or near the weigh platform and situated so that the aggregate and asphalt scales, asphalt thermometer, and pyrometer are plainly visible from within the house.

   Using approved materials, soundly construct the house to have at least 45 square feet of floor space and to be air conditioned by a unit of at least 12,000 Btu. The Contractor may install all batch controls in the house. However, do not use the house for storage or purposes other than to house the batch controls, plant operator, and Department Inspector. If choosing not to move the plant controls into the house, situate it so as to provide the scale inspector with a full view of the control panel.

   If the scale-observer's house is located on the asphalt plant, provide an adequate secondary means of escape in the event of fire or explosion.

   The Department will consider the house to be part of the plant and will not directly pay for its construction and maintenance.

C. Requirements for Continuous Mixing Plants

1. **Aggregate Proportioning.** Provide the plant with means for accurately proportioning each size of aggregate. The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for measuring volumetrically the material

drawn from each compartment. Equip bins with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock. Provide indicators for each gate to show the respective gate opening in inches.

Ensure that mineral filler can be fed into the mixer continuously and uniformly in the proportion set out in the JMF, and in a manner satisfactory to the Engineer.

2. **Weight Calibration of Aggregate Feed.** Equip the plant with an approved revolution counter that is in satisfactory working condition. Provide means to calibrate gate openings by weighing test samples. Make provisions so that materials fed out of individual orifices may be bypassed to individual test boxes. Equip the plants to handle individual test samples weighing not less than 200 pounds. Provide accurate scales to weigh such test samples.

3. **Synchronization of Aggregate Feed and Bituminous Material Feed.** Provide positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control may be achieved using mechanical means or any other positive method satisfactory to the Engineer.

4. **Mixer.** Provide a continuous mixer of an approved twin pugmill type, which is adequately heated and capable of producing a uniform mixture within the job mix tolerances. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate indicating the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Provide charts showing the rate of feed of aggregate per minute for the aggregate being used. Determine the mixing time by the weight method, using the following formula (with weights determined for the job using tests conducted by the Engineer) where:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in pounds}}{\text{Pugmill output in pounds per second}}$$

5. **Surge Hopper.** Equip the mixer with a discharge hopper with dump gates that will allow rapid and complete discharge of the mixture and of such size and design that no segregation of the mixture occurs.

6. **Platform Truck Scales.** Platform truck scales shall meet the requirements of **109**.

D. Requirements for Dryer-Drum Mixing Plants

1. **Control of Aggregate.** Stockpile and handle aggregates so as to prevent any significant amount of segregation, contamination, or degradation. Construct stockpiles as specified in **903.20**.

   Each aggregate shall have a separate feeder with a positive feed that can be easily and accurately calibrated. Provide a flow indicator and an audible warning device on each separate feeder to ensure a constant and uniform flow of aggregate from each bin onto the belt.

   Feed mineral filler, if required, into the mixer continuously and uniformly in the proportion set out in the JMF and in a manner approved by the Engineer.

2. **Synchronization of Aggregate Feed and Bituminous Material Feed.** Provide satisfactory means to allow a positive interlocking control between cold aggregate feed and asphalt. Base the control setting for the asphalt flow on the dry weight of the aggregate. Provide an acceptable method for proportioning asphalt flow as variations in aggregate flow take place. Provide a metering system to measure the flow of asphalt into the drum, and locate an approved method of checking and calibrating the metering system in the control house. Provide an automatic interlock system that will shut off the asphalt flow and the burner when the aggregate flow ceases.

3. **Temperature Control.** Provide dryer-drum mixing plants equipped with a recording pyrometer or other approved thermometric instrument sensitive to a rate of temperature change of not less than 10 °F per minute. The system shall be equipped with automatic burner controls and shall provide for temperature sensing of the bituminous mixture at discharge from the drum.

4. **Scales and Metering Systems.** Provide weights and charts for checking the accuracy of the belt scales and the bituminous metering system. The scales and meters shall be accurate within a tolerance of 0.5%.

   The belt scale that weighs the combined aggregate shall be in accordance with the National Institute of Standards and Technology Handbook 44.

5. **Sampling Devices.** Use an approved method for sampling individual cold feeds and sequential sampling of aggregate and asphalt under full scale production. The sampling device and procedures used shall be approved by the Engineer and shall not interrupt normal operation.

6. **Platform Scales.** Make certified platform scales available for checking the asphalt metering system and for weighing or checking loads of asphalt mix as specified in **109**.

7. **Silos or Surge Bins.** Provide surge bins or storage silos as specified in **407.04.A.11**. If a silo is not provided, use an approved surge bin capable of holding sufficient mix to allow the plant to operate at an efficient rate of production, and ensure the system is capable of conveying, retaining, and delivering the bituminous mixture so that it is within the JMF and without segregation. The Engineer will reject mix that is damaged in any way.

   The surge bin may include an approved weighing system. If a weighing system is included in the surge system, provide approved weights for checking the weighing system. Check the system in maximum increments of 5,000 pounds and in a minimum of 3 increments. Check the system through its entire weighing range to or above the maximum weight that is expected to be applied. The system shall be accurate within a tolerance of 0.5%.

   For surge bins that do not include a weighing system, mount platform truck scales meeting the requirements of **109** under the loading hopper.

8. **Aggregate Feed.** Proportion aggregate by feeding each size aggregate from a separate cold bin. The belt that delivers the aggregate shall have a load cell capable of registering the amount of flow from each individual bin on a readout in the control office;

alternatively, the Contractor may proportion the aggregate by a linear system based on measured RPM of each feeder belt at a constant gate opening to feed aggregate at a predetermined rate that is set in the control office and that has a readout in the control office. Ensure that the rate of feed as determined from the bin settings agrees with the load cell on the collection belt feeding the dryer within a tolerance of ±10%. If the predetermined tolerance is exceeded, an alarm shall sound, and if corrections are not made within 60 seconds, the plant shall automatically shut down. The aggregate feed system shall employ computer controlled adjustments to automatically produce mix of the correct proportions over the plant's entire range of production rates.

If the Engineer has previously calibrated and approved the plant for temporary manual operation, the plant may run for a period not to exceed 2 working days, or portions thereof, on manual should a computer breakdown occur.

9. **Electronic Data Retention.** The computer system and automatic weighing system shall include means to retain all electronic data during electrical power failures.

407.05 Hauling Equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds that have been thinly coated with a minimum amount of paraffin oil, hydrated-lime solution, or other approved material from the Department's QPL to prevent the mixture from adhering to the beds. Immediately after loading at the plant, cover each truck with a cover of canvas or other suitable material that is of sufficient size to protect the mixture from the weather. Allow the cover to lap down along the sides and rear of the truck bed a minimum of 6 inches, and use tie downs to secure the cover at a maximum of 5-foot spacing along the sides and rear of the truck bed. When necessary to ensure the mixture will be delivered on the road at the specified temperature, insulate truck beds and securely fasten the covers. Provide a 3/8-inch hole in the side of each truck bed for inserting a thermometer.

407.06 Bituminous Pavers and Material Transfer Devices

A. Pavers

Bituminous pavers shall be self-contained, power-propelled units provided with an activated screed, equipped to be heated, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the Plans. All paver extensions shall be full assembly extensions, including activated and heated screeds, auger extensions, auger guards, and throw-back blades to place mix beneath the auger gearbox. When augers are extended, the maximum distance from the augers to the end plate shall be 18 inches. Augers shall be within 4 feet of the end plate on trailing edge extendible screeds; however, if using bolt-on extensions, extend the augers a distance equal to the length of the bolt-on extensions. Do not use strike-off boxes, except on sections of continuously varying width. For shoulders less than 8 feet in width and similar construction, the Contractor may place materials using approved mechanical spreading equipment.

Equip the paver with a receiving hopper that has sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed.

The screed or strike-off assembly shall produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

Equip all asphalt paving machines with automatic grade and slope controls. Both the grade and slope controls shall be in working order at all times; however, if the automatic controls fail, the Contractor may finish the day's work using manual controls, but shall not resume work the following day until both the grade and slope controls are in first class working order.

The Engineer may allow the Contractor to pave the inside shoulder concurrently with the inside traffic lane, subject to the Engineer's approval of the price adjustment for the mix used on the shoulder and of the paving and rolling equipment. In addition, the paver shall have an articulated screed that can be adjusted to fit the pavement cross-section and a power unit capable of handling the increased loading without undue stress.

B. Material Transfer Devices (MTDs)

Provide a Material Transfer Device (MTD) capable of transferring the asphalt from the truck or trailer to the asphalt paver without coming in contact with the asphalt paver. Use a MTD when placing all asphalt mixes, including shoulder mixes, with the exception that it will not be required when placing CS mix. An exception may be allowed due to lane width or safety issues if approved by the Engineer.

The MTD shall have a minimum storage capacity of 15 tons, and shall be equipped with mixing augers in the bottom of the storage hopper that are capable of remixing or re-blending the material as the material is removed from the storage hopper. The mixing augers shall be operational and used at all times during placement of the asphalt mixes. The MTD shall have a rear discharge conveyor that swivels a minimum of 150 degrees to allow feeding the paving machine from the front, side or rear.

Insert a stationary surge hopper into the paving hopper of the paver being fed by the MTD. The stationary surge hopper shall be considered as part of the MTD and shall have sloping sides (minimum of 60 degrees from horizontal) and a minimum storage capacity of 15 tons.

Obtain the Department's approval of models and manufacturers of MTDs before using on the Project. The Department will make no direct payment for use of an MTD and will consider all cost of furnishing and operating the MTD as incidental to the work.

407.07 Rollers

Provide self-propelled rollers, of steel-wheel, pneumatic tire, and/or vibratory type, which are in good condition and capable of reversing without backlash. Operate rollers at speeds slow enough to avoid displacement of the bituminous mixture. Equip rollers with a device for moistening and cleaning the wheels as required.

The required rollers shall be on the job, inspected, and approved before the start of paving operations.

Rollers shall meet the following additional requirements:

1. The steel-wheel roller shall weigh a minimum of 8 tons and may be either a three wheel or tandem type.

2. The pneumatic tire rollers shall have a minimum contact pressure of 85 pounds per square inch. The roller shall contain two axles upon which at least seven pneumatic-tire wheels are mounted so as to ensure the rear set of tires will not track the front set. The axles shall be mounted in a rigid frame provided with a loading platform or body suitable for ballast loading. Uniformly inflate the tires. Provide the Engineer with charts or tabulations of the contact area and contact pressures for the full range of tire inflation pressures and loadings for each size of roller tire provided. In place of a pneumatic tire roller, the Contractor may substitute a combination roller (pneumatic and steel wheel combination) of the make and model approved by the Department.

3. The Contractor may use vibratory rollers if the Engineer approves the particular roller proposed for use.

When paving the inside shoulder concurrently with the inside traffic lane, provide an additional roller, having a minimum width of 4 feet to a maximum width of 1 foot wider than the inside shoulder being paved, to compact the shoulder. Do not allow either the roller(s) on the inside traffic lane or the roller on the shoulder to traverse between the inside shoulder and the inside traffic lane.

407.08 Small Tools

Provide all necessary small tools, and keep them clean and free from accumulations of bituminous materials.

CONSTRUCTION REQUIREMENTS

407.09 Weather Limitations

The Contractor may place bituminous plant mix on properly constructed and accepted subgrade or previously applied layers if:

1. The subgrade and the surface upon which the bituminous plant mix is to be placed is free of excessive moisture, and

2. The bituminous plant mix is placed according to the temperature limitations specified in Table 407.09-1 and when weather conditions otherwise allow the pavement to be properly placed, compacted, and finished.

Table 407.09-1: Temperature Limitations

Compacted Thickness	Minimum Air or Surface Temperature (°F)	
	Unmodified mixes (PG 64, 67)	**Modified mixes (PG 70, 76, 82)**
≤ 1.5 inches	45	55
> 1.5 inches to < 3.0 inches	40	50
≥ 3.0 inches	35	45

3. Do not place bituminous plant mix, with a compacted thickness of 1.5 inches or less, between November 30 and April 1. Do not place bituminous plant mix, with a compacted thickness greater than 1.5 inches, between December 15 and March 16. Only place 411-TL, 411-TLD, and 411-OGFC mixtures when the pavement surface temperature and the ambient air temperature are a minimum of 55 °F and rising; limit placement to the period from April 1 to November 1.

4. The Contractor may request a variance from the above required temperature and seasonal limitations to pave at lower temperatures if there is a benefit to the public. Submit such requests in writing at least one week before the anticipated need, and include a Paving and Compaction Plan for Cold Weather that meets the Department's Procedure. The plan shall identify what practices and precautions the Contractor intends to use to ensure the mixture is placed and compacted to meet the specifications. The plan shall include compaction cooling curves estimating the time available for compaction, the intended production, haul, and compaction rates, with paver and roller speeds estimated. The Contractor may consider using such practices as the addition of rollers, reduced production and paving rates, insulated truck beds, and heating the existing surface.

If the specified densities are not obtained, stop all paving operations and develop a new plan. All mixture failing to meet specifications will be subject to price adjustments or removal and replacement at no cost to the Department.

407.10 Conditioning the Existing Surface

If bituminous mixes are to be placed upon an existing concrete pavement, with or without a bituminous overlay, remove all excess bituminous material from joints and cracks. Remove sections of existing pavement that are broken and pumping under traffic. Remove pavement where blowups have occurred at joints or cracks to provide a minimum opening of 1 foot for the full width of the pavement.

If the bituminous mixture is to be placed upon an existing bituminous pavement, remove areas containing excess bitumen and failures in the existing surface and base as directed by the Engineer.

Adjust all manholes and catch basin frames, which are associated with the storm sewer system, to the finished grades of the pavement. Unless otherwise specified, make such adjustments at no additional cost to the Department. The respective Utility Owner(s) will properly adjust all utility manholes, utility valve covers, and similar structures, to the finished grades of the pavement, unless otherwise shown on the Plans.

Remove unsatisfactory subgrade material encountered when removing the existing pavement and replace with approved material. Use overlay mixture or other approved material to fill openings left by the pavement and base removal to the full depth of the existing pavement, as directed by the Engineer, and compact the material in layers not to exceed 3 inches in thickness.

Paint contact surfaces of curbing, gutters, manholes, and other structures with a thin, uniform coating of bituminous material before placing the mixture against them.

When shown on the Plans, bring existing surfaces that are warped and irregular to uniform grade and cross-section using the leveling mixture specified in **307**.

407.11 Preparing the Bituminous Material

A. Hot Mix Asphalt (HMA)

Heat the bituminous materials for hot mixes to the required mixing temperature specified in Table 407.11-1.

Table 407.11-1: Mixing Temperatures

PG Binder Grade	Minimum Temperature (°F)	Maximum Temperature (°F)
PG 64-22, PG 67-22	270	310
PG 70-22	290	330
PG 76-22	290	330
PG82-22	290	330

The temperature for Grading AS, Grading ACRL, and Grading TPB mixtures shall be between 225 and 275 °F, except when modified binders are used, and then the temperatures shall be between 250 and 310 °F. Aggregate should be coated and no visible drain down should occur in storage silos or hauling equipment.

B. Warm Mix Asphalt (WMA)

The Contractor may subject the produced mixture to reduced production and placement temperatures by adding a chemical warm mix additive meeting **921.06.B.3** or by making plant modifications as specified in **407.04.A.12.**

When using either WMA technology, the maximum mixing temperature for any grade of asphalt cement shall be no more than 300 °F. At the beginning of a day's production, the producer may produce up to five truckloads at the temperatures specified in Table 407.11-1 to pre-heat placement equipment (pavers, transfer devices) before producing WMA. Indicate the laboratory mixing and compaction temperatures on the JMF during the mix design approval process. A tolerance of ±5.0 °F for each temperature will be allowed.

During test strip construction, ensure that all plant-produced WMA exhibits the ability to meet the test requirements for tensile strength ratio (TSR), conditioned tensile strength, Marshall Stability and flow, volumetrics, and boil test, as specified for HMA in specifications **307**, **407**, and **411**. Procedures for testing shall be in accordance with that which is defined for quality control and acceptance in **407.03.D.2.h** and **407.20.B.3**, respectively.

407.12 Preparation of Aggregates

Unless otherwise specified, dry and heat the aggregate for hot mixes so as to produce a completed mix of a uniform temperature as specified in Table 407.11-1. Adjust flames used for drying and heating to avoid damage to the aggregate and to avoid soot on the aggregate.

On all plants requiring screens, screen the hot dried aggregate into two or more fractions as specified. Convey the separated fractions into separate compartments ready for batching and mixing with bituminous material.

407.13 Mixing

Combine the dried aggregates within the mixer in the amount of each fraction of aggregates required to meet the JMF. Measure the bituminous material and introduce it into the mixer in the amount specified by the JMF.

After introducing the required amounts of aggregate and bituminous material into the mixer, mix the materials as long as necessary to obtain a complete and uniform coating of the particles and a thorough distribution of the bituminous material. The Engineer will determine wet-mixing time for each plant and for each type of aggregate used, but in no case shall the wet-mixing time be less than 25 seconds for batch type plants and 40 seconds for continuous mix plants.

The temperature of the completed mixture (determined at the time it is dumped from the mixer), made with aggregates containing absorbed moisture that causes foaming or boiling in the completed mix, shall be not less than 225 °F. The temperature of the mix when it is discharged from the mixer shall not deviate from that specified in **407.11.A**.

The Contractor may place hot-mixed bituminous mixtures in surge or storage silos if the mixture as used from the silos meets all the specification requirements for the particular mix involved.

When using surge or storage silos, as approved by the Engineer, meet the following additional requirements:

1. Provide a surge bin or storage silo system meeting **407.04.A.11**.

2. Empty the storage silos or surge bins when directed by the Engineer to check material quantities.

3. Limit hours of plant operation, whether for storage or direct shipment to the road, to reasonable working hours to allow normal inspection of plant operations.

4. Remove bituminous mixtures placed in a surge bin on the same day in which it is stored.

5. The Contractor may store bituminous mixtures of Gradings A, AS, ACRL, and B for up to 48 hours, and Gradings BM, BM2, C, CS, CW, D, E, and F for up to 96 hours, in a storage silo by complying with the following:

   (a) Add an approved silicone additive to the asphalt cement for mixes to be stored beyond the day of mixing.

   (b) Keep the stored bituminous mixture sealed at all times during storage.

   (c) Fill the storage silo to at least 90% of capacity.

6. The Inspector will take samples of the stored material following the period of storage.

7. The stored material is subject to the same temperature, segregation, and laying requirements as required for unstored plant production.

8. The Engineer will reject mixtures having excessive segregation, lumpiness, or stiffness.

9. Locate the surge bins and storage silos in a position that enables the top of the truckload to be visible to the load operator during the loading operation.

407.14 Spreading and Finishing

For Contracts requiring night work, supply sufficient lighting and equipment as specified in **712.04.H**.

The temperature of the mixture at the time of depositing in the paver hopper shall be as specified in Table **407.11-1**.

Place the mixture upon an approved surface, and spread and strike-off to the established line, grade, and elevation using approved asphalt paving machine(s). The Engineer may approve use of echelon or full-width paving if plant production is capable of supplying the paver so that a constant forward speed can be maintained. Use preset control string lines to control the alignment of the outside edge of the pavement. Where multi-course pavements are placed, offset the longitudinal joint in one layer from that in preceding layer by approximately 1 foot; however, construct the joint in the top layer at the center-line of the pavement if the roadway comprises two lane widths, or at lane lines if the roadway is more than two lanes in width. Pave in the direction of traffic.

Do not feed a paving machine from more than one asphalt plant. Coordinate plant production and paving operations to ensure constant forward movement of the pavers. The Engineer will consider repetitive interruptions or stopping of the paver as cause for stopping the work until the Contractor corrects the situation. If the paver must be stopped for a significant period of time, construct a joint and move the paver from the roadway before the bituminous mixture has cooled sufficiently to prevent proper compaction. If the bituminous mixture cools to the extent that the required density cannot be obtained, remove and replace the mixture at no cost to the Department.

Unevenness of texture, segregation (including end-of-load segregation) as measured by a properly calibrated nuclear gauge, or tearing or shoving of bituminous mixture during the paving operation, shall be reason to stop the paving. Only resume paving operations when the condition is corrected. Immediately remove unacceptable mix and replace at no cost to the Department. The Department will not allow excessive throwing back of the bituminous mixture.

Provide automatic screed controls using either the string line, ski type grade reference system, or a non-contact averaging system on all work regardless of the paver width. The Engineer may require a string line reference system on new construction. If the base has been finished with equipment having automatic grade control or the Contractor demonstrates that an alternate method of spreading and finishing will result in a satisfactory riding surface, the Engineer may conditionally waive the string line requirement and authorize use of the ski type reference system. Regardless, the Engineer may at any time require the use of a string line reference system, even if previously waived, if in the Engineer's opinion, the use of the string line will result in a superior riding surface. When the string line system is required on a multi-course pavement, use it on at least two courses exclusive of the surface course. When using the ski type system, the ski shall have the maximum practical length and in no case shall it be less than 40 feet in length. Pavement lanes previously placed with automatic controls or to form grade may serve as the longitudinal control reference for placing adjacent lanes by using a ski or joint matching shoe.

The string line reference system shall consist of suitable wire or twine supported by approved devices that are compatible with the type of automatic paver control system used. The string line and supports shall be capable of maintaining the line and grade shown on the Plans at the point of support while withstanding the tensioning necessary to prevent sag in excess of 1/4 inches between supports spaced 50 feet apart. Install additional supports to provide a minimum spacing of 25 feet, or less as directed by the Engineer, to remove the apparent deviation of the string line from theoretical grade.

Provide all materials, equipment, labor, and incidentals necessary to construct the string line reference system, and maintain the system until its use is no longer required. Include the cost of erecting and maintaining the string line reference system in the unit price bid for other items of construction. Have the string line reference system be complete in place at least 300 feet in advance of the point where the pavement is being placed. Automatic screed controls are not required on sections of projects where service connections and other conditions interfere with their efficient operation.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, take the mixture from the hopper of the spreading machine and distribute it immediately into place using suitable shovels and other tools, and spread the mixture with rakes and lutes in a uniformly loose layer of such depth as will result in a completed course having the required thickness.

The Contractor and the Department will each be required to have an individual onsite that is certified by the Department through the HMA Roadway Certification Course.

407.15 Compaction

A. General

After spreading and striking-off the bituminous mixture and adjusting surface irregularities, thoroughly compact the mixture using methods approved by the Engineer and that are capable of achieving the specified density while the material is in a workable condition. When no density requirements are specified, use a system of compaction for roadway pavements that has previously produced the required bituminous pavement densities. The Engineer may require a control strip and random density samples to evaluate the system.

In general, accomplish compaction using a combination of the equipment specified in **407.07**. As a minimum, meet the following roller requirements, but increase the number of rollers if the required results are not being obtained.

1. Except as noted below, each paving train shall consist of a minimum of three rollers meeting **407.07**. The intermediate roller in each train shall be a pneumatic type. If the surface course contains a latex or polymer additive, the Contractor may use a steel wheel type roller for intermediate rolling instead of a pneumatic type provided the surface course meets density requirements.

2. Provide a minimum of two rollers when placing 307 CS, 411 TL, or 411 TLD mixtures. Perform breakdown rolling, as soon as possible and while the mixture is sufficiently hot, using a pneumatic tire roller having a minimum contact pressure of 85 pounds per square inch. Do not substitute a combination roller for a pneumatic roller when placing CS mix. Regulate the paver speed so rollers can maintain proper compaction of the mixture as determined by the Engineer.

3. With the Engineer’s approval, the Contractor may reduce the minimum number of rollers listed above to one roller of either the steel-wheel or vibratory type on the following types of construction and projects:

   a. Shoulder construction,

b. Incidental construction such as bridge approaches and driveways, and

c. Projects containing less than 10,000 square yards of bituminous pavement.

4. Compaction of 411-OGFC mixtures shall consist of a minimum of two passes with a steel double drum asphalt roller with minimum weight of 10 tons, before the material temperature has fallen below 185 °F. Provide a minimum of two roller units so as to accomplish the compaction promptly following the placement of the material. At no time shall a pneumatic tire roller be used or a steel wheel roller be used in vibratory mode. If the roller begins to break the aggregate, immediately stop rolling.

Unless otherwise directed by the Engineer, begin rolling at the low side and proceed longitudinally parallel to the road centerline. When paving in echelon or abutting a previously placed lane, roll the longitudinal joint first, followed by the regular rolling procedure. When paving in echelon, rollers shall not compact within 6 inches of an edge where an adjacent lane is to be placed. Operate rollers at a slow uniform speed with the drive wheels nearer the paver, and keep the rollers as nearly as possible in continuous operation. Continue rolling until all roller marks are eliminated. Do not park rollers on the bituminous pavement.

To prevent adhesion of the mixture to the rollers, keep the wheels properly moistened with water or water mixed with very small quantities of detergent or other approved material. Limit excess use of liquid.

Do not refuel rollers on bituminous pavements.

Along forms, curbs, headers, walls and other places not accessible to the rollers, compact the mixture thoroughly using hot hand tampers, smoothing irons, or with mechanical tampers. On depressed areas, the Contractor may use a trench roller to compact the mix.

B. Density Requirements

Meet the applicable density requirements specified in Tables 407.15-1 to 407.15-4.

Table 407.15-1: Density Requirements for ADT 1,000 or less

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
A	90	87
B, BM & BM2	90	87
C & CW	90	87
D	90	87
E	90	87

Table 407.15-2: Density Requirements for ADT 1,000 to 3,000

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
A	91	89
B, BM & BM2	91	89
C & CW	91	89
D	91	89
E	91	89

Table 407.15-3: Density Requirements for ADT 3,000 or greater

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
A	92	90
B, BM & BM2	92	90
C & CW	92	90
D	92	90
E	92	90

Table 407.15-4: Density Requirements for any ADT

Mix Type	% of Maximum Theoretical Density (Average)	No Single Test Less Than, %
Shoulder Mix (B, BM, BM2, D or E)	88	85
AS and A-CRL	None [1]	None
CS	None [1]	None
TL, TLD, and OGFC	None	None

[1] The Department will waive density requirements on Bituminous Plant Mix Base Grading ACRL, Grading AS and Bituminous Plant Mix Leveling Course, Grading CS; however, the Contractor shall use a system of compaction for roadway pavements that has been approved by the Engineer. When placing Bituminous Plant Mix Base Grading ACRL and Grading AS, the Contractor may replace the specified intermediate roller (pneumatic tire) with a steel-wheel type if irreparable damage to the pavement is occurring.

Correct base or surface course that tests below the minimum density so that the density of the area is equal to or above the minimum, at which point it can be used to determine the average density of the lot. Do not place any successive layers until the area has been corrected. As necessary to determine the classification of open graded or dense graded mixes and to measure segregation, use AASHTO T 269 or ASTM D3203.

Repair or replace defective mixture to the satisfaction of the Engineer and at no cost to the Department.

The Department will perform density testing in accordance with **407.20.B.5**.

C. Test Strips

Construct test strips for all A, B, BM, BM2, C, CW, D, and E mixes to establish rolling patterns, to calibrate nuclear gauges, to verify that the base course or surface course meets the density requirements of the specifications, and for mix design and production verification as required.

Before constructing the test strip, obtain the Engineer's approval of the underlying base or other pavement course. Compact the test strip using equipment as specified in this subsection and **407.07**.

Construct the test strip at the beginning of work on the pavement course. Prepare new test strips when:

1. A change in the JMF is necessary;

2. A change in the source of materials occurs;

3. A change in the material from the same source is observed;

4. There is reason to believe that the test strip density is not representative of the bituminous mixture being placed; and when

5. A change in paving or compaction equipment occurs.

With the approval of the Engineer, the Contractor may construct additional test strips.

Construct each test strip with approved bituminous mixture. The test strip shall remain in place as a section of the completed work. Construct each test strip to be 1 paver width wide, with an area of at least 400 square yards and of the depth specified for the pavement course concerned.

Immediately after placing the bituminous mixture, begin compacting the test strip. Perform compaction in a continuous and uniform manner over the entire test strip.

Continue compacting the test strip until additional roller coverage will produce no appreciable increase in density (1 pound per cubic foot), as measured using a nuclear gauge. Use the roller coverage necessary to obtain this maximum density as the rolling pattern for the remainder of the project.

Take cores on the test strip at ten randomly selected locations as designated by the Engineer. Do not take cores within 2 feet of the longitudinal edges for calibration. Provide these cores to the Department for use in calibrating the nuclear gauge and to verify that the average density of the test strip meets the density requirements of the specifications. The Department will report all densities using the corrected nuclear gauge readings. Correction factors are specific to the nuclear gauges used during the test strip construction. If a different nuclear gauge needs to be used for acceptance, it will be necessary to cut new cores from the ongoing pavement construction to calibrate the new gauge.

When testing test strip cores, the Department will determine density (bulk specific gravity) in accordance with AASHTO T 166, Method A only. All core samples shall be completely dry before testing. Air drying is permitted provided core samples are weighed at 2-hour intervals until dry in accordance with AASHTO T166, Section 6.1. Cores may also be dried in accordance with ASTM D7227.

If the density of the asphaltic concrete in the test strip does not meet specification requirements, make whatever changes are necessary to obtain the specified density. Use other sources and combinations of aggregates as necessary, subject to the Engineer’s approval, to produce a mix meeting the required density.

407.16 Joints

Place bituminous paving as continuously as possible. Do not pass rollers over the unprotected end of a freshly laid mixture unless approved by the Engineer. Form transverse joints by cutting back on the previous run to expose the full depth of the course. Use a brush or sprayed coat of bituminous material on contact surfaces of longitudinal and transverse joints just before placing additional mixture against the previously rolled material.

407.17 Pavement Samples

When directed, cut samples from the compacted pavement for testing by the Engineer. Take samples of the mixture for the full depth of the course at locations selected by the Engineer. Cut the samples with a power saw or core drill. Samples shall have a top surface area of at least 10 inches.

Fill holes left by taking samples with the same type mixture that was used to construct the course sampled, and compact to conform to the surrounding pavement. Cut samples and repair sample holes at no cost to the Department.

407.18 Surface Requirements

Test the surface with a 12-foot straightedge applied parallel to the centerline of the pavement. The deviation of the surface from the testing edge of the straightedge shall not exceed that specified for the respective types of bituminous construction under the applicable Subsections of these Specifications.

Test the transverse slopes of tilted pavements with a string-line and string-level applied at right angles to the centerline of the pavement. The percent of slope, when computed for the full width of the pavement, shall not deviate more than 0.5 percentage points from that shown on the Plans.

Test the crown in crowned pavements with a string-line applied at right angles to the centerline of the pavement. The crown shall not deviate more than 1/2 inch from that shown on the Plans.

Correct deviations that exceed the specified tolerances. Remove and replace pavement that cannot be corrected to comply with the specified tolerances at no cost to the Department.

COMPENSATION

407.19 Method of Measurement

The Department will measure:

1. Asphalt cement and mineral aggregate, including mineral filler when required, by the ton and as follows:

    a. If the mix is loaded from a storage or surge bin, the Department will determine quantities by weighing the completed mix on truck scales meeting **109** and calculating the weight of asphalt cement and mineral aggregate based on the percentages measured into the mix by the appropriate scales or meters as specified in **407.04**.

    b. If the mix is loaded directly into the hauling equipment from a batch plant, the Department will measure asphalt cement and mineral aggregate in batch quantities by scales or scales and meters as specified in **407.04.B.**

c. If a continuous mix plant is used, the Department will measure Bituminous Material for Bituminous Plant Mix Pavement by the ton in accordance with **109**. The Department will determine quantities of mineral aggregate, including mineral filler when required, by weighing the bituminous pavement mixture on truck scales meeting **109**, and deducting the weight of the bituminous material from the weight of total mixture accepted.

d. If recycled mix is permitted, the Department will measure the completed mix, including new mineral aggregate, planings, asphalt cement, and additive, by the ton in accordance with **109**.

2. Removal and disposal of existing surface (concrete) by the square yards in accordance with **109,** if such work is required as specified in **407.10**. Such measurement will include the removal of bituminous overlay.

3. Removal and Disposal of Existing Surface (Bituminous) by the square yards in accordance with **109**. Such measurement shall include the removal of base material, except concrete, as directed by the Engineer.

4. Removal of unsatisfactory subgrade material where existing pavement has been removed by the cubic yard, in accordance with **203.09**. The Department will measure material used to replace such undercutting in accordance with the specification for the type of material used.

5. Adjustment of catch basin grates and frames, water valve boxes, gas valve boxes and manhole covers and frames by each when required.

6. Liquid anti-strip additive by the gallon.

7. Hydrated lime by the ton.

The Department will measure bituminous mixtures used to fill openings left by pavement removal as specified in this Subsection **407.19**. The Department will measure base materials used to fill openings left by base removal as provided for in the respective Sections for each type specified.

The Department will not measure chemical additives or modifiers, when required, for payment, but will consider them incidental to asphalt cement.

The Department will not measure mineral filler separately for payment, but will consider it incidental to mineral aggregates.

407.20 Basis of Payment

A. General

The Department will pay for accepted quantities of Asphaltic Concrete (Hot Mix) with or without recycled material, at the contract prices, complete in place, as follows:

Item	*Pay Unit*
Bituminous Plant Mix Base (Hot Mix)	Ton
Aggregate	Ton
Asphalt Cement	Ton

The Department will pay for liquid anti-strip additive and hydrated lime anti-strip additive based on certified invoices of material cost not to exceed $15 per gallon and $90 per ton, respectively. This payment is full compensation for all labor, materials, equipment, and other incidentals incurred in using the anti-strip additive.

The Department will pay for accepted quantities of Prime Coat or Tack Coat as specified in **402** or **403**, respectively.

The Department will pay for the work required to prepare the subgrade, sub-base, base, or surface in accordance with **307.06** and **411.06** as provided for in the applicable Section or Subsection under which the work is performed.

The Department will not make direct payment for polymer or latex additives, but will consider such additives to be included in the price bid for the modified asphalt cement or modified mixture.

B. Acceptance of the Mixture

1. **General.** The Department will perform all necessary sampling and testing for acceptance purposes in strict conformance with the Department's Policies in addition to monitoring and observing the

Contractor's quality control test procedures and results. However, the Engineer will reject for use in the work any load or loads of mixture which, in the Engineer's opinion, are unacceptable due to excessive segregation, improper coating of aggregates, or excessively high or low temperature.

The Engineer will accept bituminous mixture at the plant with respect to gradation and asphalt content, on a lot basis. A standard size lot at the asphalt plant will consist of a day's production. The number of sublots in a lot will vary from n=1 to n=4 according to Table 407.20-1.

Table 407.20-1: Sublot Requirements

Quantity (tons)	Number of Sublots
3001 – 4000	4 tests
2001 – 3000	3 tests
1001 – 2000	2 tests
Less than 1000	1 test

When the total plan quantity of any mix is less than 500 tons, the Department will accept the mix on the basis of visual inspection and Contractor Quality Control certification. The Department may run extraction, gradation analysis, or other tests deemed necessary for acceptance purposes.

2. Defective Materials

a. Acceptance or Rejection. Consider the Engineer's decision to be final as to the acceptance, rejection, or acceptance at an adjusted payment of the lots.

It is the intent of these specifications that each lot of material will meet specification requirements at the time of acceptance testing. The Department will not take check samples for acceptance purposes.

All acceptance samples will be split, and half of the sample will be retained by the Inspector. If the results of an acceptance test are questioned, the Central Laboratory will test the remaining half of the acceptance sample. The Department will use the results obtained by the Central Laboratory to evaluate the quality of the lot.

b. Disposition of Lots. Remove and replace, at no cost to the Department, nonconforming lots of materials, products, or complete construction that cannot be corrected by reworking. Alternatively, the Department may accept the nonconforming work at an adjusted payment as specified in these Specifications or as directed by the Engineer.

When a deficiency is determined, the Department will apply the applicable payment as specified in these Specifications to the entire lot. When multiple deficiencies occur, the Department will apply the applicable partial payments to the lot of material that is identified by each deficiency. The Department will apply the payment adjustment for each deficiency separately so as not to affect any other payment adjustment occurring for the same lot; however, if there are two or more deficiencies in the gradation acceptance tests, the Department will apply only the greater payment adjustment. When an area or linear measurement is used to specify lot size, the Department will determine the equivalent tons of mix placed in each lot by using the average calculated spread from the plant inspector's daily report for that day's production.

3. Acceptance. The Engineer will base acceptance of the mixture on test results of consecutive random samples taken from each lot. One random sample will be taken from each sublot. The bituminous mixture will be sampled at the plant according to AASHTO T 168. The percent bitumen content of the mixture will be determined according to AASHTO T 164 or by AASHTO T 308 except as herein revised.

The Contractor may use an approved ignition furnace instead of a vacuum extractor for the use in determining asphalt content and gradation. The method of calibration and test procedures shall comply with AASHTO T 308 Method A and the following.

At least once per week, per mixture, during production, check the AASHTO T 308 correction factors with a sample of the aggregate mixture proportions, blended at the optimum asphalt content. Adjust the correction factor accordingly. Keep records of all correction factors for all mixtures. Adjusted payment for asphalt content and gradation will be based on the ignition furnace results as specified in Table 407.20-2. Use of this alternative equipment shall be at no additional cost to the Department.

The percents passing the sieves will be determined in accordance with AASHTO T 30.

Table 407.20-2: Acceptance Schedule of Payment (Asphalt Plant Mix Characteristics)

Characteristics	Pay Factor	Average Arithmetic Deviation of the Lot Acceptance Test from the JMF	
		1 Test	2 Tests or more
Asphalt Cement Content (1) (Extraction or ignition oven)	1.00	0.00-0.30	0.00-0.25
	0.95	0.31-0.35	0.26-0.30
	0.90	0.36-0.40	0.31-0.35
	0.80 (2)	over 0.40	over 0.35
Gradation 3/8 inch sieve and larger	1.00	0.00-6.50	0.00-5.70
	0.95	6.51-7.08	5.71-6.20
	0.90	7.09-7.66	6.21-6.69
	0.80 (2)	over 7.66	over 6.69
Gradation No. 4 sieve (3)	1.00	0.00-4.62	0.00-4.00
	(0.95	4.63-5.20	4.01-4.50
	0.90	5.21-5.77	4.51-5.00
	0.80 (2)	over 5.77	over 5.00

Characteristics	Pay Factor	Average Arithmetic Deviation of the Lot Acceptance Test from the JMF	
		1 Test	2 Tests or more
Gradation	1.00	0.00-3.80	0.00-3.30
No. 8, 16, 30 & 50 sieves (3)	0.95	3.81-4.46	3.31-3.91
	0.90	4.47-5.12	3.92-4.52
	0.80 (2)	over 5.12	over 4.52
Gradation	1.00	0.00-1.80	0.00-1.60
No. 100 & 200 sieves (3)	0.95	1.81-2.00	1.61-1.75
	0.90	2.01-2.20	1.76-1.90
	0.80 (2)	over 2.20	over 1.90

(1) Does not apply to 307 Grading A, AS, or ACRL mixes.

(2) If approved by the Engineer, the Contractor may accept the indicated partial pay. The Department may require removal and replacement at no cost. The Contractor may remove and replace at no cost to the Department at any time.

(3) When there is more than one reduced payment relating to gradation in 1 lot of material, only the greatest reduction in payment will be applied. Reductions applicable for any other reason will be cumulative.

Deduction for both asphalt content and gradation deficiencies will be cumulative. The Department will apply deductions to the total price of the mix (asphalt cement and aggregate combined) under the item for Asphalt Cement Content and Gradation Deduction.

4. **Additional Tests.** The Engineer may perform any test at any time to determine the effectiveness of the Contractor's quality control. In addition, the Department will conduct production verification tests parallel to that which is defined for quality control in **407.03.D.2.h**.

5. **Acceptance for Mix Density on the Roadway.** The Department will apply a deduction in payment, not as a penalty but as liquidated damages, for failure to meet the density requirements specified in **407.15**. As soon as practicable after the final rolling is completed on each lot, the Department will perform 5 density tests at locations determined by the Engineer, and will compute an average of all such tests. Deductions for failure to meet density requirements will be computed to the nearest 0.1% as a percentage

of the total payment otherwise due for each lot. The percent of total payment to be deducted will be 5 times the percent the average in-place density for each lot that fails to meet **407.15**. The Department will make deductions in monies due the Contractor for failure to meet the density requirements under the item for Density Deduction. The Department will conduct acceptance testing for density in accordance with ASTM D2950 unless otherwise specified. The Department inspector will be a certified Asphalt Roadway Technician.

For density testing purposes, the Department will divide the pavement into lots of 10,000 square yards, except for 307 Gradings A, B, BM, and BM2, which will be divided into lots of approximately 5,000 square yards. Five density tests will be performed in each lot and the average results compared with the requirements specified in Tables **407.15-1** to **407.15-4**. At the beginning of a project or at any time it is deemed advisable, the Department may consider smaller lots to evaluate compaction methods or for other reasons as approved or directed by the Engineer.

The Department will randomly select acceptance test samples that are representative of the lot or sublot. Although performing compaction after the acceptance test is acceptable, the Department will use the original test result to determine lot density. The Department may take information only samples to spot check compaction, but will not use these tests for acceptance testing.

C. Adjustments

1. Asphalt Cement Adjustment. If the Engineer sets an asphalt content other than that specified in Tables **307.09-1** and **411.09-1**, the Department will calculate a price adjustment, based on the asphalt content set by the Engineer and the Monthly Bituminous Index for the specific grade asphalt on the mix design, according to the following formula:

$$\mathrm{PA} = \frac{\mathrm{MBI} \times (\mathrm{DA} - \mathrm{BA}) \times \mathrm{T}}{100}$$

Where:

PA = Price Adjustment

MBI	=	Monthly Bituminous Index
DA	=	Percent asphalt set on the mix design
BA	=	Percent asphalt specified above to be used for bidding
T	=	Total tons asphalt mix for price adjustment

2. **Specific Gravity.** In cases where the effective combined specific gravity of the mineral aggregate exceeds 2.80, the Department will adjust the tonnage of mineral aggregate, or plant produced mixture, for payment by multiplying the tonnage of mineral aggregate, or plant produced mixture, used by a specific gravity of 2.80 and dividing by the higher specific gravity.

3. **Loss on Ignition (LOI).** If the approved JMF includes a surface mixture of limestone with gravel, granite, slag, quartzite or gneiss, perform tests for the percent LOI of the limestone aggregate in the asphalt paving mix as specified in **407.03.E.3**.

   If the percent of LOI in the aggregate differs by more than ±2% from the LOI indicated in the JMF, the Department will make a payment deduction in the price bid for the mix, not as a penalty but as liquidated damages. The percent of total payment to be deducted will be 5 times the percent that the LOI exceeds the JMF tolerance of ±2%.

   Replace or overlay all mix produced with aggregate tested and found to have a LOI that differs more than ±6% from the LOI indicated in the JMF at no additional cost to the Department.

   To determine the deduction, the Department will use lots of approximately 5,000 square yards. The Department inspector will perform sampling and testing to establish the LOI according to the Department's sampling and testing procedures. If the initial tests indicate a variation in the LOI of greater than ±2% than the value shown on the mix design, the Contractor shall perform the additional sampling necessary to establish the LOI of the aggregate in each lot, with the cost of the sampling being included in the contract unit prices bid for the paving items.

   The Department will make deductions for excess variation in LOI under the item for Material Variation (Deduction).

SECTION 411 – ASPHALTIC CONCRETE SURFACE (HOT MIX)

DESCRIPTION

411.01 Description

This work consists of constructing an asphaltic concrete pavement, composed of a mixture of coarse aggregate, fine aggregate, mineral filler if specified or required, and asphalt cement, on a prepared roadbed at the rate of application shown on the Plans or established by the Engineer.

The provisions of **407** shall apply to this work unless otherwise stipulated.

MATERIALS

411.02 Materials

Provide materials as specified in:

Mineral Aggregate **903.11**
Mineral Filler **903.16**
Asphalt Cement, PG 64-22, 70-22, 76-22 or 82-22 .... **904.01**
Chemical Additive **921.06.B**

The Engineer will accept mineral aggregate, bituminous material, and plant mix in accordance with **407.02**.

411.03 Composition of Mixtures

A. General

Composition of mixtures shall be as specified in **407.03**.

B. Proportioning

Combine the specified mineral aggregate and asphalt cement according to the proportions specified in Table 411.03-1.

Table 411.03-1: Proportions of Total Mixture, Percent by Weight

Surface Course	Effective Combined Mineral Aggregate	Asphalt Cement
Grading D	93.0 - 94.3	5.7 - 7.0 [1]
Grading E [2]	93.0 - 94.3	5.7 - 7.0 [1]
Grading E (shoulders)	92.0 - 94.7	6.0 - 6.5 [1]
Grading TL	92.5 - 94.3	5.7 - 7.5 [1]
Grading TLD	93.0 - 94.3	5.7 - 7.0 [1]
Grading OGFC	92.0 - 94.0	6.0 - 8.0 [1]

(1) If the effective combined specific gravity of the aggregate exceeds 2.80, the above proportions may be adjusted as directed by the Engineer. The upper limit for flow values shall not apply to mixes with modified asphalt liquids.

(2) The minimum allowable asphalt cement content for 411E low volume mixtures is 5.3%.

1. **Grading D.** In addition to the other requirements of these Specifications, the composition of the mineral aggregate shall be such that when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-2.

Table 411.03-2: Mixture Properties (All Roads)

Mix[1]	Stability, Min. lb-ft [2]	Flow 0.01 inch [3]	Design Void Content % [2]	Production Void Content % [2]	VMA, Min. % [2]	Dust-Asphalt Ratio [4]
411D	2,000	8 – 16	4.0 ± 0.2	3 - 5.5	14	0.6 - 1.2

(1) In order to identify critical mixes and make appropriate adjustments, the mix design shall have these required production properties for the bitumen content range of Optimum Asphalt Cement ±0.25%.

(2) Tested in accordance with AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

(3) Flow will only be required when using a non-modified binder (PG 64-22 or 67-22).

(4) The dust to asphalt ratio is the percent of the total aggregate sample that passes the No. 200 sieve, as determined by AASHTO T 11, divided by the percent asphalt in the total mix.

2. **Grading E.** In addition to the other requirements of these Specifications, if using Grading E for the riding surface, the composition of the mineral aggregate shall be such that, when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-3.

Table 411.03-3: Mixture Properties (High vs. Low Volume Roads)

Mix	Traffic Volume	Stability Minimum lb-ft [1, 3]	Flow 0.01 inch [2]	Design Void Content % [1]	Production Void Content % [1]	VMA, Min % [1]
411E	High Volume (ADT > 1,000)	2,000	8 - 16	4.0 ± 0.2	3 - 5.5	14
411E	Low Volume (ADT ≤ 1,000)	1,500	8 - 16	3.5 ± 0.5	2 - 5	n/a

(1) Tested according to AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

(2) Flow will only be required when using a non-modified binder (PG 64-22 or 67-22)

(3) Minimum stability for shoulder mixes will be 1,500 lb-ft and optimum asphalt cement content for shoulder mixes shall be as directed by the Regional Materials Supervisor.

If the design criteria specified above cannot be obtained with the aggregate submitted to the laboratory for design, provide another source of aggregate.

3. **Gradings TL and TLD.** In addition to the other requirements of these specifications, the composition of the mineral aggregate shall be such that, when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-4.

Table 411.03-4: Mixture Properties (Gradings TL and TLD)

Mix	Stability, Min lb-ft [(1)]	Design Void Content % [(1)]	Production Void Content % [(1)]	Minimum VMA % [(1)]	Dust-Asphalt Ratio [(2)]
411TL	2,000	4.0 ± 0.2	3 - 5.5	16	1.0 - 2.0
411TLD	2,000	3.8 ± 0.3	3 - 5.5	14	0.6 - 1.2

(1) Tested according to AASHTO T 245 with 75 blows of the hammer on each side of the test specimen, using a Marshall Mechanical Compactor.

(2) The dust to asphalt ratio is the percent of the total aggregate sample that passes the No. 200 sieve, as determined by AASHTO T 11, divided by the percent asphalt in the total mix.

4. **Grading OGFC.** In addition to the other requirements of these specifications, the composition of the mineral aggregate shall be such that, when combined with the required amount of bitumen, the resultant mixture will meet Table 411.03-5.

Table 411.03-5: Mixture Properties (Grading OGFC)

Mix	Minimum Void Content %	Voids in Coarse Aggregate % [(1)]	Max. Cantabro Abrasion Loss (Non-Aged) % [(1)]	Drain Down Loss % [(2)]
411OGFC	20	VCA_{DRC} > VCA_{MIX}	20	<0.3%

(1) As described in National Asphalt Pavement Association (NAPA) Publication IS-115, "Design, Construction and Maintenance of Open-Graded Friction Courses"

(2) Tested in accordance with AASHTO T 305.

C. Recycled Asphalt Pavement and Recycled Asphalt Shingles

1. **Recycled Asphalt Pavement.** The Contractor may use asphalt pavement that has been removed from a Department project or other State Highway Agency project by an approved method and stored in a Department approved stockpile. RAP combined with the appropriate aggregate, asphalt cement, and anti-strip additive

when required shall produce a mixture that will otherwise meet all the requirements specified in **903.11** and this Section **411**. The Contractor may use RAP in each mix specified in Table 411.03-6.

Table 411.03-6: Use of Recycled Asphalt Pavement

Mix Type	% RAP (Non-processed) [(1)]	Maximum % RAP (Processed) [(2)]	Maximum % RAP Processed and Fractionated [(3)]	Maximum Particle Size (inch)
411D (PG64-22, PG67-22)	0	15	20	1/2
411D (PG70-22, PG76-22, PG82-22)	0	10	15	1/2
411E (Roadway)	0	15	20	1/2
411E (Shoulder)	15	30	35	1/2
411TL (PG64-22, PG67-22)	0	15	15	5/16
411TL (PG70-22, PG76-22, PG82-22)	0	10	10	5/16
411TLD (PG64-22, PG67-22)	0	15	15	5/16
411TLD (PG70-22, PG76-22, PG82-22)	0	10	10	5/16

(1) "Non-processed" refers to RAP that has not been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed above prior to entering the dryer drum.

(2) "Processed" refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that

Mix Type	% RAP (Non-processed) (1)	Maximum % RAP (Processed) (2)	Maximum % RAP Processed and Fractionated (3)	Maximum Particle Size (inch)

above prior to entering the dryer drum.

(3) "Fractionated" refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

All mixes shall contain at least 80% virgin asphalt, except for 411E Shoulder Mix which shall have at least 65% virgin asphalt.

Obtain a representative sample from the recycled material stockpile and establish a gradation and asphalt cement content as required. Determine the gradation and asphalt content of the recycled material at the beginning of a project and every 2,000 tons thereafter. The stockpile asphalt cement content for all recycled material shall not vary from the JMF by more than ± 0.8%. Table 411.03-7 specifies the stockpile gradation tolerance for all recycled material on each sieve.

Table 411.03-7: Stockpile Gradation Tolerances for Recycled Material

Size	Tolerance
3/8 inch sieve and larger	± 10%
No. 4 sieve	± 8%
No. 8 sieve	± 6%
No. 30 sieve	± 5%
No. 200 sieve	± 4%

The Contractor is responsible for its own sampling and testing of the RAP as well as new materials for bid purposes, and for submitting the JMF as specified in **407.03**. After mixing, the moisture content of the total mix shall be no more than 0.1% as determined by oven drying, and the provisions for lowering the temperature because of boiling or foaming shall not apply.

The Engineer will accept mixture for aggregate gradation and asphalt content based on extractions in accordance with AASHTO T 164 or in accordance with AASHTO T 308.

2. **Recycled Asphalt Shingles (RAS).** Recycled Asphalt Shingles (RAS) may be included to a maximum of 5% of the total weight of mixture. The percentage of RAS used will be considered part of the maximum allowable RAP percentage. The ratio of added new asphalt binder to total asphalt binder shall be 80% or greater <u>for all 411 mixes</u>. Either the mix producer or the RAS supplier shall obtain a representative sample from the recycled material stockpile and establish a gradation and asphalt cement content as required. Determine shingle asphalt binder content according to AASHTO T 164 Method A, with a minimum sample size of 500 grams. Determine the gradation and asphalt content of the recycled material at the beginning of the Project and every 2,000 tons of recycled material used thereafter. The stockpile asphalt cement content for all recycled material shall not vary by more than 0.8%. All RAS material shall be processed to a minimum 100% passing the 3/8 inch sieve and a minimum 90% passing the No. 4 sieve.

   To conduct the gradation testing, air dry a 500 to 700-gram sample of processed shingle material, dry sieve over the 3/8-inch and No. 4 sieves, and weigh. For mix design purposes, the Contractor may use the aggregate gradation specified in Table 411.03-8 as a standard gradation instead of determining the shingle gradation according to AASHTO T 30.

Table 411.03-8: Standard Gradation (for Mix Design Purposes)

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	97
No. 8	95
No. 16	80
No. 30	60
No. 50	50
No. 100	40
No. 200	30

An aggregate bulk specific gravity (G_{sb}) of 2.650 may be used instead of determining the shingle aggregate G_{sb} according to AASHTO T 84. In addition, the effective binder available for mixing with additional aggregates shall be considered as 75% of the total binder content as determined by AASHTO T 164 and shall be the value listed as the RAS binder content on the JMF.

Scrap asphalt shingle shall not contain extraneous waste materials. Extraneous materials including, but not limited to, asbestos, metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastics, shall not exceed 0.5% by weight as determined on material retained on the No. 4 sieve. To conduct deleterious material testing, take a representative 500 to 700-gram sample of processed shingle material, place over the No. 4 sieve, and pick and weigh all extraneous waste material retained on the No. 4 sieve. Base the percent of extraneous material on the total sample weight.

RAS shall contain less than the maximum percentage of asbestos fibers based on testing procedures established by the Department, or State or Federal environmental regulatory agencies. Analyze a minimum of one sample of processed asphalt roofing material for every 500 tons of material processed for the presence of asbestos.

Before a JMF for a particular design is approved, submit the following, along with the materials and information specified in **407.03**:

a. Certification by the processor of the shingle scrap describing the shingle scrap content and source.

b. A 1000-gram sample of the processed RAS material for inspection (new designs only).

Stockpile RAS separately from other salvage material. Do not blend RAS material in a stockpile with other salvage material. Do not blend Manufacture Waste Scrap Shingles (MWSS) and Tear-Off Scrap Shingles (TOSS). In addition, do not blend virgin sand material with the processed shingles, to minimize agglomeration of the shingle material.

All RAS supplied to a Department project shall come from a certified shingle processor/supplier approved by the Division of Materials and Tests.

D. Anti-Strip Additive

Check asphaltic concrete surface mixtures (Grading D and E) for stripping by the Ten Minute Boil test for dosage rate and ASTM D4867 (Root-Tunnecliff procedure) for moisture susceptibility.

If moisture susceptibility is indicated, then mix an approved anti-strip agent with the asphalt cement at the dosage recommended by the respective test and as specified in **921.06.B**.

EQUIPMENT

411.04 Equipment

Provide equipment as specified in **407.04** through **407.08**.

To construct shoulder mixes with recycled material, provide equipment that complies with **407**, except modify the asphalt plant as approved by the Engineer to accommodate the addition of asphalt planings. If using a batch plant to produce recycled mix, heat the aggregate to a temperature that will transfer sufficient heat to the cold planings to produce a mix of uniform temperature within the specified range.

CONSTRUCTION REQUIREMENTS

411.05 General Requirements

Construct the pavement as specified in **407.09**, **407.11**, **407.12**, and **407.14** through **407.17** and the following Subsections.

411.06 Preparing the Designated Surface

Prepare the designated surface upon which the material is to be placed as specified in **404.05.**

Ensure that loops used for traffic signals are installed before applying the final surface.

411.07 Mixing

Perform mixing as specified in **407.13**. In addition, the mixing cycle for surface course mixtures may require a dry-mixing period.

411.08 Surface Requirements

The surface shall meet the requirements specified in **407.18**, and when tested according to the provisions of that Subsection, the deviation of the surface from the testing edge of the straightedge shall not exceed 1/4 inch.

COMPENSATION

411.09 Method of Measurement

The Department will measure Mineral Aggregate, including Mineral Filler when required, Asphalt Cement for Asphaltic Concrete Surface (Hot Mix), and other related items in accordance with **407.19**.

For bidding purposes, use the asphalt cement content specified in Table 411.09-1.

Table 411.09-1: Asphalt Cement Content

Mix Type	Asphalt Content, %
411-D	5.9
411-E Roadway	6.3
411-E Shoulder	6.3
411-TL	6.3
411-TLD	5.9
411-OGFC	6.0

If the Engineer sets an asphalt content other than that specified above, the Department will make a price adjustment based on the asphalt content set by the Engineer and the Monthly Bituminous Index for the specific grade asphalt cement on the mix design. The Department will calculate a price adjustment in accordance with **407.20**.

411.10 Basis of Payment

The Department will pay for accepted quantities of Asphaltic Concrete Surface (Hot Mix) or asphaltic Concrete Surface (Hot Mix) (Shoulders) with or without recycled material, at the contract prices, complete in place, in accordance with **407.20**.

SECTION 903 – AGGREGATES

903.01 Fine Aggregate for Concrete

For concrete provide aggregate conforming to AASHTO M 6, with the following exceptions and additions:

903.06 Aggregate for Plant Mix Base and Leveling Courses (Hot Mix)

For plant mix base and leveling courses, provide coarse aggregate, fine aggregate, and mineral filler when required.

If at any time the sources of materials are changed, prepare and submit a new mix design as specified in **407.03**.

A. Coarse Aggregate (retained on a No. 4 sieve)

Provide crushed stone, crushed granite, crushed gravel, crushed slag, or a combination of these materials. This material shall conform to the quality requirements of ASTM D692, except that the sodium sulfate soundness loss shall not exceed 9%, and the aggregate shall contain no more than 5% soft or nondurable particles.

Crushed gravel shall consist of siliceous particles processed from washed material. At least 70% by count of the gravel retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle. Do not add pea gravel or uncrushed particles.

For virgin coarse aggregate for Grading A, ACRL, and AS mixes, use crushed stone, crushed slag, or a combination of these materials.

The absorption of combined aggregate passing the 3/4-inch sieve and retained on the No. 4 sieve, for use in Grading CW mixes, shall not exceed 5% when tested in accordance with AASHTO T 85.

B. Fine Aggregate (passing a No. 4 sieve)

Provide limestone fines, natural sand, sand manufactured from stone, gravel, or slag, or combinations of these materials, consisting of hard, tough grains free from injurious amounts of deleterious substances. When subjected to five cycles of the sodium sulfate soundness test, the material shall have a weighted loss of not more than 12%. Do not use fine aggregate or screenings containing calcium sulfate ($CaSO_4$/gypsum) if more than 5% of the material passing the No. 8 sieve is chemically composed of sulfur trioxide (SO_3).

In natural sand or sand manufactured from gravel, the percentage of material finer than No. 200 sieve shall not exceed 5%.

For use in Grading A and AS mixes, provide virgin fine aggregate consisting of crushed stone or crushed slag only, and store the material separately from the coarse aggregate.

Ensure that the amount of deleterious substances in natural sand does not exceed the limits specified in Table 903.06-1.

Table 903.06-1: Maximum Limits for Deleterious Substances in Natural Sand

Substance	Maximum Permissible Limits, Percent by Weight
Clay Lumps	0.5
Coal and Lignite	0.5
Other deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles) and organic impurities as determined by AASHTO T 267	3.0

C. Combined Aggregate Grading

Provide the appropriate combination of coarse aggregate and fine aggregate to achieve the combined grading. Use a minimum of three sizes of aggregate for all mix designs except for C, CS, and CW mixes, which shall be designed from a minimum of two sizes of aggregate.

Establish a gradation for each aggregate used in the mix. Table 903.06-2 specifies the stockpile gradation tolerance on each sieve for each virgin aggregate component used in the mix.

Table 903.06-2: Stockpile Gradation Tolerance

Sieve Size	Gradation Tolerance
3/8 inch sieve and larger	± 10%
No. 4 sieve	± 7%
No. 8 sieve	± 5%
No. 30 sieve	± 4%
No. 200 sieve (coarse aggregate)	± 2%
No. 200 sieve (fine aggregate)	± 4%

When the coarse aggregate portion of Grading CW mix is crushed limestone, use no less than 20% and no more than 50% by weight natural sand, or sand manufactured from slag or other approved non-skid aggregate. When the coarse aggregate portion is crushed gravel or crushed slag, between 15% and 40% by weight of the mineral aggregate shall be agricultural limestone or Size No. 10 limestone screenings.

The gradations of the coarse and fine fractions of aggregate shall be such that, when combined in proper proportions, the resultant mixture will meet one of the gradings specified in Tables 903.06-3 and 903.06-4.

Table 903.06-3: Hot Plant Mix Base Course Mixture Design Range of Gradations

Sieve Size	Total Percent Passing, by Weight			
	Grading A	Grading AS	Grading ACRL	Grading B
2 inch	100	100	100	100
1-1/2 inches	81-100	75-100	80-93	95-100
3/4 inch	50-71	55-80	60-75	70-85
3/8 inch	35-50	--	--	49-72
No. 4	24-36	7-11	12-16	34-51
No. 8	13-27	--	--	23-42
No. 30	7-17	--	--	11-22

Sieve Size	Total Percent Passing, by Weight			
	Grading A	Grading AS	Grading ACRL	Grading B
No. 50	--	--	--	9-14
No. 100	0-10	0-6	0-4	4-10
No. 200	0-4.5	0-4.5	0-3.5	2.5-6.5

Table 903.06-4: Hot Plant Mix Leveling Course Mixture Design Range of Gradations

Sieve Size	Total Per Cent Passing, by Weight				
	Grading BM	Grading BM2 [(1)]	Grading C	Grading CW	Grading CS
1-1/4 inch	--	100	--	--	--
1 inch	100	--	--	--	--
3/4 inch	85-100	81-93	100	100	--
3/8 inch	59-79	57-73	70-90	75-100	100
No. 4	42-61	40-56	39-66	--	89-94
No. 8	29-47	28-43	23-47	43-67	53-77
No. 30	13-27	13-25	10-27	23-47	23-42
No. 50	7-20	9-19	8-15	--	--
No. 100	4-10	6-10	4-8	4-10	9-18
No. 200	0-6.5	2.5-6.5	2.5-6.5	2.5-6.5	6-13.5

(1) When using natural sand as the fine aggregate, limit it to a maximum amount of 20% by weight of the mineral aggregate.

For asphalt treated permeable base as specified in **313**, meet the gradation requirements specified in Table 903.06-5.

Table 903.06-5: Gradation Requirements for Asphalt Treated Permeable Base

Sieve Size	Total Percent Passing by Weight
2 inch	100
1-1/2 inch	70-100
3/4 inch	55-80
No. 4	0-11
No. 100	0-4
No. 200	0-3

903.07 Reserved

903.08 Reserved

903.09 Reserved

903.10 Aggregate for Bituminous Plant Mix Surface Course (Cold Mix)

For cold bituminous plant mix, provide mix aggregate, consisting of crushed stone or crushed slag, meeting the quality requirements of ASTM D692. Crushed slag aggregate retained on the No. 4 sieve shall contain no more than 20% by weight of glassy particles.

The amount of material finer than the No. 200 sieve, as determined in accordance with AASHTO T 11, shall not exceed 1%. If all material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this percentage may be increased to 1.5.

For leveling and surface course mixtures, provide mix aggregate meeting the gradation requirements specified in **903.22** for Size No. 68.

For key or choker aggregate, provide crushed stone, crushed slag, or crushed gravel meeting the gradation requirements specified in **903.22** for Size No. 8 and the same quality requirements as the mix aggregate.

903.11 Aggregate for Asphaltic Concrete Surface Courses (Hot Mix)

Provide aggregate, consisting of a combination of coarse and fine aggregate, and mineral filler when required or specified. Use a minimum of three sizes of aggregates for all mix designs.

If at any time the sources of materials are changed, provide a new mix design as specified in **407.03.C.2**.

A. Coarse Aggregate (retained on a No. 4 sieve)

Provide aggregate, consisting of crushed stone, crushed slag, crushed gravel, crushed granite, crushed quartzite, crushed gneiss, or combinations of these materials. The coarse aggregate shall meet the quality requirements of ASTM D692, with the following exceptions and additions:

1. Sodium sulfate soundness loss shall not exceed 9%.

2. Material retained on the No. 4 sieve shall contain a maximum of 20% elongated pieces (length greater than five times the average thickness).

3. Combined aggregate shall consist of siliceous particles processed from washed material, of which at least 70% by count of the material retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle. Do not add pea gravel or uncrushed particles. The absorption of the crushed combined aggregate retained on the No. 4 sieve shall not exceed 5% when tested in accordance with AASHTO T 85.

4. Crushed slag coarse aggregate shall contain no more than 20% by weight of glassy particles.

B. Fine Aggregate (passing a No. 4 sieve)

Provide fine aggregate, consisting of natural sand, fines prepared from stone, slag, gravel, granite, quartzite, gneiss, or combinations of these materials. The fine aggregate shall meet the following requirements:

1. Fine aggregate shall consist of hard tough grains free from injurious amounts of clay, loam, or other deleterious substances.

2. When subjected to five cycles of sodium sulfate soundness test, the fine aggregate shall have a weighted loss of not more than 12%.

3. Manufactured sand shall have no more than 5% passing the No. 200 sieve when tested in accordance with AASHTO T 11.

4. Do not use fine aggregate or screenings containing calcium sulfate ($CaSO_4$/gypsum) if more than 5% of the material passing the No. 8 sieve is chemically composed of sulfur trioxide (SO_3).

5. Wash and grade natural sand so that not more than 5% will be retained on the No. 4 sieve.

6. For fine aggregate consisting of natural sand, the amount of material finer than a No. 200 sieve, as tested in accordance with AASHTO T 11, shall not exceed 4% by weight.

   The amount of deleterious substances in natural sand shall not exceed the limits specified in Table 903.11-1.

Table 903.11-1: Limits of Deleterious Substances in Natural Sand used in Hot Mix

Substance	Maximum Permissible Limits Percent by Weight
Clay Lumps	0.5
Coal and Lignite	0.5
Other deleterious substances (such as shale, alkali, mica, coated grains, soft and flaky particles) and organic impurities as determined by AASHTO T 267	3.0

7. When using agricultural limestone as a portion of the fine aggregate, manufacture it from sound, durable stone that is

crushed so that at least 85% will pass the No. 8 sieve and at least 50% will pass the No. 30 sieve.

C. Combined Aggregate Grading

Provide aggregate fractions sized, graded, and combined in proportions that will ensure the resulting composite blend will meet one of the gradation requirements specified in Table 903.11-2, together with the additional requirements pertaining to the constituents of the blend specified thereafter.

Establish a single value for each sieve size required in the mix for each virgin aggregate stockpile, with an allowable stockpile tolerance on each sieve as specified in Table **903.06-2**.

When using Gradings D or E for the surfacing of shoulders or for other non-traffic lane construction, the Contractor may modify the design with the Engineer's approval.

Table 903.11-2: Asphalt Concrete Surface Course Mixture Designation Design Range of Gradations

Sieve Size	Total Percent Passing by Weight				
	Grading D	Grading E	Grading TL	Grading TLD	Grading OGFC
3/4 inch	--	--	--	--	100
5/8 inch	100	100	--	--	--
1/2 inch	95-100	95-100	100	100	85-100
3/8 inch	80-93	80-93	100	90-100	55-75
No. 4	54-76	54-76	89-94	54-76	10-25
No. 8	35-57	35-57	53-77	35-57	5-10
No. 30	17-29	17-29	23-42	17-33	--
No. 50	10-18	10-18	--	10-18	--
No. 100	3-10	3-11	9-18	3-10	--
No. 200	0-6.5	0-8	6-14	4-7	2-4

1. **Grading D and TLD.** Use fine aggregate consisting of natural sand or sand manufactured from gravel, slag, or from crushed stone aggregate meeting the physical and chemical requirements specified in **903.24**. The use of carbonate rocks such as limestone and dolomite or other aggregates that tend to polish under traffic will not be permitted in the coarse aggregate and will be permitted only to the extent specified herein in the fine aggregate.

   When using limestone screenings or agricultural limestone, the maximum amount by weight of the mineral aggregate shall be 25% unless the material is shown to meet the same requirements for limestone as specified in Table **903.24-1** for Surface Mixtures. In no case shall the combined aggregate blend consist of less than 75% non-skid material. When using natural sand as fine aggregate, limit it to a maximum amount of 25% by weight of the mineral aggregate. The Contractor may substitute a maximum of 5% mineral filler meeting the requirements of **903.16** for an equal quantity of the limestone fines. If the mixture does not comply with the design criteria, provide another source of aggregate.

   When using gravel as the coarse aggregate for a 411 Grading D mix, use a minimum of 20% by weight limestone screenings, agricultural limestone, or mineral filler.

   Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

2. **Grading E.** When using Grading E as a surface for traffic lanes, 50% to 80% of the mineral aggregate shall be composed of crushed limestone, and the remaining 50% to 20% shall be natural sand, slag sand, sand manufactured from gravel or other approved non-skid aggregates, or any combination of these materials, with the following exceptions:

   a. The sand percentage on the Job Mix Formula (JMF) shall range from 20% to 50%. However, if needed to meet or improve the specified design criteria, the Contractor may alter the limestone and sand percentage by 5% from the percentage shown on the original JMF. If altering the aggregate percentages shown on the original JMF, submit a revision of the original design showing the altered percentages of aggregate.

b. When using Grading E for surfacing of shoulders or other non-traffic lane construction, the mineral aggregate may be composed entirely of limestone, including Size No. 10 (screenings) and manufactured sand, but in no case shall the mineral aggregate for this construction consist of less than 50% limestone.

c. Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

3. **Grading OGFC.** A minimum of 75% of the aggregate shall meet the requirements specified in **903.24** for Surface Mixtures (Non-Skid Aggregates). The coarse aggregate shall have at least 90% crushed aggregate with two fractured faces and 100% with one fractured face as determined in accordance with ASTM D5821. The coarse aggregate shall have a LA Abrasion value of less than 30% and a maximum absorption of 3.0%.

   Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

4. **Grading TL.** A minimum of 75% of the aggregate shall meet the requirements specified in **903.24** for Surface Mixtures (Non-Skid Aggregates) for the appropriate traffic level. The mixture shall contain a maximum of 15% natural sands.

   Recycled Asphalt Pavement (RAP) milled from Department or other State Highway Agency projects shall be assumed to contain 75% non-skid material.

903.12 Aggregate for Slurry Seal and Micro-Surface

A. Aggregate for Slurry Seal

A minimum of 50% of the aggregate shall be crushed slag, crushed granite, or crushed stone (crushed stone as specified in **903.24**), meeting the requirements of ASTM D692, except the gradation shall be as specified in Table 903.12-1. The aggregate shall have a minimum sand equivalent, as determined in accordance with AASHTO T 176, of 45.

Use a pug mill to mix blends of more than one aggregate source. Do not blend aggregates with a front end loader. Proportion the aggregate to produce a uniform gradation meeting the requirements specified in Table 903.12-1.

Table 903.12-1: Gradation Limits for Aggregate for Slurry Seal Based on Wash Gradation

Sieve	Design Master Range (Total Percent Passing)	Mixture Control Tolerances
3/8 inch	100	
No. 4	90-100	±6.0
No. 8	65-90	±5.0
No. 16	45-70	±5.0
No. 30	30-50	±4.0
No. 50	20-38	±4.0
No. 100	12-28	±3.0
No. 200	8-16	±3.0

B. Aggregate for Micro-Surface

A minimum of 50% of the–aggregate shall be crushed slag, crushed granite, or crushed stone (crushed stone as specified in **903.24**) meeting the gradation limits specified in Table 903.12-2 and the physical properties of ASTM D692, except the percent of fractured pieces shall be 100. The aggregate shall have a minimum sand equivalent, as determined in accordance with AASHTO T 176, of 65. Polish-resistant aggregates will not be required for leveling courses, provided they will be covered with riding surface mixtures.

Use a pug mill to mix blends of more than one aggregate source. Do not blend aggregates with a front end loader. Proportion the aggregate to produce a uniform gradation meeting the requirements specified in Table 903.12-2.

Table 903.12-2: Gradation Limits for Aggregate for Micro-Surfacing Based on Wash Gradation

Sieve	Design Master Range (Total Percent Passing)	Mixture Control Tolerances
3/8 inch	100	
No. 4	70-98	±6.0
No. 8	45-70	±5.0
No. 16	28-50	±5.0
No. 30	19-34	±4.0
No. 50	12-25	±4.0
No. 100	7-18	±2.0
No. 200	4-15	±2.0

903.13 Aggregate for Bituminous Seal Coat

Provide aggregate consisting of crushed stone, crushed slag, or crushed gravel, meeting the quality requirements of ASTM D692, except that at least 50% by count of crushed gravel aggregates shall have at least one fractured face. Crushed slag aggregate retained on the No. 4 sieve shall contain no more than 20% by weight of glassy particles. Provide aggregates meeting the requirements of **903.24**.

The amount of material finer than the No. 200 sieve shall not exceed 1%. If all material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, the percentage may be increased to 1.5.

Use aggregate meeting the gradation requirements in **903.22** for the size identified on the Plans and in accordance with Table **405.06-1**.

903.14 Aggregate for Double Bituminous Surface Treatment

Provide aggregate meeting **903.13**. In the mat, use aggregate meeting the gradation requirements specified for Size No. 7 in **903.22**. In the seal, use aggregate meeting the gradation requirements specified for Size No. 8 in **903.22**. Ensure that at least 90% of the aggregate particles retained on the No. 4 sieve have one or more fractured faces fractured for the approximate average diameter or thickness of the particle.

903.15 Aggregate for Aggregate-Cement Base Course

Provide coarse aggregate, composed of sound, tough, durable fragments of crushed stone, crushed slag, crushed or uncrushed gravel, or crushed or uncrushed chert, which may be blended with crushed recycled concrete or screened reclaimed asphalt pavement (RAP), and fine aggregate composed of natural or manufactured sand, and silt-clay or other finely divided mineral matter.

Provide gravel or chert aggregate that is screened and of such gradation that 100% will pass a 1-1/2 inch sieve, not more than 75% will pass the No. 4 sieve, and not less than 5% nor more than 15% will pass the No. 200 sieve. The fraction passing the No. 40 sieve shall have liquid limit not greater than 35, and a plasticity index not greater than 10. Provide crushed stone or slag aggregate that is sized and proportioned to meet the gradation requirements specified in **903.05** for Grading D. Blend materials, if required, at the screening plant or at the stationary mixing plant.

The Contractor may use recycled concrete aggregate or reclaimed asphalt pavement (RAP), at a maximum rate of 25% by weight, provided the combined aggregate blend meets all the requirements specified above. Crush and screen the recycled concrete and/or asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the recycled stockpiles free of bricks, steel, wood, and all other deleterious materials. The virgin and recycled material blend shall meet the quality requirements specified in Table **903.05-1**.

Ensure that the combined total of shale, organic material, and other unwanted substances does not exceed 5% by weight.

903.16 Mineral Filler

Provide mineral filler conforming to AASHTO M 17, except that the mineral filler shall be non-plastic.

903.17 Aggregate for Underdrains

Provide crushed stone, crushed slag, or washed gravel meeting the quality requirements of ASTM D692 and the gradation requirements specified for Size 6, 7, 8, 57, or 78 in **903.22**.

903.18 Aggregate for Sand-Asphalt Surface Course

Provide aggregate, consisting of natural sand, crushed siliceous material, or a combination of these materials, meeting the quality requirements of ASTM D1073. For natural sand, the percentage of material finer than the No. 200 sieve shall not exceed 5.

The natural sand or combination of these materials shall meet the gradation requirements specified in Table 903.18-1.

Table 903.18-1: Gradation Requirements for Aggregate for Sand-Asphalt Surface Course

Sieve Size	Total Percent Passing by Weight
No. 4	100
No. 8	95-100
No. 30	50-80
No. 50	30-60
No. 100	8-25
No. 200	2-10

903.19 Lightweight Aggregates for Structural Concrete

Provide lightweight aggregate conforming to AASHTO M 195, with the following additions:

1. Produce the lightweight aggregate by fusing raw shale, slate, or clay in a rotary kiln, to yield particles having a wear of not more than 40% when tested in accordance with AASHTO T 96.

2. The lightweight coarse aggregate shall conform to the gradation requirements for size 3/4 inch to No. 4, as shown in Table 1 of AASHTO M 195.

3. The absorption of the coarse aggregate shall not exceed 10% when tested in accordance with AASHTO T 85.

4. When the coarse aggregate is subjected to five alterations of the sodium sulfate soundness test in accordance with AASHTO T 104, the weighted percentage of loss shall not be more than 9.

5. Concrete with approximately 6% air content made from the aggregate shall have a minimum durability factor of 90% when tested in accordance with AASHTO T 161.

6. Use material listed on the Department's QPL.

903.20 Stockpiling Aggregates

Clean and grub sites for aggregate stockpiles before storing aggregates, and ensure the ground is firm, smooth, and well-drained. Maintain a cover of at least 3 inches of aggregate to prevent contamination by soil or foreign material. Build the stockpiles in layers not exceeding 4 feet in height, and have each layer completely in place before starting the next layer to prevent segregation. Deposit the material so as to prevent coning, except in the case of aggregate composed essentially of material finer than the No. 4 sieve and base material.

Do not dump, cast, or push material over the sides of stockpiles, except in the case of aggregate for base material and fine aggregate materials.

Unless otherwise approved, store aggregates from different sources or of different gradings, or that differ in specific gravity by more than 0.03, in separate stockpiles. To prevent the aggregates from mixing, either locate stockpiles of different types or sizes of aggregates far enough apart, or separate them with suitable walls or partitions.

When building stockpiles, only operate trucks or other equipment on a stockpile in a manner approved by the Engineer. Use stockpiling methods that will prevent both excessive degradation of the aggregate and contamination of the stockpile with foreign matter. The Engineer will determine excessive degradation by conducting sieve tests of samples taken from any portion of the stockpile over which equipment has operated; failure of such samples to meet all gradation requirements for the aggregate is cause for discontinuing such stockpiling procedure.

903.21 Test Methods

In stating requirements for most materials in Section **903**, reference has been made to AASHTO and ASTM Standard Specifications for materials. The current AASHTO or ASTM Standard Specification effective at the time of letting for a particular Contract shall be the governing specification. Those Specifications, in turn, include reference to the respective AASHTO and ASTM methods of sampling and testing. In a few instances, however, properties of materials in Section **903** have been specified without reference to corresponding AASHTO and ASTM Standard Specifications. In such instances, the methods of sampling and testing specified in Table 903.21-1 will govern.

Table 903.21-1: Aggregate Sampling and Testing Methods

Test	Test Method
Unit Weight	AASHTO T 19
Percentage of Wear	AASHTO T 96
Soundness	AASHTO T 104
Liquid Limit	AASHTO T 89
Plastic Limit and Plasticity Index	AASHTO T 90
Sieve Analysis	AASHTO T 27
Hydrometer Analysis	AASHTO T 88
Material Passing No. 200 Sieve in Aggregate	AASHTO T 11
Ten Minute Boil Test	**407.03.E.2**
Resistance to Plastic Flow by Marshall Method	AASHTO T 245 [1]

[1] Use a mechanically operated hammer with a rotating base. The compaction hammer shall have a slanted, circular tamping face. The slant on the face shall be 1.6% + 0.0/-0.1.

903.22 Sizes of Coarse Aggregate

See AASHTO M 43.

Table 903.22-1: Standard Sizes of Processed Aggregate

Size	Nominal Size, Square Openings	Amounts Finer than Each Laboratory Sieve (Square Openings), Percent by Weight														
		4"	3-1/2"	3"	2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	No.4	No.8	No.16	No.50	No.100
1	3-1/2" - 1-1/2"	100	90-100	--	25-60	--	0-15	--	0-5	--	--	--	--	--	--	--
2	2-1/2" - 1-1/2"	--	--	100	90-100	35-70	0-15	--	0-5	--	--	--	--	--	--	--
24	2-1/2" - 3/4"	--	--	100	90-100	--	25-60	--	0-10	0-5	--	--	--	--	--	--
3	2"-1"	--	--	--	100	90-100	35-70	0-15	--	0-5	--	--	--	--	--	--
357	2" - No. 4	--	--	--	100	95-100	--	35-70	--	10-30	--	0-5	--	--	--	--
4	1-1/2" - 3/4"	--	--	--	--	100	90-100	20-55	0-15	--	0-5	--	--	--	--	--
467	1-1/2" - No. 4	--	--	--	--	100	95-100	--	35-70	--	10-30	0-5	--	--	--	--
5	1" - 1/2"	--	--	--	--	--	100	90-100	20-55	0-10	0-5	--	--	--	--	--
56	1" - 3/8"	--	--	--	--	--	100	90-100	40-85	10-40	0-15	0-5	--	--	--	--
57	1" - No. 4	--	--	--	--	--	100	95-100	--	25-60	--	0-10	0-5	--	--	--
6	3/4" - 3/8"	--	--	--	--	--	--	100	90- 100	20-55	0-15	0- 5	--	--	--	--
67	3/4" - No. 4	--	--	--	--	--	--	100	90-100	--	20-55	0-10	0-5	--	--	--
68	3/4" - No. 8	--	--	--	--	--	--	100	90-100	--	30-65	5-25	0-10	0-5	--	--
7	1/2" - No. 4	--	--	--	--	--	--	--	100	90-100	40-70	0-15	0-5	--	--	--
78	1/2" - No. 8	--	--	--	--	--	--	--	100	90-100	40-75	5-25	0-10	0-5	--	--
8	3/8" - No. 8	--	--	--	--	--	--	--	--	100	85-100	10-30	0-10	0-5	--	--
89	3/8" - No. 16	--	--	--	--	--	--	--	--	100	90-100	20-55	5-30	0-10	0-5	--
9	No. 4 - No. 16	--	--	--	--	--	--	--	--	--	100	85-100	10-40	0-10	0-5	--
10	No. 4 – 0 (1)	--	--	--	--	--	--	--	--	--	100	85-100	--	--	--	10-30

(1) Screenings

903.23 Reserved

903.24 Aggregates for Riding Surfaces (Polish-Resistant Aggregates)

Provide coarse aggregate consisting of crushed gravel, crushed granite, crushed slag, crushed quartzite, or crushed gneiss meeting the BPN requirements of the table below. The Contractor may use other crushed aggregate provided it has the chemical, physical, and performance characteristics specified in Table 903.24-1.

Table 903.24-1: Quality Requirements for Type I, II, III, and IV Aggregate

Aggregate Property	Test Method	Type I (all roads)	Type II (all roads)	Type III (15,000 ADT max, excluding Interstates)	Type IV (5,000 ADT max)
Silica Dioxide Content, % min	ASTM C25	40%	30%	20%	10%
Calcium Carbonate Content, % max		32%	--	--	--
Acid Insoluble Residue, % min	ASTM D3042	50%	35%	25%	--
British Pendulum Number,[1] min	AASHTO T 278 AASHTO T 279	30	30	25	22

[1] After 9 hours of accelerated polishing using the British Wheel in accordance with AASHTO T 279

In addition to the requirements specified in Table 903.24-1, Type II, III, and IV aggregates shall have met the preapproval process of the Division of Materials and Tests. All aggregate types must also maintain a satisfactory level of field performance to remain an approved source.

Process and stockpile the material as an independent and separate operation. The Engineer will sample and test each stockpile for approval prior to use.

SECTION 904 – BITUMINOUS MATERIALS

904.01 Asphalt Cements

Only obtain asphalt cement for use on Department projects from Certified Asphalt Suppliers that have an approved Quality Control Plan in accordance with the Department's Standard Operating Procedures.

Asphalt cement shall conform to AASHTO M 320 and Department procedures.

Instead of PG 64-22, the Contractor may use asphalt cement graded to PG 67-22. PG 67-22 shall conform to the requirements of AASHTO M 320 when the applicable tests are conducted at 67 °C and -12 °C, and the dynamic shear of the rolling thin film, pressure aged vessel sample is tested at 26.5 °C.

To modify the asphalt, properly blend styrene butadiene (SB), styrene butadiene styrene (SBS), or styrene butadiene rubber (SBR) to a PG 64-22 or PG 67-22 base asphalt.

In addition to the above requirements, the PG 70-22, PG 76-22, and 82-22 shall meet the requirements specified in Table 904.01-1.

Table 904.01-1: Requirements for Asphalt Cement

Property	PG 70-22	PG 76-22	PG 82-22
Ring & Ball Softening Point, degrees F, minimum	128	135	150
Elastic Recovery by means of Ductilometer, % minimum	45	65	70

A. Test Procedures

1. **Elastic Recovery by means of a Ductilometer.** Test in accordance with AASHTO T 301 at 77 °F.

2. **Screen Test.** Pour a 1,000-gram sample heated to 275 °F through a No. 10 sieve. Ensure no lumps or particles are retained on the sieve.

3. **Viscometer Test.** In addition to the above, all hot mix asphalt mix plants using modified liquid asphalt products shall have a rotational viscometer, meeting ASTM D4402 requirements, with a thermostatically controlled cell. The mix producer shall run a minimum of one test per week on samples taken from the Contractor's storage tank. Viscosity values shall be in the ranges specified in Table 904.01-2 when tested at 275 °F.

Table 904.01-2: Asphalt Cement Viscosity Requirements

Property	PG 70-22	PG 76-22	PG 82-22
Viscosity Range (centipoise)	650-3,000	1,000-3,000	2,000-4,000 (1)

(1) Store PG82-22 at proper temperatures to maintain pumpability.

B. Materials Certification

Furnish a certification to the Engineer on each project stating that the asphalt cement provided meets the Department's specification. Ensure that quality control and compliance testing are completed in accordance with the asphalt supplier's approved quality control plan and Department procedures.

Where blending or modification occurs after the material has left the storage tanks, the supplier shall conduct a complete series of tests on a sample taken on the first day's production and biweekly thereafter for each grade being produced. Brookfield viscosity and DSR original tests shall be performed daily at the point of blending or modification. The DSR value $G^*/\sin\delta$ shall be ≥ 1.0 kPa at the high PG grade temperature (i.e., 158 °F for PG 70-22).

In addition, the producer shall provide a temperature-viscosity curve with a recommended mixing temperature range. In order to develop a temperature-viscosity curve, it may be necessary to run the viscosity test at a higher temperature, based on the softening point of the modified asphalt cement.

904.02 Reserved

904.03 Emulsified Asphalts

Provide emulsified asphalts meeting the test requirements specified in Table 904.03-1.

Table 904.03-1(a): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CAE-P	CSS-1	CSS-1H	SS-1H	TST-1P	CQS-1H
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	10-50	20-100	20-100	20-100	10-75	20-100
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	n/a	n/a	n/a	n/a	n/a	n/a
Storage Stability Test, 24- h, %	T59	1 Max	1 Max	1 Max	1 Max	n/a	n/a
5-day Settlement, %	T59	n/a	n/a	n/a	n/a	n/a	n/a
Particle Charge	T59	Positive	Positive	Positive	n/a	n/a	Positive
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max
Residue by	T59	Distillation	Distillation	Distillation	Distillation	Distillation[1]	Distillation
Residue, %	T59	n/a	57 Min	57 Min	57 Min	55-60	62 Min
Demulsibility, %	T59	n/a	n/a	n/a	n/a	n/a	n/a
Distillate, %	T59	55 Max	n/a	n/a	n/a	n/a	n/a
Oil Test, %	T59	12 Max	n/a	n/a	n/a	n/a	n/a
Stone Coating	T59	n/a	n/a	n/a	n/a	n/a	n/a
Float Test, seconds	T50	n/a	n/a	n/a	n/a	n/a	n/a
Penetration	T49	300 Min	100-250	40-90	40-90	75-150	40-90
Elastic Recovery, % [2]	T301	n/a	n/a	n/a	n/a	25 Min	n/a
Ductility @ 77 °F, cm	T51	40 Min	40 Min	40 Min	40 Min	n/a	40 Min
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	10-35	n/a
R&B Softening	T53	n/a	n/a	n/a	n/a	n/a	n/a

Practices	AASHTO Test Method	CAE-P	CSS-1	CSS-1H	SS-1H	TST-1P	CQS-1H
Point, °F							
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	n/a	n/a	n/a

(1) Distill at 400°F

(2) Straight-sided mold, 20-cm elongation, 5 min hold, 25 °C

Table 904.03-1(b): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CQS-1HP	SS-1	AEP	CRS-2	AE3
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	20-100	20-100	10-50	n/a	n/a
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	n/a	n/a	n/a	100-400	50 Min
Storage Stability Test, 24- h, %	T59	n/a	1 Max	n/a	1 Max	n/a
5-day Settlement, %	T59	n/a	n/a	5 Max	n/a	5 Max
Particle Charge	T59	Positive	n/a	n/a	Positive	n/a
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	n/a
Residue by	T59	Distillation[(1)]	Distillation	Distillation	Distillation	Distillation
Residue, %	T59	62 Min	57 Min	n/a	65 Min	n/a
Demulsibility, %	T59	n/a	n/a	n/a	40 Min	n/a
Distillate, %	T59	n/a	n/a	55 Max	n/a	30 Max
Oil Test, %	T59	n/a	n/a	12.0 Max	3.0 Max	6.0 Max
Stone Coating	T59	n/a	n/a	n/a	n/a	90 Min
Float Test, seconds	T50	n/a	n/a	20 Min	n/a	200 Min
Penetration	T49	40-90	100-200	n/a	100-250	n/a
Elastic Recovery, % [(2)]	T301	n/a	n/a	n/a	n/a	n/a
Ductility @ 77 °F, cm	T51	70 Min	40 Min	n/a	40 Min	n/a
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	n/a
R&B Softening Point, °F	T53	135 Min	n/a	n/a	n/a	n/a
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	n/a	n/a

[(1)] Distill at 350 °F

[(2)] Straight-sided mold, 20-cm elongation, 5 min hold, 25 °C

Table 904.03-1(c): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CRS-2P	RS-2	RS-1	TTT-1	TTT-2
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	n/a	n/a	20-100	30 Min	n/a
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	100-400	75-400	n/a	n/a	15-100
Storage Stability Test, 24- h, %	T59	1 Max	1 Max	1 Max	1 Max	1 Max
5-day Settlement, %	T59	n/a	n/a	n/a	5 Max	n/a
Particle Charge	T59	Positive	n/a	n/a	n/a	Positive
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max
Residue by	T59	*Evaporation*	Distillation	Distillation	Distillation	Distillation (1)
Residue, %	T59	65 Min	63 Min	55 Min	40 Min	58 Min
Demulsibility, %	T59	40 Min	60 Min	60 Min	n/a	n/a
Distillate, %	T59	n/a	n/a	n/a	n/a	n/a
Oil Test, %	T59	n/a	n/a	n/a	n/a	n/a
Stone Coating	T59	n/a	n/a	n/a	n/a	n/a
Float Test, seconds	T50	n/a	n/a	n/a	n/a	n/a
Penetration	T49	75-175	100-200	100-200	5-15	40-90
Elastic Recovery, % (2)	T301	50 Min	n/a	n/a	n/a	n/a
Ductility @ 77 °F, cm	T51	40 Min	40 Min	40 Min	40 Min	n/a
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	n/a
R&B Softening Point, °F	T53	125 Min	n/a	n/a	60-75	n/a
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	1.0 Min	n/a

(1) Distill at 350 °F

(2) Straight-sided mold, 20-cm elongation, 5min hold, 25 °C

The producer may conduct a 24-hour (1% Max) storage stability test instead of the 5-day settlement test if the emulsions are to be used within 5 days.

Obtain emulsified asphalts for use on Department projects from Certified Emulsified Asphalt Suppliers that have an approved Quality Control Plan in accordance with the Department's Standard Operating Procedures.

All emulsified asphalts shall be homogeneous, and shall adhere firmly to the surface of the mineral aggregate. Failure of the emulsified asphalt to perform satisfactorily on the job is cause for rejection, regardless of its ability to pass laboratory tests.

Use the AE-3 of such stability that it will remain constant and uniform while being mixed with dry or approximately dry aggregate, and that will thoroughly and uniformly coat the entire surface of each fragment while being manipulated and incorporated into the Work. The emulsified asphalt after being incorporated into the Work shall show no signs of re-emulsifying.

When approved by the Engineer, the Contractor may substitute cationic emulsions for anionic emulsions.

Use latex, polymer, and other emulsifiers of styrene butadiene rubber (SBR) or natural latex when manufacturing CQS-1hp. Mill such emulsifiers into the asphalt cement so as to show no separation after mixing.

When using modified emulsions in micro-surface mixtures, the blended mixture when combined with aggregate and mineral filler shall be:

1. Capable of filling up to 1/2-inch wheel ruts in one pass;
2. Capable of field regulation of the setting time; and
3. Suitable for nighttime placement.

Combine the latex with the asphalt emulsion at the emulsion mill to produce a homogeneous mixture. Latex modified emulsions, upon standing undisturbed for a period of 24 hours, shall have a uniform color throughout, showing no color striations.

SECTION 921 – MISCELLANEOUS MATERIALS

921.01 Water

For mixing concrete, use water that is reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, and other substances injurious to the finished product. Test water in accordance with AASHTO T 26. The Contractor may use water known to be of potable quality without testing. Where the source of water is relatively shallow, enclose the intake so as to exclude silt, mud, grass, and other foreign materials.

921.02 Calcium Chloride

A. Solid Form

Provide solid forms of calcium chloride conforming to the requirements of AASHTO M 144, for the type specified, except that the Department will waive requirements for total alkali chlorides and impurities when calcium chloride is to be used in mineral aggregate base or surface courses.

B. Liquid Form

Provide liquid forms of calcium chloride consisting of a clear liquid free from suspended matter and that meets the requirements specified in Table 921.02-1.

Table 921.02-1: Calcium Chloride Liquor

Component	Concentration of Calcium Chloride Liquor	
	32%	**38%**
Total Calcium Chloride by Weight, min.	32	38
Total Magnesium Chloride by Weight, max.	0.5	0.5

Do not use a calcium chloride solution of less than 32%.

Include with each shipment of calcium chloride liquor a certification from the manufacturer that states the concentration and new weight, and guarantees the percentage of calcium chloride.

921.03 Sodium Chloride

Provide sodium chloride conforming to ASTM D632, for the type specified.

921.04 Lime

Provide lime conforming to the requirements of ASTM C977, for the type specified.

921.05 Select Material for Soil-Cement Base

Provide select material for soil-cement base of such general character as to be classified as Group A-1 or A-2, in accordance with AASHTO M 145, and of such size that all will pass the standard 1-1/2 inch sieve.

921.06 Chemical Additives

A. Admixtures

1. **Portland Cement Concrete Mixtures.** Provide additives that are listed on the QPL and conform to AASHTO M 194 for the following seven types of admixtures:

   Type A - Water reducing admixtures
   Type B - Retarding admixtures
   Type C - Accelerating admixtures
   Type D - Water-reducing and retarding admixtures
   Type E - Water-reducing and accelerating admixtures
   Type F - Water-reducing, high range admixtures
   Type G - Water-reducing, high range admixtures and retarding admixtures
   Type S - Specific performance admixtures

   Before the Department will approve any admixture for use in Portland cement concrete mixtures under these Specifications, either the manufacturer of the admixture or the Contractor shall furnish the Department documentary evidence that the material proposed for use has been tested in accordance with the test methods in AASHTO M 194 and meets the requirements of that specification. Documentary evidence shall include the results of tests conducted by a testing laboratory inspected at regular intervals by the National Bureau of Standards and approved by the Department. The Department may require a notarized certification from the manufacturer stating that the material is identical to that originally approved and has in no way been changed or altered.

2. **Air-Entraining Admixtures.** Use air-entraining admixtures that are listed on the Department's QPL and conform to AASHTO M 154, except that the tests for bleeding, bond strength, and volume change will not be required.

   The Department may approve a product if the manufacturer or Contractor furnishes test data from a recognized laboratory showing that the air-entraining admixture proposed for use conforms to the requirements of these Specifications. A recognized laboratory is defined as one of the following: A State Transportation Department Laboratory; a Federal Highway Administration Laboratory; or other laboratories that are regularly inspected by the Cement and Concrete Reference Laboratory and approved by the Department.

B. Bituminous Additives

1. **Anti-Stripping Additive.** Use hydrated lime conforming to ASTM C977 or other heat-stable asphalt anti-stripping additive containing no ingredient harmful to the bituminous material or the workmen and that does not appreciably alter the specified characteristics of the bituminous material when added in the recommended proportions.

   When hydrated lime is the anti-stripping additive, use an amount equal to 1% by weight of the aggregate. Uniformly coat the aggregate with the lime, to the Engineer's satisfaction, before adding the bituminous material to the mixture.

   When using an anti-stripping additive other than hydrated lime, the percentage of anti-stripping additive used shall range between 0.3% to 0.5% by weight of the asphalt cement.

   The Department's QPL identifies qualified antistripping products. Do not use any product unless it appears on this list.

2. **Silicone Additives.** Mix silicone additives at the rate of 1 pint of silicone per 4 gallons of diesel fuel. The Contractor may use a 1/2 pint of this mixture per 1,000 gallons of asphalt.

3. **Warm Mix Asphalt (WMA) Additives.** The Contractor may add organic wax or foaming additives to bituminous plant mix to reduce placement temperatures as specified in **407.11**. Introduce the WMA additives into the mixture at a constant rate, sufficient to produce the mix temperatures specified in **407.11**, and in a manner approved by the Department. Record all changes to the proportions of the additive used during the course of mix production. The Department's QPL identifies qualified WMA additives. Only use additives appearing on this list.

921.07 Masonry Stone

Provide sound, dense, and durable masonry stone, free from excessive cracks, pyrite intrusions, and other structural defects. Ensure that stones

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Supplemental Specifications

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STATE OF TENNESSEE

(Rev. 11-16-15) January 1, 2015
(Rev. 6-27-16)
(Rev. 12-2-16)
(Rev. 5-15-17)

Supplemental Specifications - Section 300

of the

Standard Specifications for Road and Bridge Construction

January 1, 2015

Subsection 303.01 (pg. 220) 5-15-17; add the following sentence as the last sentence of the 2nd paragraph:

> "Mineral aggregates base shall be Type A or Type B, whichever is shown on the Plans and called for in the bid schedule. Reclaimed Concrete Aggregate (RCA) may be used as an alternate for Type A or Type B base material."

Subsection 303.02 (pg. 220-221) 5-15-17; add the following sentence to the last sentence of the 1st paragraph:

> "Depending upon whether the Plans require Type A or Type B base, provide mineral aggregate meeting 903.05. For Type A base, use aggregate of Grading D. For Type B base, the Contractor may use aggregate of Grading C or D. For RCA, use grading specified in 903.05-C."

Subsection 303.07 (pg. 222-223) 5-15-17; modify the 1st sentence of the 1st paragraph to the following:

> "Construct Mineral Aggregate Base, Type A, ~~or~~ Type B, or RCA in one or more layers, to the compacted thickness shown on the Plans."

Subsection 303.08 (pg. 223-224) 5-15-17; add the last sentence to the last paragraph of subsection A:

> "For Mineral Aggregate Base, Type A, use the stationary plant method. For Mineral Aggregate Base, Type B, requiring the blending of two or more materials, use either the stationary plant method or the road mix method (mechanical mixer), except as provided for in **903.05**. For Mineral Aggregate Base, Type B, requiring additive, use either stationary plant mixing or road mixing. When using RCA as a replacement for Mineral Aggregate Base, Type A or Type B, use the intended method of mixing for the material listed above."

Subsection 303.10 (pg. 225-227) 5-15-17; add subsection c.:

"**2. Density Requirements**

a. **Type A Base.** The average density of each lot of Type A base, unless otherwise specified, shall be within 100% of maximum density as determined according to AASHTO T 99, Method D, with no individual test less than 97% of maximum density.

b. **Type B Base.** The average density of each lot of Type B base, unless otherwise specified, shall be not less than 97% of maximum density as determined according to AASHTO T 99, Method D, with no individual test being less than 95% of maximum density.

c. **RCA Base.** The average density of each lot of RCA base, unless otherwise specified, shall be not less than 100% of maximum density as determined according to AASHTO T 99, Method D, with no individual test less than 97% of maximum density. The moisture content shall be within ±3% of the optimum moisture content as determined by an independent laboratory analysis. Mixing of the material with water shall be completed per Section 303.08."

Subsection 303.14 (pg. 228) 5-15-17; revise the first sentence of A.:

"**A. Mineral Aggregate for Mineral Aggregate Base, Type A or Type B, or RCA**

The Department will measure Mineral Aggregate for Mineral Aggregate Base, Type A, ~~or~~ Type B, or RCA, by the ton, in accordance with **109**."

Subsection 307.03 (pg. 246) 11-16-15; Modify Table 307.03-3:

B. Recycled Asphalt Pavement for Bituminous Plant Mix Base, Table 307.03-3

Table 307.03-3: Mixtures Using RAP

Mix Type	% RAP (Non-processed)(1)	Maximum % RAP (Processed)(2)	Maximum % RAP Processed & Fractionated (3)	Maximum Particle Size (inches)
307-ACRL	0	00	-	-
307-AS	0	00	15	-
307-A	15	20	35	1-1/2
307-B	15	30	35	1-1/2
307-BM	15	30	35	3/4
307-BM2	15	30	35	3/4
307-C	15	30	35	3/8
307-CW	15	30	35	1/2
307-CS	0	15	25	5/16

(1) "Non-processed" refers to RAP that has not been crushed and screened or otherwise sized prior to its use.

(2) "Processed" refers to RAP that has been crushed and screened

or otherwise sized such that the maximum recycled material particle size is less than that listed in Table 307.03-3 prior to entering the dryer drum.

(3) "Fractionated" refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes (e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

(4) RAP for 307-AS must be processed in a manner such that the minimum particle size is no smaller than 3/4" prior to solvent extraction. For RAP containing gravel as coarse aggregate, the maximum allowable RAP content shall be 10%.

2. Recycled Asphalt Shingles (RAS) RAS may be included to a maximum of 3% of the total weight of the mixture.

Subsection 307.03 (pg. 246) 5-15-17; Modify Table 307.03-3:

B. Recycled Asphalt Pavement for Bituminous Plant Mix Base, Table 307.03-3

Table 307.03-3: Mixtures Using RAP

Mix Type	% RAP (Non-processed)(1)	Maximum % RAP (Processed)(2)	Maximum % RAP Processed & Fractionated (3)	Maximum Particle Size (inches)
307-ACRL	0	00	-	-
307-AS	10	10~~00~~	10~~15~~	-
307-A	15	20	35	1-1/2
307-B	15	30	35	1-1/2
307-BM	15	30	35	3/4
307-BM2	15	30	35	3/4
307-C	15	30	35	3/8
307-CW	15	30	35	1/2
307-CS	0	15	25	5/16

(1) "Non-processed" refers to RAP that has not been crushed and screened or otherwise sized prior to its use.

(2) "Processed" refers to RAP that has been crushed and screened or otherwise sized such that the maximum recycled material particle size is less than that listed in Table 307.03-3 prior to entering the dryer drum.

(3) "Fractionated" refers to RAP that has been processed over more than one screen, producing sources of various maximum particle sizes

(e.g., 3/4 to 1/2 inch, 1/2 inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.

~~(4) RAP for 307-AS must be processed in a manner such that the minimum particle size is no smaller than 3/4" prior to solvent extraction. For RAP containing gravel as coarse aggregate, the maximum allowable RAP content shall be 10%.~~

Subsection 307.03 (pg. 250) 6-27-16; C. revise the last paragraph to the following:

"Mix an approved antistrip agent with the asphalt cement at the dosage as specified in **921.06.B**."

Subsection 307.06 (pg. 250) 12-2-16; add the following as the second paragraph:

"Do not place AS/ACRL which cannot be covered by the next course of pavement within the same construction season."

Subsection 313.03 (pg. 273) 11-16-15; B. Bituminous Treated Permeable Base, add the following sentence to the end of the paragraph:

"Recycled Asphalt Pavement (RAP) meeting the requirements of 307.03.B may be incorporated into asphalt treated permeable base up to 15% by weight of aggregate. RAP must be processed in a manner such that the minimum particle size is no smaller than ¾" prior to solvent extraction. Treated permeable base mixtures containing RAP shall contain at least 65% virgin asphalt binder. For RAP containing gravel as a coarse aggregate, the maximum allowable RAP content shall be 10%"

Subsection 313.03 (pg. 273) 5-15-17; B. Bituminous Treated Permeable Base, revise the sentence added on 11-16-15 to the following sentence:

"Recycled Asphalt Pavement (RAP) meeting the requirements of 307.03.B may be incorporated into asphalt treated permeable base up to 10~~5~~% by weight of aggregate. ~~RAP must be processed in a manner such that the minimum particle size is no smaller than ¾" prior to solvent extraction.~~ Treated permeable base mixtures containing RAP shall contain at least 65% virgin asphalt binder. For RAP containing gravel as a coarse aggregate, the maximum allowable RAP content shall be 10%.

Mix an approved antistrip agent with the asphalt cement at the dosage as specified in **921.06.B.**"

Subsection 313.10 (pg. 276) 5-15-17; Basis of Payment, add the sentence as the third paragraph:

"The cost of antistrip additive used in Bituminous Plant Mix (Hot Mix) will be included in the price of Treated Permeable Base."

S T A T E **O F** **T E N N E S S E E**

(Rev. 5-18-15)
(Rev. 7-13-15)
(Rev.11-16-15)
(Rev. 6-27-16)
(Rev. 12-2-16)
(Rev. 1-6-17)
(Rev. 5-15-17)
(Rev. 11-6-17)

January 1, 2015

Supplemental Specifications - Section 400

of the

Standard Specifications for Road and Bridge Construction

January 1, 2015

Subsection 402.03 (pg. 282) 5-27-16; revise 0.2 to 0.05 in the range as shown in the 2nd paragraph:

> "The distributor shall be designed, equipped, maintained, and operated so that bituminous material at even heat may be applied uniformly on variable surface widths at readily determined and controlled rates from 0.05 to 0.5 gallons per square yard, with uniform pressure, and with an allowable variation from any specified rate of plus or minus 0.02 gallons per square yard."

Subsection 403.02 (pg. 285-286) 12-2-16; Bituminous Materials, remove trackless tack information from specifications and reference the QPL for approved Emulsified Trackless Tacks, remove trackless tacks from Table 403.02-1:

> "Emulsified Asphalt, SS-1, SS-1h, CSS-1, CSS-1h, TST-1P, CQS-1h, CQS-1hp……………………………………904.03 or Approved Emulsified Trackless Tack from the QPL.

Table 403.02-1: Tack Coat Application Temperatures

Material	Temperature Range
SS-1, SS-1h, CSS-1, TST-1P, CQS-1h, CQS-1hp and CSS-1h	60 to 140 °F

Subsection 403.02 (pg. 285-286) 11-16-15; Bituminous Materials, update the reference to 904.03, add TTT-3 to Table 403.02-1:

"Emulsified Asphalt, SS-1, SS-1h, CSS-1, CSS-1h, TST-1P, CQS-1h, CQS-1hp, TTT-1, TTT-2, TTT-3 ………………………………………………………………………………..904.03"

Table 403.02-1: Tack Coat Application Temperatures

Material	Temperature Range
SS-1, SS-1h, CSS-1, TST-1P, CQS-1h, CQS-1hp and CSS-1h	60 to 140 °F
TTT-1	160 to 180 °F
TTT-2	120 to 160 °F
TTT-3	100 to 180 °F

Subsection 403.05 (pg. 286) 11-16-15; A. Emulsified Asphalt, Add the following paragraph at the end of the subsection:

"Take a minimum of 3 cores throughout the length of the project for informational tack coat shear testing. Include the underlying layer. Not required for mats less than one inch thick."

Subsection 403.05 (pg. 287) 11-16-15;) B. Test Strip, modify the 2nd paragraph to update the rate as 0.08 and 0.12:

"If placing the bituminous material upon a milled surface, apply the tack material at a rate of between 0.08 and 0.12 gallons of applied emulsion per square yard."

Subsection 403.05 (pg. 287) 6-27-16; revise the last sentence of the 2nd paragraph:

"If placing the bituminous material upon a milled surface, apply the tack material at a rate of between 0.08 and 0.12 gallons applied emulsion per square yard."

Subsection 403.05 (pg. 287), 11-6-17; Revise the 1st sentence of the 1st paragraph:

"When the Contract requires bituminous material for fog sealing of shoulders, provide emulsified asphalt meeting **403.02** or an item from QPL 40A ~~meeting **403.02**~~**."**

Subsection 404 (pg. 289-293) 1-6-17; Remove the entire subsection. All specifications regarding Double Bituminous Surface Treatment has been incorporated into subsection 405. All references shall be updated to subsection 405.

Subsection 405 (pg. 294-298) 1-6-17; replace subsection 405 with the following:

"405.01 Description

This work consists of constructing a bituminous seal coat consisting of one or more applications each of bituminous material and cover aggregate.

MATERIALS

405.02 Materials

Provide materials as specified in:

Mineral Aggregate, Size Nos. 7, 8, 78, 89.............. 903.13
Mineral Aggregate………………………………..... 903.14
Emulsified Asphalt, CRS-2p 904.03

Apply seal coat at a temperature range of 60 to 140 °F.

EQUIPMENT

405.03 Equipment

Provide a power broom or other mechanical sweeping equipment, equipment for heating bituminous material, a pressure distributor meeting the requirements of 402.03, pneumatic-tire and steel-wheel rollers, self-propelled mechanical aggregate spreading equipment that can be adjusted so as to spread accurately at the specified rate, and such other equipment and small tools as may be required to perform the work in a satisfactory manner.

CONSTRUCTION REQUIREMENTS

405.04 Limitations

Only apply bituminous material:

1. When the designated surface is dry, firm, and properly cured;
2. Between April 15 and October 1; and, unless otherwise directed,
3. When the ambient temperature in the shade and away from artificial heat is 70°F or more.

405.05 Preparing the Designated Surface

Before placing seal coat, clean all surfaces to be sealed by sweeping with a motorized broom to remove any loose material. Clean depressions and cracks not reached by the power broom using hand brooms or pressurized air.

Cover any utility installations to prevent adherence of the bituminous mixture. Suitable covering includes plywood disks, sand, craft paper, roofing felt or other approved methods. Remove the protective coverings before opening the road to traffic. The cost for these adjustments shall be included in the bid price for other items.

The Plans will indicate whether the surface is to be constructed on a treated or untreated subbase, a granular base, an asphalt base, or on an existing surface. The surface of the base or sub-base upon which the construction is to be placed shall meet the requirements of the applicable Section of Part 3, Bases and Subgrade Treatments, of these Specifications.

Condition existing surface, if called for on the Plans, as specified in 407.10. Condition existing mineral aggregate base as specified in 310.

Construct and maintain Prime Coat or Tack Coat, if shown on the Plans, as specified in 402 or 403, respectively.

405.06 Application

A. Applying Bituminous Material:

Have all equipment calibrated prior to starting work. The TDOT inspector shall be present during calibration to determine aggregate spread rate and distributor rates. Distributor trucks shall have proper calibration of spray equipment. Spray nozzles should be clean, properly angled, and appropriately sized for the desired application rate. Stop work if the distributor is not applying material properly, such as gaps in application or streaking.

Place a 500 ft. test strip for the bituminous seal coat at the beginning of the project to assure proper coverage and proper equipment calibration. The test section is to verify break time of emulsion and chip retention. The test strip shall be able to carry normal traffic within 3 hours. If normal traffic cannot be carried, the emulsion shall be adjusted and another test strip is required.

At least 14 working days before the scheduled start of construction of any bituminous seal coat, submit a sample of aggregate intended for use for the determination of the appropriate application rates of bituminous material and aggregate. Apply emulsified asphalt by pressure distributor at a uniform rate in accordance with Table 405.06-1 below. The exact rate will be established by the Engineer.

Table 405.06-1: Application Rates for Bituminous Material

Aggregate Size (per 903.22)	Aggregate Spread Rate (lb/yd^2)	Emulsion Shot Rate (gal/yd^2)
7	25 – 30	0.30 – 0.45
78	22 – 28	0.28 – 0.38
8	20 – 25	0.20 – 0.35
89	17 – 23	0.17 – 0.28

Before beginning each spread, place building paper across the roadway surface with the forward edge exactly coinciding with the end of the preceding covered spread. Start distributors on the paper, the width of which shall allow the full force of all nozzles to be in effect before the forward edge of the paper is reached. If required by the Engineer, also stop the spread on building paper. Remove the paper immediately after its use, and dispose of properly. Immediately correct all defects in application.

The length of spread of bituminous material shall not exceed that which trucks loaded with cover material can immediately cover.

The spread of bituminous material shall not extend more than 6 inches wider than the width covered by the cover material. Do not allow the bituminous material to chill or otherwise impair retention of the cover material.

Do not allow traffic on the bituminous material until it has been covered with mineral aggregate.

Treat areas that are inaccessible to the distributor with either hand sprays or pouring pots as directed by the Engineer.

B. Application of Double Bituminous Surface Treatment:

First Application

Apply the first application of emulsified asphalt using pressure distributors at a uniform rate established by the Engineer within the range of 0.30 to 0.38 gallons per square yard. Apply each spread of bituminous material so as not to be more than 6 inches wider than the width covered by the immediate spread of cover aggregate. Each width of spread shall not be less than half the surface to be treated.

Before beginning each spread, place building paper across the roadway surface with the forward edge exactly coinciding with the end of the preceding covered spread. Start distributors on the paper, the width of which shall allow the full force of all nozzles to be in effect before the forward edge of the paper is reached. If required by the Engineer, also stop the spread on building paper. Remove the paper immediately after its use, and dispose of properly. Immediately correct all defects in application.

Treat areas that are inaccessible to the distributor with hand sprays or pouring pots as directed by the Engineer.

If treating less than the full width of the roadway, do not spread the aggregate on the inside 6 inches of either the first or second application until the adjacent lane has been treated. Immediately following each application, uniformly cover the applied bituminous material with Size No. 7 mineral aggregate that is reasonably free of surface moisture.

Spread the aggregate at a rate between 24 and 30 pounds per square yard, as established by the Engineer, using a self-propelled mechanical spreader; except on short projects of 1/2 mile in length or less, self-propelled mechanical spreading equipment will not be required. Back the truck on the aggregate being spread, without driving on or over uncovered bituminous material.

The length of bituminous material spread shall not exceed that which trucks loaded with cover material can immediately cover.

Second Application

Apply the second application of emulsified asphalt in the same manner as the first application, at a uniform rate established by the Engineer within the range of 0.20 and 0.35 gallons per square yard.

Spread mineral aggregate, Size No. 8, in the same manner as the first spread at a rate established by the Engineer within the range of 16 to 28 pounds per square yard.

Immediately after each spread of cover aggregate, broom to achieve uniform coverage. Use a power source, which is independent of the drive train that propels the equipment, to power the revolving brooms of mechanical sweeping equipment. Place additional aggregate by hand on thin or bare areas.

405.07 Spreading and Rolling Aggregate

A. Spreading

Immediately after bituminous material has been applied, no more than two minutes, spread and embed the mineral aggregate cover in the bituminous material. Spread the aggregate as close to the application of bituminous material as is practicable, and cover each distributor load applied immediately. Aggregates shall be moistened and visually damp at the time of placement.

Spread the aggregate in accordance with the rates specified in Table 405.06-1. The exact rate will be established by the Engineer. Back the truck on the aggregate being spread, without driving on or over uncovered bituminous material. If treating less than the full width of roadway, do not spread the aggregate on the inside 6 inches of the bituminous spread until the adjacent lane is treated. Immediately after spreading the aggregate, perform hand-brooming to achieve uniform coverage. Place additional aggregate by hand on thin or bare areas.

The speed of the spreader shall be such that the aggregates are not rolling over, and starting and stopping of the spreader is minimized. Use of previously used (swept) aggregates is not permitted.

B. Rolling – Bituminous Seal Coat

Immediately after distributing the aggregate, roll the entire surface by moving in a longitudinal direction, beginning at the outer edges and progressing toward the center of the roadway, with each trip of the roller overlapping the previous trip by half the width of the rear wheel. Perform initial rolling with a self-propelled pneumatic tire roller, and follow with steel-wheel rolling. The amount and sequence of rolling shall be as directed by the Engineer. Complete the initial rolling of the aggregate within 1 hour after applying the bituminous material.

Use power brooms to correct irregularities by sweeping the aggregates from areas of thick or heavy distribution to areas of thin or light distribution. Then continue rolling using both steel-wheel and pneumatic rollers until the aggregate is thoroughly embedded in the bituminous material. The Engineer may require additional rolling at a later date. Redistribute excess or loose aggregate that was thrown out of place.

Slow moving traffic may use the section or roadway upon which the aggregate has been spread.

Rolling and Curing – Double Bituminous Seal Coat

Immediately after spreading and brooming the cover aggregate, roll the entire surface, beginning at the edges and progressing to the center. Begin rolling within 30 minutes after spreading the aggregate. Perform initial rolling with a self-propelled pneumatic tire roller, and follow with steel-wheel rolling. The amount and sequence of rolling shall be as directed by the Engineer.

Allow the first application of bituminous material and aggregate to cure for as long as deemed necessary by the Engineer before beginning the second application. Immediately before the second application of bituminous material, roll the surface with a steel-wheel roller.

For the second application of bituminous material and cover aggregate, repeat the same rolling and curing procedures as required for the first application.

The Contractor may allow slow-moving traffic to use sections of the roadway where the bituminous material has been covered with mineral aggregate.

405.08 Shoulders

Restore shoulders that have been disturbed by the Contractor's construction operations at no cost to the Department. Remove all objectionable material placed on the shoulders by the Contractor as directed by the Engineer.

Construct shoulders, when specified, as provided for under **208**.

405.09 Maintenance and Protection

Maintain in a satisfactory condition each completed section of seal coat until the entire Project is complete. Maintenance shall include making repairs where failures occur, and maintaining the seal coat in a smooth uniform condition; and brooming, dragging, and rolling when required.

After the final application, maintain the work in a satisfactory condition for at least 10 calendar days. If all other requirements of the Contract have been fulfilled, the Department will not charge working time during the 10-day maintenance period against the Contract time.

For final cleanup, sweep up all excessive quantities of loose, dislodged cover aggregate that may have collected along the edge of the completed seal coat, and dispose of this material as directed by the Engineer.

405.10 Method of Measurement

The Department will measure Mineral Aggregate and Bituminous Material by the ton in accordance with **109**. The Department may use net certified weights as a basis of measurement for mineral aggregate, subject to correction for aggregate that is lost, wasted, or otherwise not incorporated into the Work.

405.11 Basis of Payment

The Department will pay for accepted quantities of Bituminous Seal Coat, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Bituminous Material	Ton
Mineral Aggregate	Ton

The Department will measure and pay for the work required to prepare the designated surface, as provided for under **405.05**, in accordance with the applicable Section or Subsection under which the work is performed."

Subsection 407.02 (pg. 300-301) 12-2-16; Replace the 4th paragraph:

"If anti-stripping additive, other than hydrated lime, meeting 921.06.B.1 is required, use approved in-line blending equipment, as specified in 407.04.A.6, to add it at the mixing plant or inject it at the asphalt terminal. Manufacture's documentation that asphalt binders will continue to meet requirements listed in subsection **904** after the anti-stripping additive is added shall be provided by the contractor with the mix design submittal. For mix designs submitted more than six months in advance, the documentation shall be resubmitted prior to use of the mix design with updated test results."

Subsection 407.02 (pg. 300) 11-16-15; Materials, add the following at the end of the fourth paragraph:

"If anti-stripping additive, other than hydrated lime, meeting **921.06.B.1** is required, use approved in-line blending equipment, as specified in **407.04.A.6**, to add it at the mixing plant or inject it at the asphalt terminal. Provide manufacture's documentation ensuring asphalt binders will continue to meet requirements listed in Subsection **904** after anti-stripping additives are added."

Subsection 407.06 (pg. 327), 5-18-15; - A. Pavers. Replace the entire first paragraph with the following:

"Bituminous pavers shall be self-contained, power-propelled units provided with an activated screed, equipped to be heated, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thickness shown on the Plans. All screed extensions shall be full assembly extensions, including activated and heated screeds. Pavers shall include throw-back blades, reverse augers, or equivalent to place mix beneath the auger gearbox. Auger extensions shall be incorporated in a manner such that the maximum distance from the augers to the end plate shall be 18 inches. Screed extensions may extend beyond the 18-inch maximum from auger extensions only when extending for short-term temporary deviations in pavement width such as driveways. Do not use strike-off boxes, with the exception of sections with continuously varying width."

Subsection 407.11 (pg. 332) 12-2-16; Add the following to the paragraph below Table 407.11-1:

"Minimum temperature for OGFC mixes shall be 280º."

Subsection 407.15, C. Test Strips. (pg. 340-341) 11-16-15; Add the following paragraph after the 7th paragraph of the subsection:

"Take an additional 3 cores after placement of the surface layer on the tack coat test strip described in subsection **403.05.B**. Include the underlying pavement layer for shear testing. These cores will be for informational testing only. Not required for mats less than one inch thick"

Subsection 407.15 (pg. 341) 6-27-16; remove the 2nd sentence of the 8th paragraph:

"Take cores on the test strip at ten randomly selected locations as designated by the Engineer. Provide these cores to the Department for use in calibrating the nuclear gauge and to verify that the average density of the test strip meets the density requirements of the specifications. The Department will report all densities using the corrected nuclear gauge readings. Correction factors are specific to the nuclear gauges used during the test strip construction. If a different nuclear gauge needs to be used for acceptance, it will be necessary to cut new cores from the ongoing pavement construction to calibrate the new gauge."

Subsection 407.15 (pg. 341) 12-2-16; remove "randomly selected" from 1st sentence of the 8th paragraph as follows:

"Take cores on the test strip at ten locations as designated by the Engineer."

Subsection 407.15 A. 3. c. (pg. 337-338) 5-15-17; update 10,000 square yards to 1,000 tons:

"c. Projects containing less than 1,000 tons or bituminous pavement."

Subsection 407.20 A. (pg. 345), 11-6-17; Revise the second paragraph as follows:

"The Department will pay for liquid anti-strip additive and hydrated lime anti-strip additive based on certified documentation ~~invoices~~ of material costs not to exceed $15 per gallon and $90 per ton, respectively."

Subsection 407.20 (pg. 346) 5-18-15; Basis of Payment; B. Acceptance of Mixture; Modify the last paragraph to revise 500 tons to 1000 tons:

"When the total plan quantity of any mix is less than 1000 tons, the Department will accept the mix on the basis of visual inspection and Contractor Quality Control certification. The Department may run extraction, gradation analysis, or other tests deemed necessary for acceptance purposes."

Subsection 407.20 (pg. 348) 11-16-15; Table 407.20 – 2, make the following changes:

Table 407.20-2: Acceptance Schedule of Payment (Asphalt Plant Mix Characteristics)

Characteristics	Pay Factor	Average Arithmetic Deviation of the Lot Acceptance Test from the JMF	
		1 Test	2 Tests or more
Asphalt Cement Content (1) (Extraction or ignition oven)	1.00	0.00-0.30	0.00-0.25
	0.95	0.31-0.35	0.26-0.30
	0.90	0.36-0.40	0.31-0.35
	0.80 (2)	over 0.40	over 0.35
Gradation 3/8 inch sieve and larger	1.00	0.00-6.50	0.00-5.70
	0.95	6.51-7.08	5.71-6.20
	0.90	7.09-7.66	6.21-6.69
	0.80 (2)	over 7.66	over 6.69
Gradation No. 4 sieve (3)	1.00	0.00-4.62	0.00-4.00
	0.95	4.63-5.20	4.01-4.50
	0.90	5.21-5.77	4.51-5.00
	0.80 (2)	over 5.77	over 5.00

Subsection 407.20 (pg. 350) 11-16-15; B. 5. Acceptance for Mix Density on the Roadway, Replace the entire 2nd paragraph with the following:

"For density testing purposes, the Department will divide the pavement into lots of 1,000 tons. Five density tests will be performed in each lot and the average results compared with the requirements specified in Tables 407.15-1 to 407.15-4. At the beginning of a project or at any time it is deemed advisable, the Department may consider smaller lots to evaluate compaction methods or for other reasons as approved or directed by the Engineer."

Subsection 411.03 (pg. 363) 11-16-15; 2. Recycled Asphalt Shingles (RAS), change 5% to 3% in the 1st sentence of the 1st paragraph.

"Recycled Asphalt Shingles (RAS) may be included to a maximum of 3% of the total weight of mixture."

Subsection 411.03 B. Anti-strip Additive (pg. 365) 6-27-16; revise the 2nd paragraph:

"Mix an approved anti-strip agent with the asphalt cement at the dosage as specified in **921.06.B**."

Subsection 414.02 (pg. 369) 11-16-15; Materials, add the following paragraph to the end of the subsection:

"Ensure that no deleterious material is introduced into aggregate stockpiled at project site."

Subsection 414.02 (pg. 369) 11-6-17; Revise the last sentence:

"For a slurry seal, use a Type CQS-1h emulsified asphalt. For micro-surfacing use a type CQS-1hp or CSS-1hp emulsified asphalt."

STATE OF TENNESSEE

(Rev. 5-18-15)
(Rev. 11-16-15)
(Rev. 6-27-16)
(Rev. 12-2-16)
(Rev. 5-15-17)
(Rev. 11-6-17)

January 1, 2015

Supplemental Specifications - Section 900

of the

Standard Specifications for Road and Bridge Construction

January 1, 2015

Subsection 903.01 - Table 903.01-1 (pg. 920), 5-18-15; Replace Note (1) with the following:

"(1)If the fine aggregate is manufactured from crushed stone and if material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 5%.

Subsection 903.01 - Table 903.01-1, Table 903.01-2 (pg. 921), 5-15-17; replace Tables 903.01-1 and 903.01-2 with the following Tables:

Table 903.01-1: Limits of Deleterious Substances in Fine Aggregate for Concrete

Substance	Maximum Permissible Limits Percent by Weight
Clay Lumps	0.5
Coal and Lignite	0.5
Material Passing the No. 200 Sieve (1)(3)	3.0
Other deleterious substances (such as shale, alkali, mica, coated/grains, soft and flaky particles) (1) (2)	3.0

(1) If the fine aggregate is manufactured from crushed stone and if material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 10%.

(2) Determine other organic impurities according to AASHTO T 267.

(3) If the fine aggregate is manufactured from crushed gravel and if material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 3.5%.

Table 903.01-2: Gradation Requirements for Fine Aggregate

Sieve Size	Total Percent Passing by Weight
3/8 inch	100
No. 4	95-100
No. 16	50-90
No. 50	5-35
No. 100	0-20
No. 200 (1)	0-3

(1) If the fine aggregate is manufactured from crushed stone and if material finer than the No. 200 sieve consists of the dust of fracture, essentially free from clay or shale, this limit may be increased to 10%.

Subsection 903.03 (pg. 922) 5-15-17; Coarse Aggregate for Concrete, add the following as the 4th paragraph:

"Coarse aggregate in two-lift composite pavements shall consist of Size No. 467 in the lower lift, graded as specified in 903.22. Coarse aggregate in the upper lift shall be Size No. 57 or 67 graded as specified in 903.22 and shall meet 903.24 riding surface requirements."

Subsection 903.03 (pg. 922-923) 11-16-15; Coarse Aggregate for Concrete, modify the 4th and 5th paragraphs, update Table 903.03-1: Coarse Aggregate Sizes to the following:

"Coarse aggregate in Portland cement concrete bridge decks and overlays on interstates and four or more lane highways consisting of Size No. 57 shall meet 903.24.

The coarse aggregates for travel lanes and bridge decks shall be crushed and consist of stone, slag, gravel, quartzite, gneiss, or combination thereof with an absorption of plus 4 material not to exceed 5%. Do not use uncrushed gravel, pea gravel, or any other uncrushed particles. Crushed gravel, if used, shall consist of siliceous washed particles after processing, of which at least 70% by count of the material retained on the No. 4 sieve contains a minimum of two fractured faces. One face shall be fractured for the approximate average diameter or thickness of the particle."

Table 903.03-1

Application	Coarse Aggregate Size (1)
Structural concrete	No. 57
Self-Consolidating concrete	Maximum-No.67
Prestressed concrete	No. 57 or 67
Precast concrete	Any size fraction
Concrete curbing placed by machine-extrusion methods	No. 7, 57, 67, or 78

Cement treated permeable base (2)	No. 57

(1) Gradation shall conform to **903.22**.
(2) Aggregate shall meet the quality requirements specified below.

Subsection 903.03-2 (pg. 924) 5-15-17; Revise Table 903.03-2: Limits of Deleterious Substances in Coarse Aggregate for Concrete, update Material passing No. 200 Sieve and Footnote 2:

Table 903.03-2: Limits of Deleterious Substances in Coarse Aggregate for Concrete

Substance	**Maximum Percent by Weight**
Soft or non-durable fragments (fragments that are structurally weak such as shale, soft sandstone, limonite concretions, gypsum, weathered schist, or cemented gravel), and organic impurities as determined by AASHTO T 267 (1)	3
Coal and lignite (1)	1
Clay lumps (1)	0.25
Material passing the No. 200 sieve (1) (2)	1.5
Thin or elongated pieces (length greater than 5 times average thickness)	10
Other local deleterious substances (1)	1

(1) The sum of the percentages of these materials (i.e., soft or non-durable fragments, coal and lignite, clay lumps, material passing the No. 200 sieve, and other local deleterious substances) shall not exceed 5.0.
(2) For crushed aggregate, if all the material finer than the No. 200 sieve, as determined in accordance with AASHTO T 11, consists of the dust of fracture, essentially free of clay or shale, this limit may be increased to 2.0.

Subsection 903.05 – B. Type B Aggregate (pg. 927), 5-18-15; Replace the 1st paragraph of subsection 3. With the following:

"3. Do not use material having clay content greater than 12%, as determined by hydrometer analysis performed in accordance with AASHTO T 88. Material may be used having a clay content exceeding 12% if a plasticity index-fines product does not exceed 3 when calculated by the following formula"

Subsection 903.05 – Aggregate for Mineral Aggregate Base and Surface Courses (pg. 928) 5-15-17; add section C to the bottom:

C. Reclaimed Concrete Aggregate. Provide material comprised of concrete reclaimed from the demolition of a concrete structure or pavement. Reclaimed Concrete Aggregate may only be used as a mineral aggregate base course, subbase or shoulder course. The material shall be free of any materials classified as Solid or Hazardous Waste, especially asbestos, lead and mercury, with test results submitted by the contractor to the Project Supervisor. These test results shall be certified and notarized. The percentage of wear as determined in accordance with AASHTO T 96 shall not exceed 50. Deleterious substances shall be kept to a minimum, and may not be higher than the amounts listed on Table 903.05-3.

Table 903.05-3: Deleterious Materials

Material	Maximum Permissible Limits Percent by Weight
Brick	5
Bituminous Concrete Materials	5
Weathered Rock	2
Wood	0.1
Metals	0.1

The gradations of the coarse and fine fractions of aggregate shall be such that, when combined in proper proportions, the resultant mixture will fall within the grading specified in Table 903.05-4.

Table 903.05-4: RCA Grading Tolerances

Sieve Size	Total Percent Passing per Weight
1 ½ inch	100
1 inch	85-100
¾ inch	60-95
3/8 inch	50-80
No. 4	40-65
No. 16	20-40
No. 100	5-18

Subsection 903.05 – Aggregate for Mineral Aggregate Base and Surface Courses (pg. 925) 5-15-17; add reference to subsection **903.05 C.** in the second paragraph of subsection A.:

"**903.05 Aggregate for Mineral Aggregate Base and Surface Courses**

Provide crushed stone, crushed slag, crushed or uncrushed gravel, or crushed or uncrushed chert that may be blended with crushed recycled concrete or screened reclaimed asphalt pavement (RAP), together with material such as manufactured sand or other fine materials that are either naturally contained or added as needed to conform to these Specifications.

Provide aggregate of Types A and B, as specified below.

A. Type A Aggregate

Provide hard, durable particles or fragments of stone, slag, gravel, or chert, and other finely divided mineral matter.

The Contractor may use recycled concrete aggregate per 903.05 C. or reclaimed asphalt pavement~~,~~ at a maximum rate of 25% by weight~~,~~ for Type A aggregate, provided the combined aggregate blend meets all the requirements specified below. Crush and screen the recycled concrete and asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the recycled stockpiles free of bricks, steel, wood, and all other deleterious materials. "

Subsection 903.05 – Aggregate for Mineral Aggregate Base and Surface Courses (pg. 925-926) 5-15-17; add reference to subsection **903.05 C.** in the second paragraph of subsection B.:

"For Provide crushed or uncrushed gravel, crushed or uncrushed chert, crushed stone or crushed slag, and other finely divided particles.

The Contractor may use recycled concrete aggregate per 903.05 C. or reclaimed asphalt pavement~~,~~ at a maximum rate of 30% by weight~~,~~ for Type B aggregate, provided the combined aggregate blend meets all the requirements specified below. Crush and screen recycled concrete and asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the recycled stockpiles free of bricks, steel, wood, and all other deleterious materials."

Subsection 903.06 - C. Combined Aggregate Grading (pg. 930) 11-16-15; add the following sentence at the end of the first paragraph:

"For mixtures including recycled asphalt pavement, RAP, and/or recycled asphalt shingles, RAS, stockpiles will not be considered as contributing to the required minimum of three stockpile sizes."

Subsection 903.11 - Aggregate for Asphaltic Concrete Surface Coarses (Hot Mix) (pg. 934) 11-16-15; add the following sentence at the end of the first paragraph:

"For mixtures including recycled asphalt pavement, RAP, and/or recycled asphalt shingles, RAS, stockpiles will not be considered as contributing to the required minimum of three stockpile sizes."

Subsection 903.11 (pg. 934) 11-16-15; A. Coarse Aggregate (retained on a No. 4 sieve), revise the 1st paragraph and subsection 3:

"Provide aggregate, consisting of crushed stone, crushed slag, crushed gravel, crushed granite, crushed quartzite, crushed gneiss, or natural combinations of these materials.",

"3. Combined aggregate shall consist of siliceous particles processed from washed material, of which at least 70% by count of the material retained on the No. 4 sieve shall have a minimum of two fractured faces, one of which must be fractured for the approximate average diameter or thickness of the particle. Do not add pea gravel or uncrushed particles. The absorption of the crushed aggregate retained on the No. 4 sieve shall not exceed 5% when tested in accordance with AASHTO T 85."

Subsection 903.11 - A. Coarse Aggregate (retained on a No. 4 sieve) (pg. 934), 5-18-15; revise subsection 2. as follows:

"2. Material retained on the No. 4 sieve shall contain a maximum of 10% elongated pieces (length greater than five times the average thickness)"

Subsection 903.11 C.3. (pg. 938), 6-27-16; revise the 1st paragraph of subsection C.3 to the following:

"**3. Grading OGFC.** A minimum of 75% of the aggregate shall meet the requirements specified in 903.24 for Surface Mixtures (Non-Skid Aggregates). The coarse aggregate shall have at least 90% crushed aggregate with two fractured faces and 100% with one fractured face as determined in accordance with ASTM D5821. The coarse aggregate shall have a LA Abrasion value of less than 40% and a maximum absorption of 3.0%."

Subsection 903.11 (pg. 938), 12-2-16; Add the following to C. as subsection 5.:

"**5. Grading C, CS, CW.** The mixture shall meet all requirements of **903.06.** When using Grading C, CS, or CW as a final riding surface for traffic lanes and the design ADT is greater than 1000, a minimum of 75% of the aggregate shall meet the requirements specified in **903.24** for Surface Mixtures (Polish-Resistant Aggregate) for the appropriate levels."

Subsection 903.12 (pg. 938) 11-16-15; A. Aggregate for Slurry Seal, revise the 1st paragraph a A. as shown; delete the 2nd paragraph:

"The aggregate shall be crushed slag, crushed granite, or crushed stone (crushed stone as specified in 903.24), meeting the requirements of ASTM D692, except the gradation shall be as specified in Table 903.12-1. The aggregate shall have a minimum sand equivalent, as determined in accordance with AASHTO T 176, of 45.

Subsection 903.12 (pg. 939) 11-16-15; B. Aggregate for Micro-Surface: modify the first paragraph, delete the second paragraph:

"The aggregate shall be crushed slag, crushed granite, or crushed stone (crushed stone as specified in **903.24**) meeting the gradation limits specified in Table 903.12-2 and the physical properties of ASTM D692, except the percent of fractured pieces shall be 100. The aggregate shall have a minimum sand equivalent, as determined in accordance with AASHTO T 176, of 65. Polish-resistant aggregates will not be required for leveling courses, provided they will be covered with riding surface mixtures.

Subsection 903.12 (pg. 939) 5-15-17; B. Aggregate for Micro-Surface: Add the following as the 2nd paragraph:

"If blending aggregates from more than one source, use automated proportioning and blending equipment which has individual bins for each aggregate source used to produce a stockpile meeting the job mix formula gradation. Proportion and blending equipment shall be calibrated at the beginning of production. All aggregate sources shall meet the requirements of **Table 903.24-1**. Do not blend aggregates with a front end loader. Proportion the aggregate to produce a uniform gradation meeting the requirements specified in Table 903.12-2. The contractor shall provide a Type A laboratory as defined by **106.06** capable of verifying gradation at the location where blending occurs."

Subsection 903.13 (pg. 940), 12-2-16; modify the last sentence of the 1st paragraph:

"Provide aggregate consisting of crushed stone, crushed slag, or crushed gravel, meeting the quality requirements of ASTM D692, except that at least 50% by count of crushed gravel aggregates shall have at least one fractured face. Crushed slag aggregate retained on the No. 4

sieve shall contain no more than 20% by weight of glassy particles. Provide aggregates meeting the requirements of **903.24 except, if ADT is less than 1000**."

Subsection 903.15 (pg. 941), 5-15-17; revise the 3rd paragraph:

"The Contractor may use recycled concrete aggregate per 903.05 C. or reclaimed asphalt pavement (RAP), at a maximum rate of 25% by weight~~,~~ provided the combined aggregate blend meets all the requirements specified above. If blending, crush and screen the recycled concrete and/or asphalt to produce a uniform stockpile before blending it with the virgin material. Keep the reclaimed asphalt pavement stockpiles free of bricks, steel, wood, and all other deleterious materials. The virgin and reclaimed pavement blend shall meet the quality requirements specified in Table **903.05-1**."

Subsection 903.24 (pg. 946), 5-18-15; Modify the 1st paragraph to the following:

"Provide coarse aggregate consisting of crushed gravel, crushed granite, crushed slag, crushed quartzite, crushed gneiss, or crushed sandstone. Other crushed aggregate may be used provided it has the chemical, physical, and performance characteristics specified in Table 903.24-1."

Subsection 904.01 (pg. 948) 11-16-15; Asphalt Cements, add the following between the 4th and 5th paragraphs:

"Polyphosphoric acid may be used as a modified not exceeding 0.5% by weight of asphalt binder and may only be used when the primary modifier is one of the styrene-based products listed above."

Subsection 904.01 (pg. 948) 11-6-17; Asphalt Cements, modify the fourth paragraph with the following:

"To modify the asphalt, properly blend one or more modifier(s) consisting of styrene butadiene (SB), styrene butadiene styrene (SBS), or styrene butadiene rubber (SBR), or Ground Tire Rubber (GTR) to a PG 64-22 or PG 67-22 base asphalt.

GTR used to modify asphalt shall meet the requirements of 921.17. Blending of GTR into asphalt cement shall occur only at the asphalt terminal. "

Subsection 904.01 (pg. 948), 11-6-17; Asphalt Cements, add the following paragraph as the next to last paragraph:

"In addition to the above, asphalt cement modified with GTR shall meet the following requirement. The temperature difference determined by the Separation Test shall not exceed 15 °F. The separation test shall consist of taking the difference in softening point, as determined by the Ring and Ball Test (AASHTO T53), between the top and bottom thirds of a specimen prepared per ASTM D7173."

Subsection 904.01 (pg. 949), 12-2-16; Modify Table 904.01-1:

"**Table 904.01-1: Requirements for Asphalt Cement**

Property*	PG 64-22, PG 67-22	PG 70-22	PG 76-22	PG 82-22
Non-recoverable creep compliance at 3.2kPa, Jnr(3.2), kPa^{-1} at 64°C, Max	4.5	1.0	0.5	0.5
% Difference in Non-Recoverable Creep Compliance, Jnr(diff) at 64°C, %, Max	75	75**	n/a	n/a

* Tested in accordance with AASHTO T350.
** Shall be waived if Jnr(3.2) is equal to or less than 0.5

PG76-22 and PG82-22 grade asphalts shall meet the requirements for Indication of Elastic response as defined in Appendix X1 of AASHTO M332. PG70-22 grade asphalts shall have a minimum percent recovery at 3.2 kPa of 29%."

Subsection 904.01 (pg. 948-950) 5-18-15; revise the 1st paragraph to add the word cement, add sentence to the end of the 2nd paragraph, add "cement high-temperature grade properties to the 4th paragraph, remove the grades of asphalts and add asphalt cements to the 5th paragraph, update Table 904-01-1 to remove "Ring and Ball" and" Elastic Recovery", add "Non-recoverable creep compliance" requirements to Table 904-01-1, add footnote to Table, add a 6th paragraph, remove A. Test Procedures and Table 904.01-2, remove Materials Certification header, remove 8th paragraph, and revise the 9th paragraph:

"Only obtain asphalt cement for use on Department projects from Certified Asphalt Cement Suppliers that have an approved Quality Control Plan in accordance with the Department's Standard Operating Procedures.

Asphalt cement shall conform to AASHTO M 320 and Department procedures. Direct Tension testing is not required.

Instead of PG 64-22, the Contractor may use asphalt cement graded to PG 67-22. PG 67-22 shall conform to the requirements of AASHTO M 320 when the applicable tests are conducted at 67 °C and -12 °C, and the dynamic shear of the rolling thin film, pressure aged vessel sample is tested at 26.5 °C.

To modify the asphalt cement high-temperature grade properties, properly blend styrene butadiene (SB), styrene butadiene styrene (SBS), or styrene butadiene rubber (SBR) to a PG 64-22 or PG 67-22 base asphalt.

In addition to the above requirements, asphalt cements shall meet the requirements specified in Table 904.01-1.

Table 904.01-1: Requirements for Asphalt Cement

Property*	PG 64-22, PG 67-22	PG 70-22	PG 76-22	PG 82-22
Non-recoverable creep compliance at 3.2kPa, Jnr(3.2), kPa^{-1} at 64°C, Max	4.5	1.0	0.5	0.5
% Difference in Non-Recoverable Creep Compliance, Jnr(diff) at 64°C, %, Max	75	75	75	75

* Tested in accordance with AASHTO T350.

All modified grades shall meet the requirements for Indication of Elastic response as defined in Appendix X1 of AASHTO M332.

Furnish a certification to the Engineer on each project stating that the asphalt cement provided meets the Department's specification. Ensure that quality control and compliance testing are completed in accordance with the asphalt supplier's approved quality control plan and Department procedures.

In addition, the asphalt cement supplier shall provide a temperature-viscosity curve for PG 64-22 and PG 67-22 asphalt cements with a recommended mixing temperature range. In order to develop a temperature-viscosity curve, it may be necessary to run the viscosity test at a higher temperature, based on the softening point of the modified asphalt cement."

Subsection 904.01(pg. 949), 6-27-16; Modify Table 904.01-1:

Table 904.01-1: Requirements for Asphalt Cement

Property	PG64-22 PG67-22	PG70-22	PG76-22	PG82-22
Non-recoverable creep compliance at 3.2kPa, Jnr(3.2), kPa^{-1} at 64°C, Max	4.5	1.0	0.5	0.5
% Difference in Non-Recoverable Creep Compliance, Jnr(diff) at 64°C, %, Max	75	75	75	n/a

Subsection 904.01 B. (pg. 949) 11-6-17; Asphaltic Cements, B. Materials Certification, add the following as the last sentence of the first paragraph:

> **"**Furnish a certification to the Engineer on each project stating that the asphalt cement provided meets the Department's specification. Ensure that quality control and compliance testing are completed in accordance with the asphalt supplier's approved quality control plan and Department procedures. Identify on the certification, the type(s) of modifier used."

Subsection 904.03 (pg. 951) 11-16-15; Emulsified Asphalts, Add "TTT-3" to 904.03-1 with the following requirements:

Saybolt-Furol Viscosity @ 77 °F, seconds	10-100
Particle Charge	Positive
Sieve Test, %	0.1 Max
Residue by	Distillation(1)
Residue, %	50 Min
Demulsibility, %	65 Min
Penetration	40-90

1-Distill at 350°F

Subsection 904.03 (pg. 954), 12-2-16; Revise Table 904.03-1(c) to remove TTT-1, TTT-2, and TTT-3:

Table 904.03-1(c): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CRS-2P	RS-2	RS-1
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	n/a	n/a	20-100
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	100-400	75-400	n/a
Storage Stability Test, 24- h, %	T59	1 Max	1 Max	1 Max
5-day Settlement, %	T59	n/a	n/a	n/a
Particle Charge	T59	Positive	n/a	n/a
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max
Residue by	T59	*Evaporation*	Distillation	Distillation
Residue, %	T59	65 Min	63 Min	55 Min
Demulsibility, %	T59	40 Min	60 Min	60 Min
Distillate, %	T59	n/a	n/a	n/a
Oil Test, %	T59	n/a	n/a	n/a
Stone Coating	T59	n/a	n/a	n/a
Float Test, seconds	T50	n/a	n/a	n/a
Penetration	T49	75-175	100-200	100-200
Elastic Recovery, % (2)	T301	50 Min	n/a	n/a

Practices	AASHTO Test Method	CRS-2P	RS-2	RS-1
Ductility @ 77 °F, cm	T51	40 Min	40 Min	40 Min
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a
R&B Softening Point, °F	T53	125 Min	n/a	n/a
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a

Subsection 904.03 (pg.954), 5-18-15; Replace with the following:

Subsection 904.03, Table 904.03-1(c). Modify as follows for TTT-1, TTT-2:

Table 904.03-1(c): Test Requirements for Emulsified Asphalt

Practices	AASHTO Test Method	CRS-2P	RS-2	RS-1	TTT-1	TTT-2
Saybolt-Furol Viscosity @ 77 °F, seconds	T59	n/a	n/a	20-100	20-100	10-100
Saybolt-Furol Viscosity @ 122 °F, seconds	T59	100-400	75-400	n/a	n/a	n/a
Storage Stability Test, 24- h, %	T59	1 Max	1 Max	1 Max	1 Max	1 Max
5-day Settlement, %	T59	n/a	n/a	n/a	n/a	n/a
Particle Charge	T59	Positive	n/a	n/a	n/a	Positive
Sieve Test, %	T59	0.1 Max	0.1 Max	0.1 Max	0.1 Max	0.1 Max
Residue by	T59	*Evaporation*	Distillation	Distillation	Distillation	Distillation (1)

Practices	AASHTO Test Method	CRS-2P	RS-2	RS-1	TTT-1	TTT-2
Residue, %	T59	65 Min	63 Min	55 Min	50 Min	50 Min
Demulsibility, %	T59	40 Min	60 Min	60 Min	n/a	n/a
Distillate, %	T59	n/a	n/a	n/a	n/a	n/a
Oil Test, %	T59	n/a	n/a	n/a	n/a	n/a
Stone Coating	T59	n/a	n/a	n/a	n/a	n/a
Float Test, seconds	T50	n/a	n/a	n/a	n/a	n/a
Penetration	T49	75-175	100-200	100-200	0-20	40-90
Elastic Recovery, % (2)	T301	50 Min	n/a	n/a	n/a	n/a
Ductility @ 77 °F, cm	T51	40 Min	40 Min	40 Min	n/a	n/a
Ductility @ 40 °F, cm	T51	n/a	n/a	n/a	n/a	n/a
R&B Softening Point, °F	T53	125 Min	n/a	n/a	60-75	n/a
Original G*/sind @ 82 °C	T315	n/a	n/a	n/a	1.0 Min	n/a

(1) Distill at 350 °F

(2) Straight-sided mold, 20-cm elongation, 5min hold, 25 °C

Subsection 908.04 (pg. 968), 5-18-15, High Strength Bolts, A. Specifications; Add the following to the first paragraph:

> "Unless otherwise shown on the Plans, mechanically galvanize all bolts, nuts and washers in accordance with ASTM B695 Class 50."

Subsection 908.04 (pg. 968), 12-2-16, High Strength Bolts, A. Specifications; revise the first paragraph:

> "Unless otherwise shown on the Plans, all bolts, nuts and washers shall be coated with acceptable coating in accordance with ASTM F3125 for the respective grade."

Subsection 908.04 (pg. 968) 12-2-16; revise A. Specifications, 1.:

"A. Specifications: 1. Bolts. ASTM F3125, Grade 325 and Grade 490 - High Strength Bolts for Structural Joints"

Subsection 908.04 (pg. 970) 12-2-16; Revise C. Testing, 3. Assemblies, subsection f., update Table 908-04-2:

C. Testing, 3. Assemblies, f. Table 908.04-2 The minimum rotation, from a snug tight condition (10% of the specified proof load), shall be as specified in Table 908.04-2.

Table 908.04-2: Rotation from Snug Tight Condition

Bolt Length	Minimum Rotation from Snug
Up to and including 4 diameters	240 degrees (2/3 turn)
Over 4 diameters, but not exceeding 8 diameters	360 degrees (1 turn)
Over 8 diameters	480 degrees (1-1/3 turn)

(Note: These values differ from those shown in ASTM F3125.)

Subsection 909.02(pg. 977), 12-2-16; Remove the 4th paragraph referencing a tolerance of 5% from B. Steel Posts and Braces.

Subsection 909.02 (pg. 980-981), 12-2-16; Remove the word minimum from Table 909.02-1:

Table 909.02-1: Post and Braces

Application	Material	ASTM Specification	Nominal Diameter (inches)	Outside Diameter (inches)
Line Posts	Galvanized steel pipe	F1083	1.5	1.900
	Aluminum alloy standard (ANSI Schedule 40) pipe	B429, Alloy 6063, Temper T6	1.5	1.900
	Triple coated steel pipe with a	F1043, Group I-C	1.5	1.900

Application	Material	ASTM Specification	Nominal Diameter (inches)	Outside Diameter (inches)
	0.120-inch wall thickness			
End, Corner, and Pull Posts	Galvanized standard steel pipe	F1083	2.0	2.375
	Aluminum alloy standard (ANSI Schedule 40) pipe	B429, Alloy 6063, Temper T6	2.0	2.375
	Triple coated steel pipe with a 0.130-inch wall thickness	F1043, Group I-C	2.0	2.375
End and Corner Braces	Galvanized standard steel pipe	F1083	1.25	1.660
	Aluminum alloy standard (ANSI Schedule 40) pipe	B429, Alloy 6063, Temper T6 (for corner posts: B241)	1.25	1.660
	Triple coated steel pipe with a 0.111-inch wall thickness	F1043, Group I-C	1.25	1.660

Subsection 909.03 (pg. 983), 12-2-16; Remove the last paragraph of the subsection.

Subsection 912.05 (pg. 1001), 6-27-16; Add subsection 912.05 – Brick Paving Units:

"912.05 Brick Paving Units

Provide brick of the kind and grade specified.

A. Masonry Brick

1. Sidewalk: ASTM C902, Class SX, Type 1
2. Crosswalks and Roadway: ASTM C1272, Type R

B. Concrete Brick and Truncated Dome Concrete Brick

Provide brick conforming to ASTM C936

C. Truncated Dome Brick

Provide brick conforming to ASTM C902, Class SX, Type 1"

Subsection 915.02 (pg. 1007), 6-27-16; modify the description of 915.03, remove zinc coated, iron from 915.02 A. update the first paragraph of 915.02 A., Remove subsection B. Aluminum Coated Steel Pipe, Revise C. to become B., revise D to become C, Remove 1st and 2nd paragraphs of D now C, revise E to become D, update 915.03 to match index title: :

"SECTION 915 – METALLIC PIPE

915.01 Ductile Iron or Cast Iron Pipe
Provide ductile iron pipe conforming to ASTM A716 for the specified diameters and strength classes. Unless otherwise specified, either smooth, corrugated, or ribbed pipe may be furnished. For pipe diameters in excess of 48 inches, conform to ANSI Standard for Cast Iron Pit Cast Pipe, or as otherwise specified in the Contract, for the specified diameter and strength class.
Provide cast iron drain pipe conforming to ASTM A74. Unless otherwise specified, provide ductile iron pressure pipe for water lines or sewer construction conforming to the requirements of ASTM A377 for the diameters and working pressures specified.

915.02 Corrugated Metal Pipe Culverts, Pipe Arches, and Underdrains
A. Corrugated Steel Pipe, Pipe Arches, and Underdrains
Provide corrugated steel pipe, pipe arches, or underdrains, including special sections, such as elbows and flared ends, that conform to AASHTO M 36, aluminum-coated Type 2 meeting AASHTO M274. Special Sections shall be the same thickness as the pipe, arch, or underdrain to which they are joined. Furnish shop-formed elliptical pipe and shop-strutted pipe only where shown on the Plans.

B. Corrugated Aluminum Pipe, Pipe Arches, and Underdrains
When using corrugated aluminum pipe, pipe arches, or underdrains, conform to the applicable requirements of AASHTO M 196. Use special sections, such as elbows and flared end sections

that conform to the applicable requirements of AASHTO M 196 and that are of the same gauge as the conduit to which they are joined.

C. Structural Plate Corrugated Steel and Aluminum Structures

Corrugated aluminum alloy structural plate for pipe, pipe arches, and arches shall conform to the requirements of AASHTO M 219.

D. Bituminous Coating
When material supplied for any of the items specified above are to be bituminous-coated, ensure that the metal to be coated is free of grease, dirt, and other contaminants. Bituminous coating and paving shall conform to the requirements of AASHTO M 190. Apply the coating in accordance with the manufacturer's recommended procedures and as directed by the Department."

915.03 Polymer Pre-coated, Corrugated Steel Pipe, Culverts and Underdrains
Provide polymer pre-coated corrugated steel pipe conforming to AASHTO M 245, Grade250/250, unless otherwise specified."

Subsection 916.05 E. (pg. 1012); 12-2-16, Add sentence to first paragraph:

"Fabricators must be AISC certified as specified in **602.04 A.4**."

Subsection 917.02.A.6. (pg. 1023), 6-27-16; Revise the following:

"**6. Anchor Bolts.** Use anchor rods of high strength steel meeting the requirements of ASTM F 1554, Grade to be determined by design. Fit each anchor bolt with a hex nut and lock-washer."

Subsection 918.04 (pg. 1036), 12-2-16; add as a 2nd paragraph:

"For small quantities less than 100 units of seeding or sod, bagged pelletized or agricultural limestone meeting the Department of Agriculture Tennessee Liming Materials Act may be utilized."

Subsection 921 (pg. 1049), 11-6-17, Section 921 – Miscellaneous Materials, add Ground Tire Rubber to the Index:

Subsection 921.01 (pg. 1049), 5-18-15, Water; Replace subsection with the following:

"For mixing concrete, use water that is reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable matter, and other substances injurious to the finished product. Water provided by a municipal utility may be used without testing.

All other water shall have quality results submitted in accordance with the frequency listed in Table 921.01-01. All water quality results shall adhere to Table 921.01-2.

Table 921.01-1 Testing Frequency for Mixing Water

Water Source	**Testing Frequency(1)**
Municipal	NA
Non-Municipal	Every 3 months; tested annually after 4

	consecutive passing tests

(1) The frequency may vary at the discretion of the Department.

Table 921.01-2 Quality Requirements for Mixing Water

Maximum Concentration in Mixing Water	**Limits**	**ASTM Test Method** (1)
Chloride Ion Content, ppm	500	C114
Alkalies as (NaO2 + 0.658 K2O), ppm	600	C114
Sulfates as SO4, ppm	3000	C114
Total Solids by mass, ppm	50000	C1603
pH	4.5-8.5	(2)
Resistivity, Minimum, kohm-cm	0.500	D1125
Soluble Carbon Dioxide, ppm	600	D513
Calcium and Magnesium, ppm	400	D511
Iron, ppm	20	(2)
Phosphate, ppm	100	D4327

(1) Other methods (EPA or those used by water testing companies) are generally acceptable.
(2) No ASTM method available.

Subsection 921.06 (pg.1051) 11-16-15; B. Bituminous Additives - 1. Anti-Stripping Additive, replace the ASTM C977 reference with AASHTO M 303.

"Use hydrated lime conforming to AASHTO M 303or other heat-stable asphalt anti-stripping additive containing no ingredient harmful to the bituminous material or the workmen and that does not appreciably alter the specified characteristics of the bituminous material when added in the recommended proportions.**"**

Subsection 921.06 B. Bituminous Additives (pg.1052) 10-10-16; revise the 3rd paragraph to the following:

"When using an anti-stripping additive other than hydrated lime, use a dosage rate of 0.3%, unless either gravel is used as a coarse aggregate or test results indicate moisture susceptibility, in which case mix at a dosage rate of 0.5%.

Subsection 921.06 B. 2. (pg. 1052) 11-6-17; B. Bituminous Additives, 2. Silicone Additives, Remove description and add the following sentence:

"2. Silicone Additives. ~~Mix silicone additives at the rate of 1 pint of silicone per 4 gallons of diesel fuel. The Contractor may use a ½ pint of this mixture per 1,000 gallons of asphalt.~~ The amount of silicone added to asphalt cement shall not exceed 2 oz. of silicone per 5500 gallons asphalt cement."

Subsection 921.17 (pg. 1060) 11-6-17; Ground Tire Rubber, add the following subsection:

"921.17 Ground Tire Rubber

Provide Class 30-1 Ground Tire Rubber (GTR) as defined by ASTM D5630 except for as noted in table 921.17-1. The material shall also be certified to meet the requirements of Table 921.17-01. Include certification of the GTR with the bill of lading for the modified asphalt cement.

Table 921.17-1: Requirements for Ground Tire Rubber

Property	Specification
Specific Gravity	1.15 +/- 0.05
Moisture Content	0.75% Max
Ferrous Metal Content	0.01% Max
Fiber Content	0.5% Max
Ash (ASTM E1131)	10% Max