TN TDOT Department of Transportation

HOT MIX ASPHALT ROADWAY CERTIFICATION

VERSION 24.0

Division of Materials and Tests 2024

Instructors

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Helpful Links

Std Specs, Circulars, Etc:

Standard Operating Procedure

1.

Introduction

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Hot Mix Asphalt Roadway Certification School

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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.

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

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

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Purpose-
WHY we are here

- TDOT Specifications §407.14
  - "The Contractor and the Department will be required to have a certified Roadway Asphalt specialist present on any paving project…"
- FHWA-TDOT Stewardship Agreement (23 CFR 637B) requires that all sampling and testing be conducted by qualified technicians.

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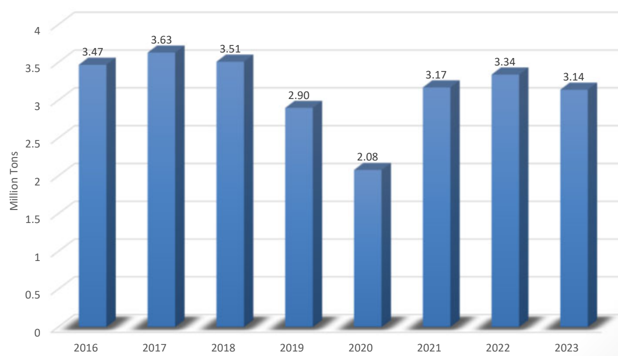
Purpose-
WHY we are here

- Investment!!!
- About 3 to 3.5 Million Tons/year of HMA ($250M to $300M)



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Course Objectives

- Develop a working knowledge of all aspects of HMA construction
- Develop an understanding of how construction quality affects performance
- Recommend and encourage good construction practices

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Course Objectives

- Identify and solve problems quickly
- Facilitate communication and cooperation
- Review TDOT Specification requirements and procedures

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Course Schedule

DAY 1

9:00- 9:30 a.m.	Introduction
9:30 – 10:00 a.m.	Project Organization and Communication
10:00 - 10:45 a.m.	Asphalt Materials
10:45- 11:00 a.m.	Break
11:00- 11:45 a.m.	Surface Preparation
11:45- 12:30 p.m.	Lunch (Provided)
12:30 – 1:30 p.m.	Tack Coat
1:30 – 1:45 p.m.	Break
1:45 – 2:45 p.m.	HMA Delivery
2:45 – 4:15 p.m.	Placement

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Course Schedule

DAY 2

9:00 – 10:00 a.m.	Joint Construction
10:00 – 10:15 a.m.	Break
10:15 - 11:45 a.m.	Compaction
11:45 - 12:30 p.m.	Lunch (Provided)
12:30 - 1:45 p.m.	Density and QA/QC
1:45 - 2:15 p.m.	Special Topics
2:15 - 2:30 p.m.	Break
2:30 – 3:30 p.m.	Specs & Review

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Course Schedule

DAY 3

9:00 a.m. – 11:00 a.m. Exam (Open Book, 2-Hour Limit)

No Cell Phone on an exam table/desk.

For test results

- Contact Kim after 2 weeks from the exam date by EMAIL only

Kimberly.Whitby@tn.gov

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Quick Rundown of TDOT Asphalt Mix Types

- Before we go any further, let's get caught up on the different types of TDOT mixes and what their names are.

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Quick Rundown of TDOT Asphalt Mix Types

- 307 Mixes
  - **A, ACRL, AS, B, BM, BM2, CS, & CW**
    - *These mixes are called "307" mixes because they are specified in Section 307 of the spec book for "Bituminous Plant Mix Base"*
    - *Oddly enough, not all of the mixes listed above are true "base" mixes.*

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Quick Rundown of TDOT Asphalt Mix Types

- 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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Quick Rundown of TDOT Asphalt Mix Types

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

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Quick Rundown of TDOT Asphalt Mix Types

- 307 Mixes: **CW, CS**
  - ***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. Also used as a binder layer under OGFC.*

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Quick Rundown of TDOT Asphalt Mix Types

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

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Quick Rundown of TDOT Asphalt Mix Types

- 411 Mixes: **D, E, E-shoulder**
  - *Surface mixes, aka "where the rubber meets the road"*
  - ***D** – Most common TDOT surface mix.*
  - ***E** – Occasionally in low-traffic areas*
  - ***E-shoulder***

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Quick Rundown of TDOT Asphalt Mix Types

- More 411 Mixes: **TL, TLD, TLE, 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".*
  - ***TLE** – Basically TLD with non-surface aggregate.*
  - ***Open-Graded Friction Course (OGFC)** – A porous, open-graded mixture used at surface to reduce hydroplaning.*

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2.

Organization & Communication

Project Organization and Communication

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Communication

- Most important parts of a project
  - Planning
  - Organization
- Sharing information and have an open dialogue with all parties involved
  - Project Engineer, Plant Tech., etc.

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Communication

Eliminate surprises and keep everyone involved and informed

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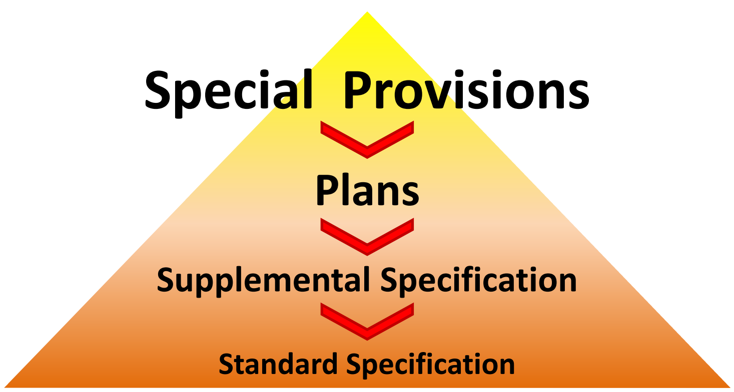
Project Documents

- Order of Hierarchy (§105.04)



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Project Documents

1. Special Provisions
   - Additions or revisions to the standard or supplemental specifications that are applicable only to an individual project
   - Examples of special provisions could include specialty mix types (CAM, CIR, etc.) and other items that are not “run-of-the-mill”.

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Project Documents

2. Plans
   - The drawings that show the location, character, dimensions, and details of the work to be done
   - Include pavement cross-sections, which mix types are to be used, spread rates, etc.

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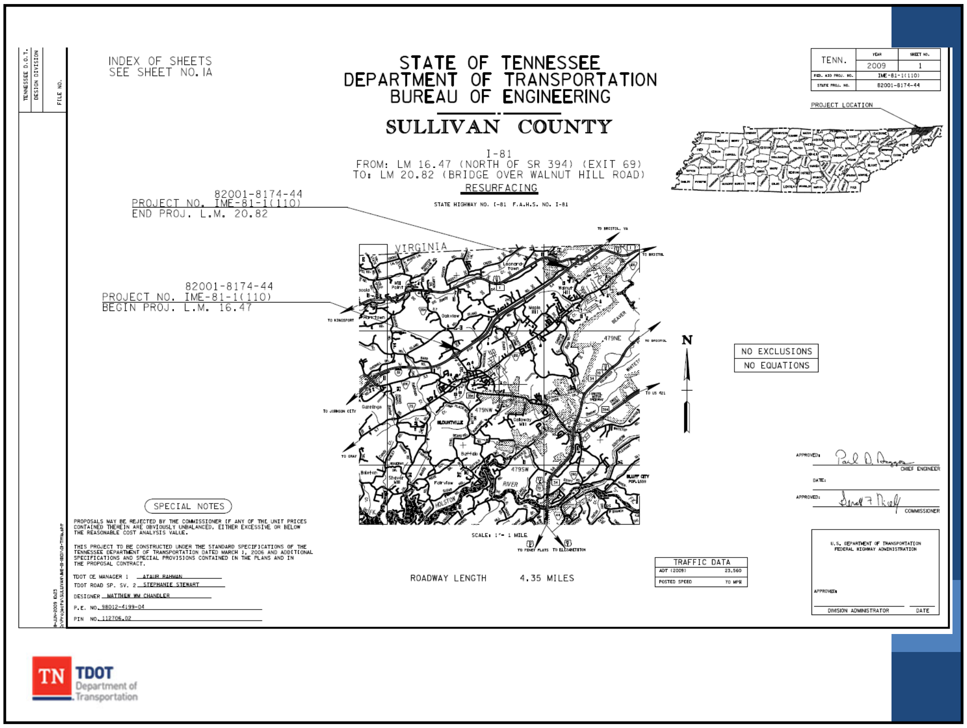
INDEX OF SHEETS
SEE SHEET NO. 1A
STATE OF TENNESSEE
DEPARTMENT OF TRANSPORTATION
BUREAU OF ENGINEERING
SULLIVAN COUNTY
I-81
FROM: LM 16.47 (NORTH OF SR 394) (EXIT 69)
TO: LM 20.82 (BRIDGE OVER WALNUT HILL ROAD)
RESURFACING
82001-8174-44
PROJECT NO. IME-81-1(110)
END PROJ. L.M. 20.82
82001-8174-44
PROJECT NO. IME-81-1(110)
BEGIN PROJ. L.M. 16.47
VIRGINIA
PROJECT LOCATION
NO EXCLUSIONS
NO EQUATIONS
SPECIAL NOTES
ROADWAY LENGTH 4.35 MILES
TRAFFIC DATA
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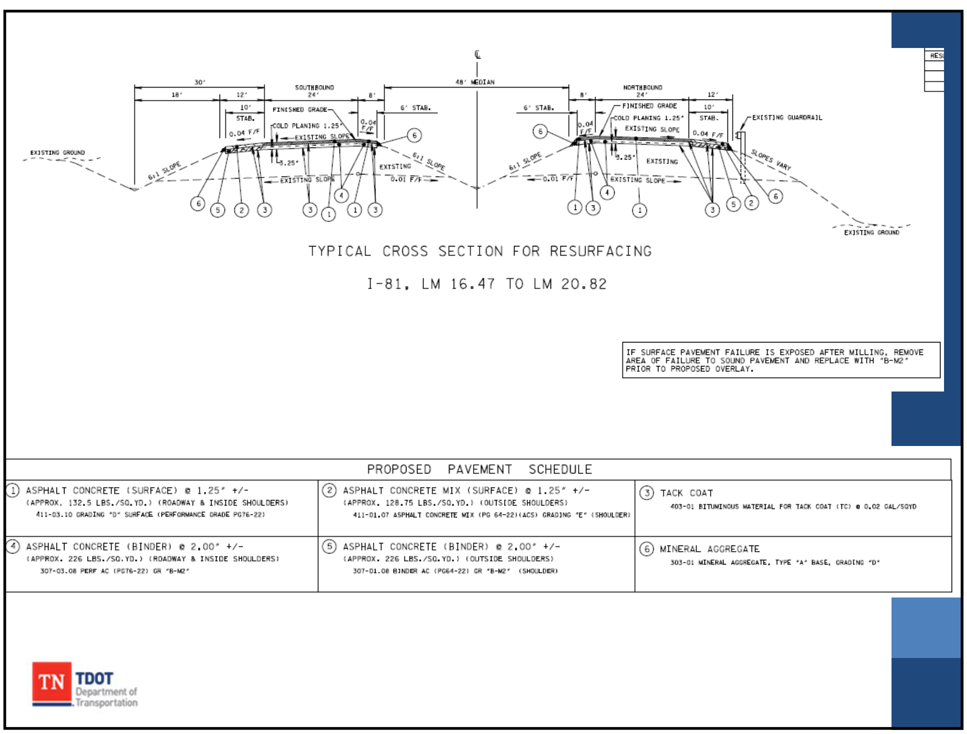
SOUTHBOUND
NORTHBOUND
48' MEDIAN
FINISHED GRADE
COLD PLANING 1.25"
EXISTING SLOPE
EXISTING GROUND
EXISTING GUARDRAIL
TYPICAL CROSS SECTION FOR RESURFACING
I-81, LM 16.47 TO LM 20.82
IF SURFACE PAVEMENT FAILURE IS EXPOSED AFTER MILLING, REMOVE AREA OF FAILURE TO SOUND PAVEMENT AND REPLACE WITH "B-M2" PRIOR TO PROPOSED OVERLAY.
PROPOSED PAVEMENT SCHEDULE
1 ASPHALT CONCRETE (SURFACE) @ 1.25" +/-
(APPROX. 132.5 LBS./SQ.YD.) (ROADWAY & INSIDE SHOULDERS)
411-03.10 GRADING "D" SURFACE (PERFORMANCE GRADE PG76-22)
2 ASPHALT CONCRETE MIX (SURFACE) @ 1.25" +/-
(APPROX. 128.75 LBS./SQ.YD.) (OUTSIDE SHOULDERS)
411-01.07 ASPHALT CONCRETE MIX (PG 64-22)(ACS) GRADING "E" (SHOULDER)
3 TACK COAT
403-01 BITUMINOUS MATERIAL FOR TACK COAT (TC) @ 0.02 GAL/SQYD
4 ASPHALT CONCRETE (BINDER) @ 2.00" +/-
(APPROX. 226 LBS./SQ.YD.) (ROADWAY & INSIDE SHOULDERS)
307-03.08 PERF AC (PG76-22) GR "B-M2"
5 ASPHALT CONCRETE (BINDER) @ 2.00" +/-
(APPROX. 226 LBS./SQ.YD.) (OUTSIDE SHOULDERS)
307-01.08 BINDER AC (PG64-22) GR "B-M2" (SHOULDER)
6 MINERAL AGGREGATE
303-01 MINERAL AGGREGATE, TYPE "A" BASE, GRADING "D"
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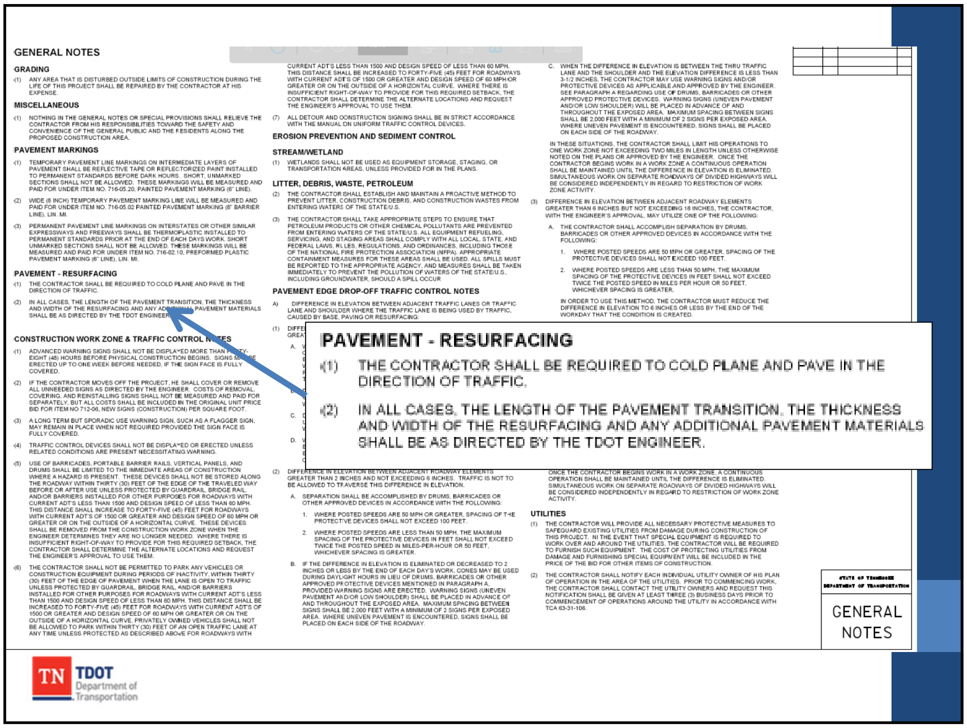

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Project Documents

GENERAL SPECIFICATIONS

3. Supplemental Specifications
   - Approved additions and/or revisions to the standard specifications
4. Standard Specifications
   - The directions, provisions, and requirements for performing the work illustrated and described in the plans

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TDOT Standard Specifications for Road and Bridge Construction

- Sections 307, 403, 407, 411, 415 attached
- Supplemental Specifications attached

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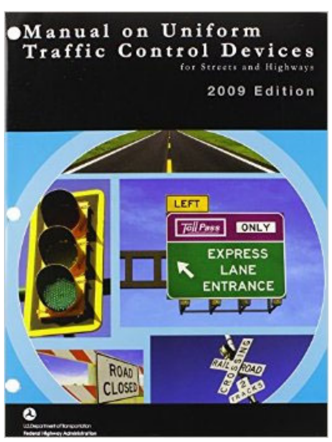
Referenced Manuals or Documents



- AASHTO or ASTM Specifications for Sampling and Testing
- Manual on Uniform Traffic Control Devices (MUTCD)
- TDOT Circular Letters, Policy/Procedure memorandums, etc...

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Project Records

- Checklist- Completed at start-up *(Circular letter – Back of this book)*
- Test Strip- Roller patterns/Nuclear Gauge Calibration
- DWR- Daily production info., guests, incidents, weather, etc.
- Daily Reports- Density *(Standard form for density also in back of book)*

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Pre-Construction/Paving Conference

105.06 Planning of the Operations-Preconstruction Conference

After the Contract is fully executed and before beginning work, provide the Engineer with a complete and practicable plan of operations in accordance with **108.03**, which shall provide for the orderly and continuous performance of the Work. After submitting the plan of operation, attend a preconstruction conference arranged by the Engineer. Make available at the meeting all data necessary to substantiate the plan of operation and scheduling. When applicable, also provide the following at the conference:

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1. Plan of Operation;
2. Material Suppliers List, including name and location of suppliers;
3. 24-hour emergency contact information for Traffic Control, Erosion Control, Customer Service, and Employee Safety professionals;
4. Copy of Signed Agreement between Prime Contractor and DBE Subcontractor;
5. Detouring/Controlling Traffic Plan;
6. Erosion control and storm water pollution prevention plan;
7. Traffic Control Certification Letter;
8. Proposed traffic signing diagram;
9. Contractor Employee Safety and Health Program (ESHP) Certification Letter;
10. Listing of all subcontractors and the items and/or material they are involved with; and
11. Buy America including all steel to be used including utilities, traffic and other steel components incorporated into the Project.

Ensure that all subcontractors have a safety program or participate in that of the Contractor. The Contractor is responsible for work site safety and conducting all operations to protect the workers engaged in duties connected with the Work.

In addition to this basic plan of operations, notify the Engineer of planned or contemplated operation details sufficiently in advance of starting each phase so that the Engineer may arrange for inspection. Such notice shall include the nature and location of the work planned or contemplated, the date and time of starting, and any hours outside of the conventional working day and working week during which the prosecution of such work is contemplated. Performing any work without notifying the Engineer and in the absence of inspection or a written waiver will constitute sufficient grounds for rejection of that portion of the Work.

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Pre-Construction/Paving Conference

- Basically, go over the plan of operations for the project.
- Make sure everyone is on the same page and understands the specifications and requirements of the work
- Coordinate with local/utilities to minimize impact to them and us.

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Safety…

Is *Everyone's* Business!

Worker Safety and the Motoring Public Safety are a PRIORITY!!!

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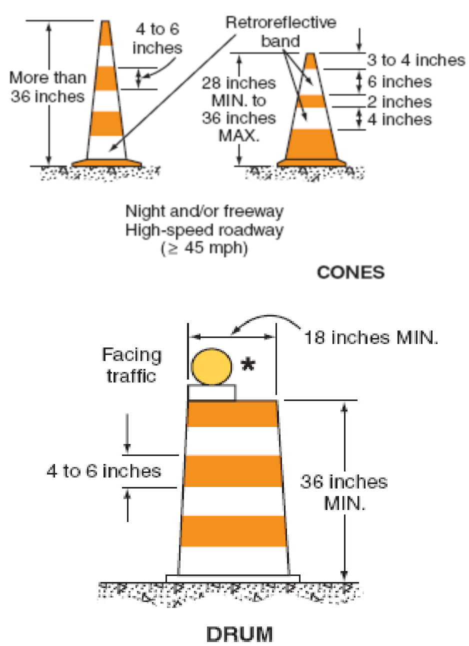

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Personal Protective Equipment Policy (305-01)

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Table A

Personal Protective Equipment Requirements

Activity	Scope of Work		Eye/Face	Head	Hearing	Foot	Additional PPE / Comments
Construction Activities							
TDOT Construction Projects	Any time on TDOT construction project ROW		*		*		* REQUIRED AS NEEDED

HIGH VISIBILITY LEGWEAR REQUIRED FOR ALL NIGHT OPERATIONS

ANSI: Type 1 Class C

Impact Rated for Min. 2,000lbs ↑

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Personal Protective Equipment Policy (305-01)

Must wear reflective legwear at night, either reflective pants or gaiters

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Stationing

- Roadway projects are linear construction and so the reference for where you are on the project relates to reference line. (usually the centerline)
- Distances along this line are marked in 100 foot stations.
- Shown as 1+00, 2+00, 3+00, etc

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Stationing

- Locations between stations are designated as +XX feet from the last station. So if you are 25' along centerline past station 100 you are at station 100+25.
- The distance between any two stations can be done by simply subtracting and ignoring the (+) in the station.

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Stationing

- Why do we use these and not say a sign or mile post?
- Mile posts/county signs are not surveyed into position and are of dubious accuracy.
- It is recommended to stake the project/or mark with paint stations to give accurate measurement/locations.

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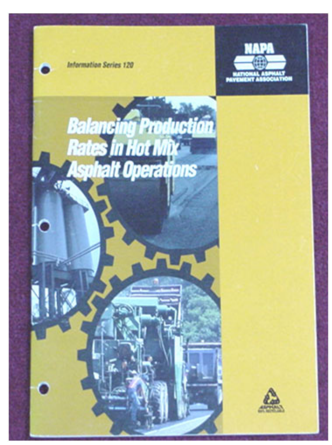
Balancing Act

- Plant Production
- Mixture Delivery
- Placement Rate
- Compaction Rate



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3.

Asphalt Materials

Materials for Asphalt Pavement

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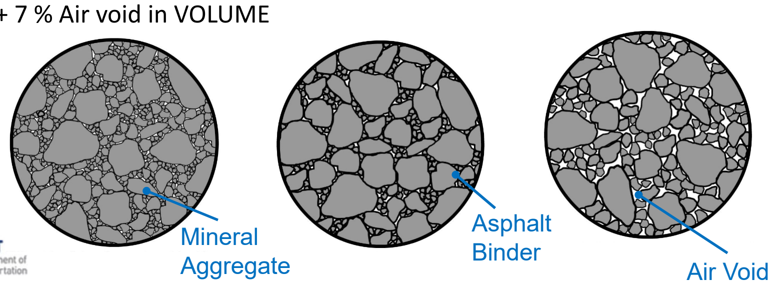
Basic Components of AC Mix

- Asphalt is made up of a combination of **Crushed Rock and Asphalt**.
- **Rocks glued together with asphalt**

86 % of Aggregates (crushed rock)
+ 7 % Asphalt
+ 7 % Air void in VOLUME



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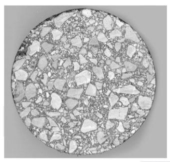
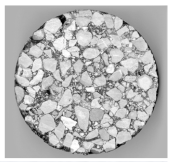
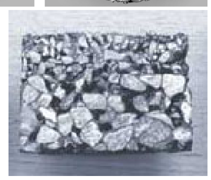
Aggregates

- Form the structural skeleton of the pavement
- Makes up about 95% of the mixture in weight
- Most of the strength of the pavement is from the stone to stone interaction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Asphalt Binder

- The glue that holds the aggregate together and turns it into pavement.
- About 5% by weight of the mix
- Alternatively known as: Asphalt Binder, Asphalt, Asphalt Cement, or Liquid AC
- Final by-product of oil refining process

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Asphalt Pavement and Sandcastle in Performance

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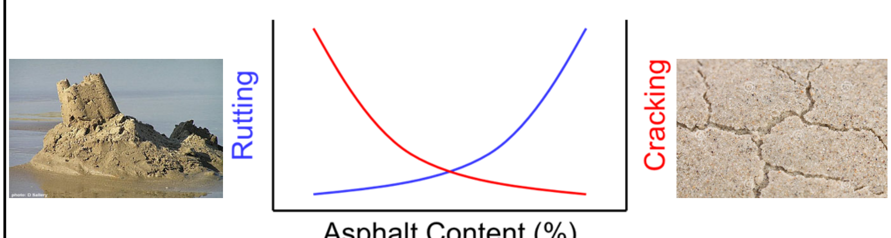
Cracking vs. Rutting



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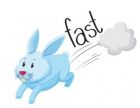
Asphalt Binder Behavior

Higher Temp

Viscous **soft** Longer Loading time

Elastic **hard** Shorter Loading time



Lower Temp

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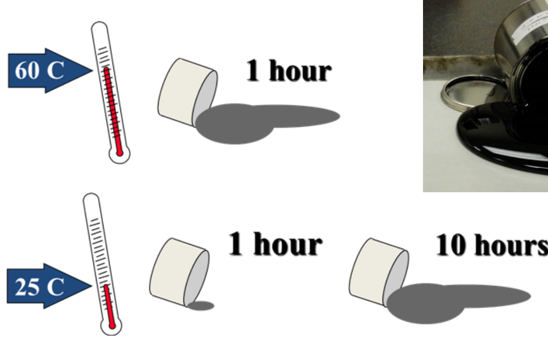
Asphalt Binder-Viscous

- Is a highly viscous liquid.
- At room temperature: asphalt feels solid but it is still liquid. Barely…



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Asphalt Binder-Elastic

- Asphalt's elastic properties means that when you place a load on it, it will bend; but when you remove the load it ***bounces*** back.
- This allows asphalt pavements to flex under heavy loads unlike a rigid material like concrete.
- Like viscosity, elastic behavior is temperature dependent.
  - ✓ As **temperature goes up**, elasticity goes down.
  - ✓ Additionally as the amount of time the surface is under load, elasticity goes down.

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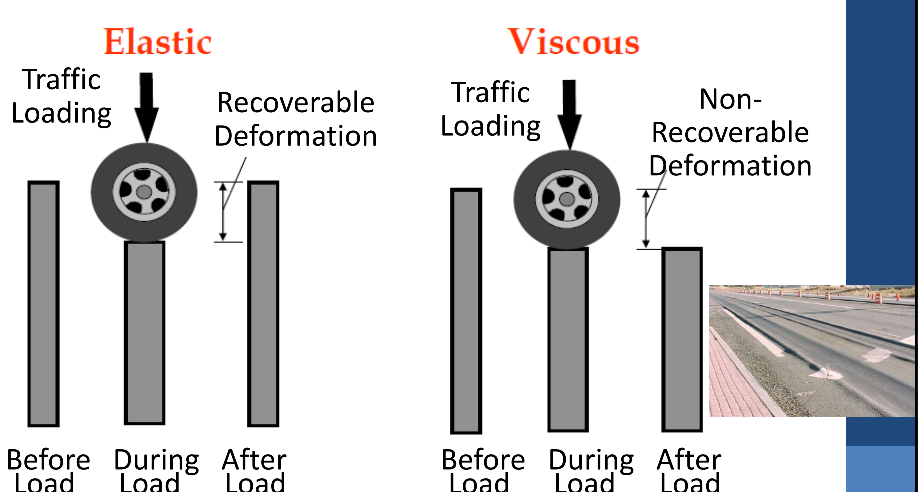
Effect of Visco-Elasticity



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Liquid Asphalts

- The **Performance Grade** (**PG**) system is the method of categorizing an asphalt cement **binder** used in asphalt pavement relative to its rated **performance** at different temperatures.
  - **PG 64-22**
  - **(Pronounced PG 64 "<u>minus</u>" 22)**
  - Minimum pavement design temp (°C) – Thermal Cracking
  - Average-7 day Max Pavement Design temp (°C) – Resist Rutting
  - Performance Grade

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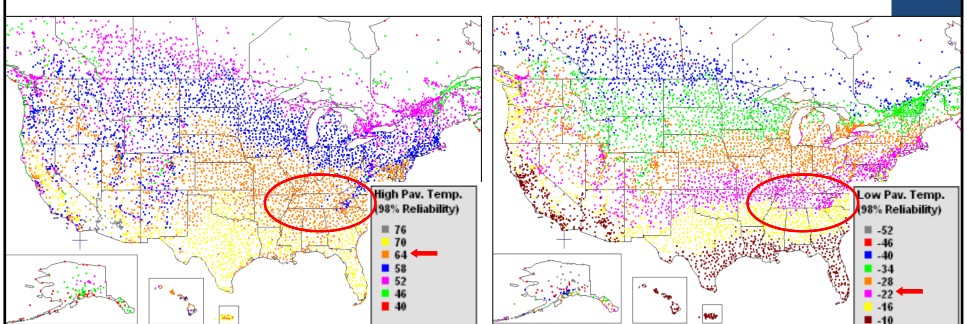
Asphalt Binder Selection



- Long-Term Pavement Performance (LTPP) program 7928
- Weather Stations in the US and Canada
- Binder Selection based on Temperature
- ***<u>PG 64 minus 22</u>*** is the most commonly used binder in TN

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Liquid Asphalts

- Section 904 of the TDOT spec book addresses these materials
  - What do you need to know?
    - TDOT typically uses 5 different "grades"
      - PG 64-22, PG 67-22, PG 70-22, PG 76-22, and PG 82-22
    - As the first two digits get higher, the material gets stiffer
    - 70, 76, and 82 are all considered "modified".

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Modified Binder

- To reduce the amount and severity of pavement distresses and to increase service life.
- Improved rutting resistance, less thermal (cold-temperature) cracking, and some modified binders provide improved stripping (moisture damage) resistance.
- PG grade is the concept of "Useful Temperature Interval (UTI)." Max to min temperature range where the binder is expected to perform properly.
- **Rule of 90: greater than 90? Then it is modified binder**
  - PG 64-22: 64°-(-22°)=64°+ 22°=86° (Unmodified)
  - PG 76-22: 76°-(-22°)=76°+ 22°=98° (Modified)

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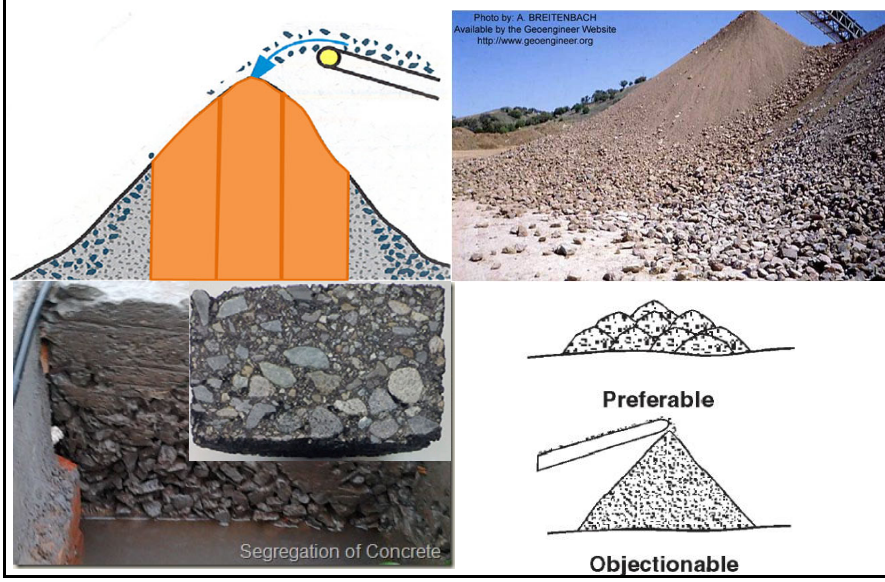
Aggregate Segregation



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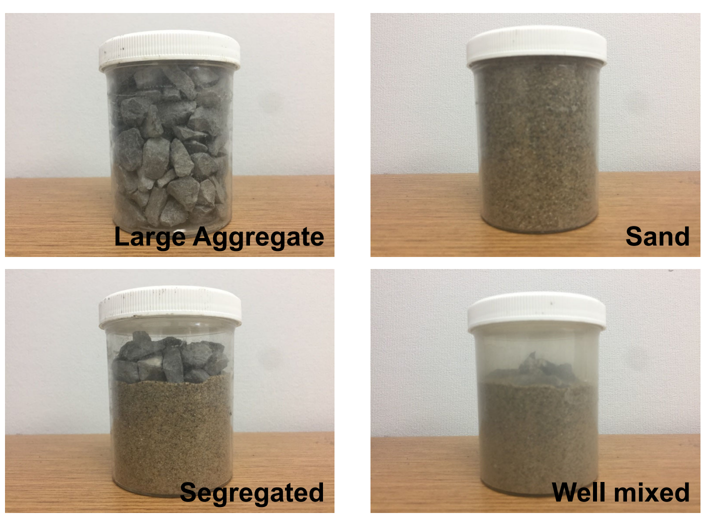
Aggregate Segregation



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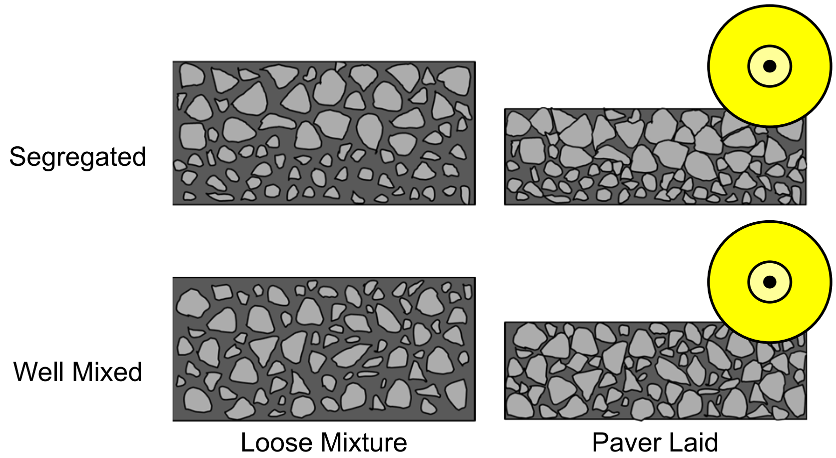
Aggregate Segregation



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Segregation

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4.

Surface Preparation

Surface Preparation and Milling Techniques

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- *The performance of an HMA pavement under traffic is directly related to the condition of the surface on which it was placed.*
- *Surface can be subgrade, aggregate base, or existing HMA or concrete pavement.*
- *Surface preparation often does not get the attention it needs.*
- *It is easy to cover up problems with HMA, but rarely do the problems go away.*

2

Objectives

- Preparation of an Existing Surface
- Materials and Construction Techniques for Patching
- Preparing a Milled Surface
- Proper Techniques for Placing Leveling Courses
- Role of the TDOT inspector

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Pavement Repair

- Selecting the best corrective action.
  - Cost, Longevity, Site Conditions, etc.
- Materials/Techniques
- Future Projects

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- *Pavement repair techniques must:*
  - *Match the repair technique to the existing conditions.*
  - *Use the proper materials and procedures to complete the repair and achieve long term performance.*
- *If the pavement failure is load related, the pavement material must be removed and replaced down to sound material.*

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- *After patching and sealing, and prior to applying the tack coat, the surface MUST be properly cleaned.*
- *Typically, a power broom or street sweeper is used.*
- *Any foreign material (dried mud, spilled asphalt, etc.) must be removed to insure a strong bond between layers.*
- *Cleaning is typically done immediately prior to placing the tack coat.*

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- *Preparing an existing pavement for an overlay may be as simple as sweeping the surface and spraying a tack coat...*

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- … or it may involve numerous other procedures:
  - patching
  - placing a leveling course
  - milling the existing surface
- Depends on the nature of the problem

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- *Sometimes, pavement preparation before an overlay may involve coming back to replace someone else's handiwork.*

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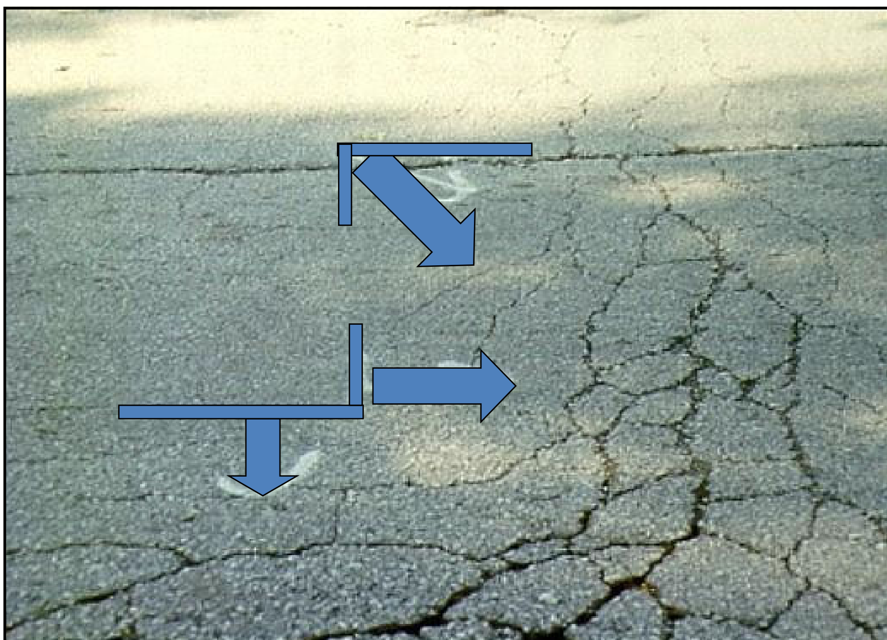

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- *The first step is marking the outline for the repair. The failed area should be cut back to sound pavement.*

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- *This patch would have been easier to repair if the edges were kept straight.*

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- *Properly constructed patches will perform well, whether or not the patch is part of pavement preparation prior to an overlay.*
- *Pre-construction meeting item: Utility repair coordination, so that utilities are not cutting trenches across a brand new pavement.*

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- *What about crack filling / sealing?*
- *This is an average size crack, a candidate for filling.*
- *Cracks must be cleaned and prepared properly prior to filling so the sealant will adhere to the pavement.*

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- *Typically, cracks less than 3/8" wide are too small to be filled effectively. The sealant does not enter the crack.*
- *The amount of reflective cracking in an overlay may be reduced by using a surface treatment (chip seal or slurry seal), depending on the cause of the cracking.*
- *TDOT does not use surface treatments as crack fillers even though they can be more economical than crack sealing, since crack sealing is more labor intensive.*

25

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- *This crack is large enough to be treated with a patch.*

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Concrete Pavement Failure

29

- *Concrete pavement surface preparation is similar to other existing surfaces.*
- *Problems with reflective cracking in asphalt overlays of concrete have led to several techniques to prevent or control the reflective cracking.*

30

Why do we mill?

- Removal of the existing pavement to the desired depth
- To restore the pavement surface to the specified grade and slope
- To help improve the ride-ability of an existing surface

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- *Milling can be used in lieu of leveling to remove the high spots from an existing surface.*
- *Milling is frequently used when maintaining the surface profile is necessary, such as in curb and gutter situations.*
- *Milling can also be used to remove mix related problems.*
- *Milling can be varied in width from 0.5 ft to over 13 ft.*
- *The largest milling machines can remove to depths over 8 inches.*
- *The RAP removed from the surface can be saved for future recycling.*

32


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RX-500
YIELD
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- *Proper pavement repairs when milling and overlaying are even more important, since milling removes some of the pavement structure.*
- *Underlying pavement problems may be uncovered during milling.*
- *As this photo shows, milling often leaves a very dirty and dusty surface. Multiple sweepings are often necessary to make sure all of the dust and dirt is removed.*

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Proper Milling Techniques

- Smooth Milling and Smooth Roads go hand in hand.

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The Future

- *Less projects with Binder and Scratch*
- *More projects with Mill and Overlay*
- *Fewer chances to improve smoothness*
- *Forced to look at the front of the paving train*

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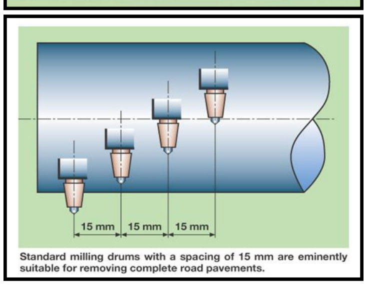
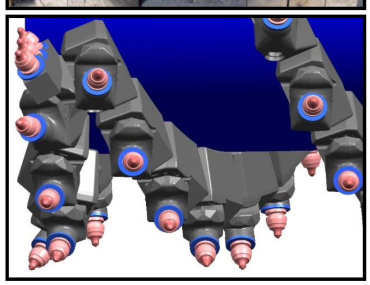
STANDARD CUTTING PATTERN





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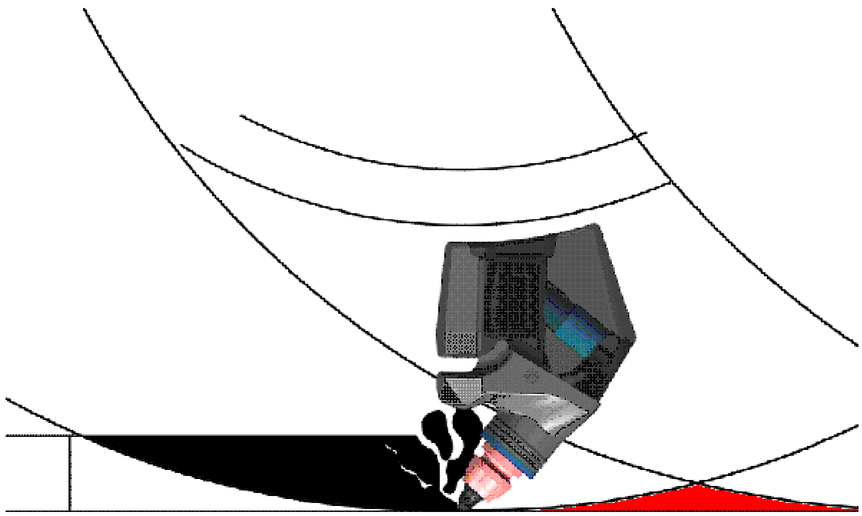
Speed is a factor



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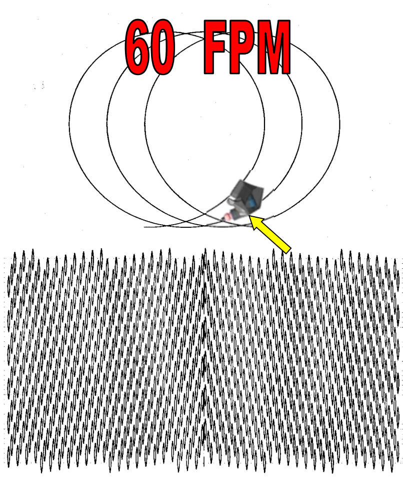
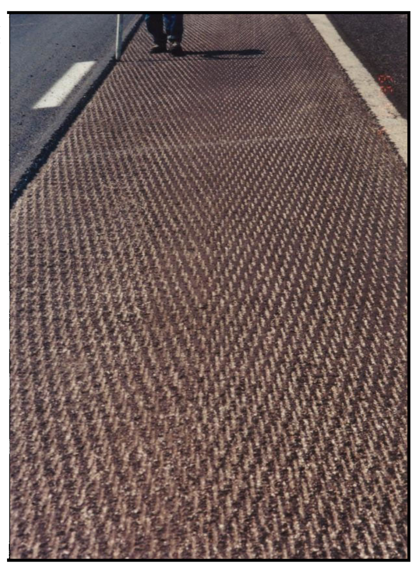
CUTTING PATTERN





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Section 415.03

When milling the roadway for hot mix overlays the maximum allowable forward speed shall be:

- 60 ft/min when the teeth spacing is ½ - 5/8 in.
- 80 ft/min when the teeth spacing is < ½ in.

NOTE: <u>Maximum</u> of 5/8" tooth spacing

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Section 415.03 cont'd.

415.03-General Requirements.
.... After planing, the finished surface shall provide a smooth riding surface *<u>free from gouges</u>*, ridges, oil film, and other imperfections of workmanship, *<u>having a uniform texture</u>*, and true to the required grade and cross section

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Placing Leveling Courses

- Leveling can be used to correct low spots and cross section deficiencies.
- Other terms include scratch course, wedge, and leveling course.
- The extent of leveling course is marked off, and then placed with a paver or by hand.
- Compaction of leveling courses is best achieved with a rubber-tired roller, rather than steel wheel rollers, since thickness will vary.

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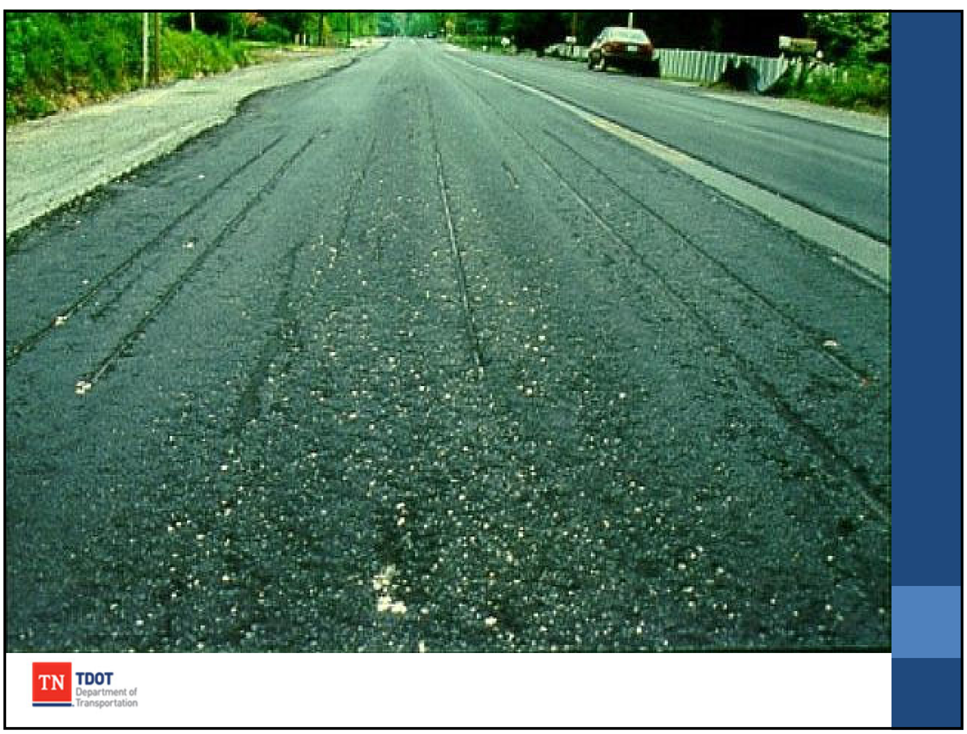
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- *Be careful with the maximum aggregate size in the HMA and leveling course thickness…*
- *The center was thinner than the edges–the white aggregate pieces were being crushed and drug by the screed.*

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Role of the TDOT Inspector

- Circular Letter 407.14-01: "Hot Mix Asphalt Roadway Inspector Checklist"
  - Milling/Cold Planing

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5.

Tack Coat

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Tack Coat

1

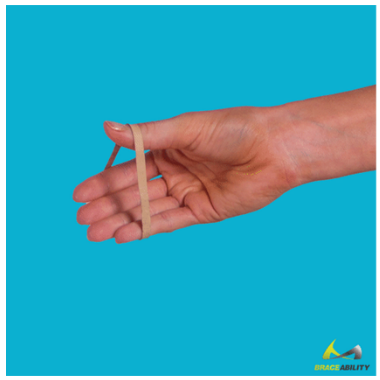
What is Tack Coat?

<u>TACK COAT:</u>
A thin layer of bituminous material placed between layers of hot mix asphalt to promote bonding

2

Why use Tack Coat?

Asphalt Pavement is flexible under traffic.



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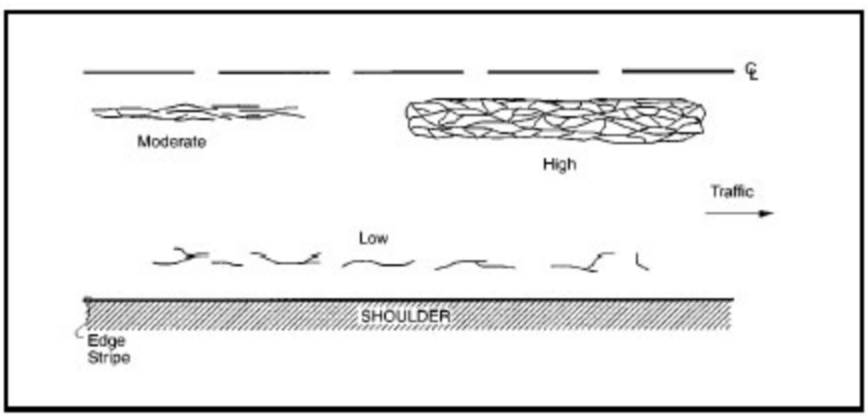

FIGURE 3
Distress Type ACP 1 - Fatigue Cracking

4

Lessen Fatigue Failures

Limit how much flexing happens under traffic.

How?

Make the pavement thicker.

But stacking layers on layers won't work alone.

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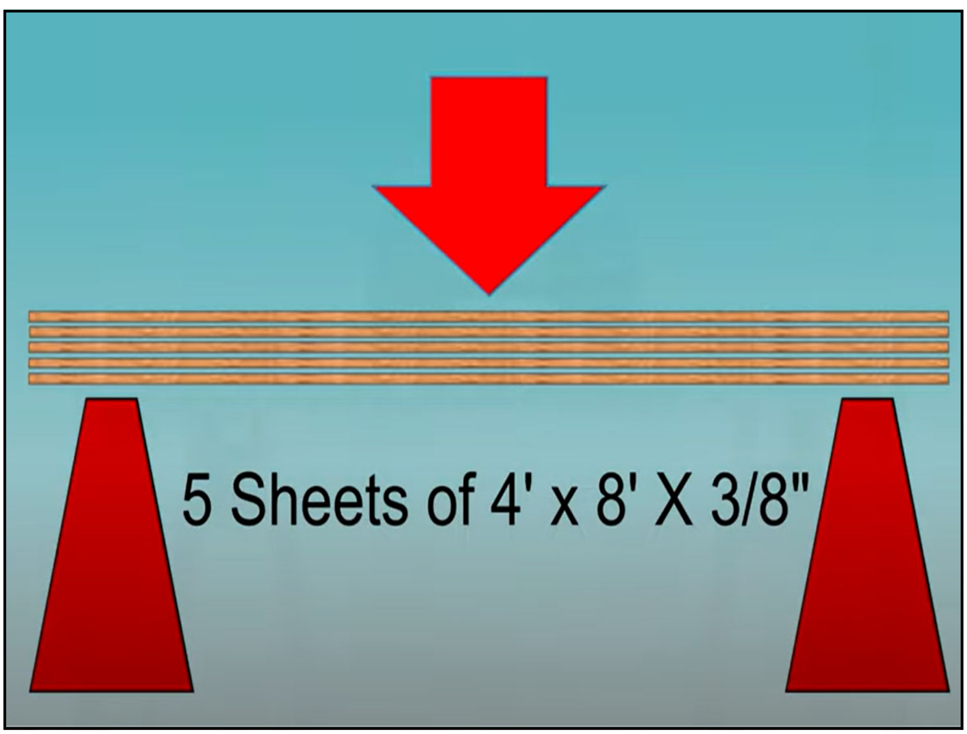

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Unbonded layers mostly act independent of each other, overall stiffness isn’t greatly improved

Bonded layers mostly together, gives a much stiffer reaction.

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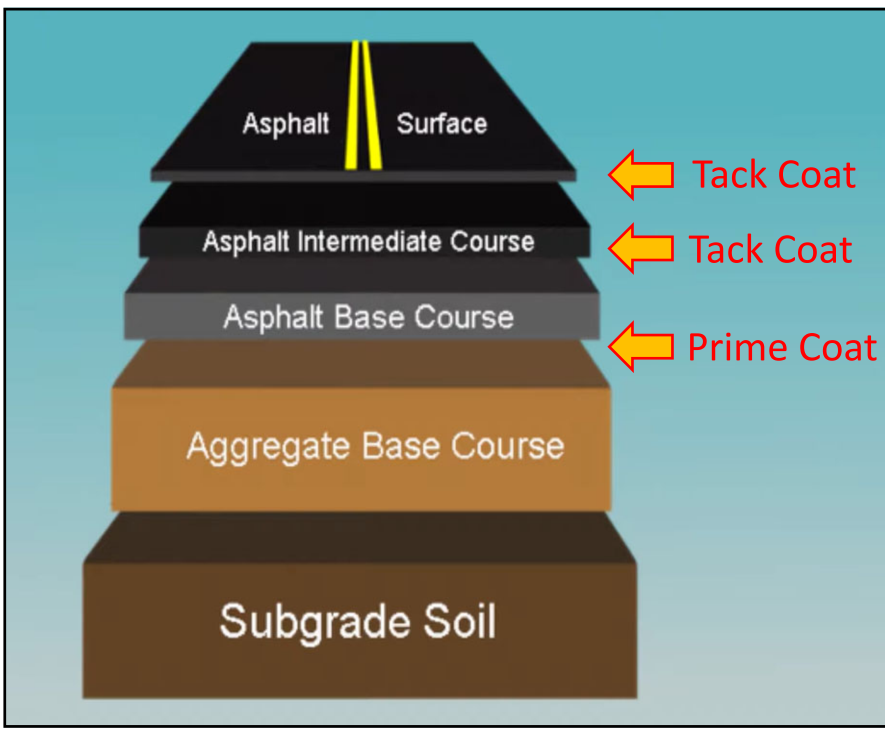

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Loss of Pavement Life

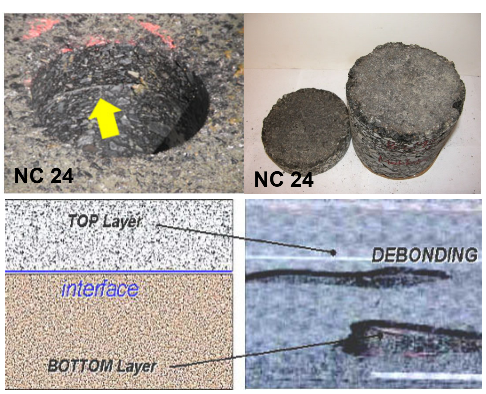
Asphalt Institute: compared to 100% coverage

- 0% coverage (no tack) = 60-75% less life
- 70% coverage (Zebra Stripes) = 70% less life
- 90% coverage = 50% less life.

9

Why Else use Tack Coat?

- Layer interface separation (AKA Debonding)
- Caused by ***insufficient bonding force*** between layers



Slippage

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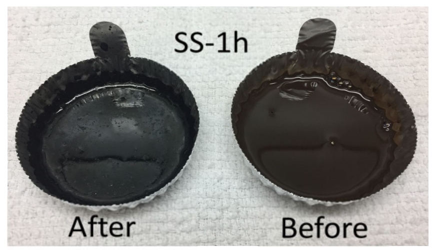
Components of an Emulsion

- Emulsions are typically approximately 60% asphalt and 40% part water.



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Tack Coats

- Materials allowed for use as tack on TDOT projects*:
  - Asphalt emulsions:
    - SS-1, SS-1h, CSS-1, CSS-1h, CQS-1h, CQS-1hp, TST-1p, RS-1, CRS-1, and QPL approved Trackless Tacks
- *TDOT Spec – Section 403

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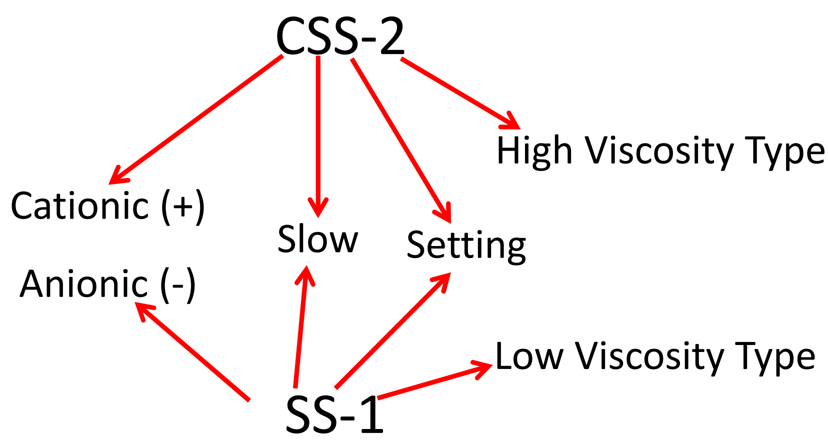
Grade and Classification



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Classified by Reactivity and Particle Charge

Reactivity

	Cationic	Anionic	
	+	–	
Rapid-Setting	CRS	RS	Chip Seal
Medium-Setting	CMS	MS	Open Graded Mix
Quick-Setting	CQS	QS	Dense Graded Mix
Slow-Setting	CSS	SS	Dense Graded Mix

14

Handling Asphalt Emulsions

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Handling Asphalt Emulsion

- Diluting emulsions is not allowed by TDOT on HMA project, except for some sealing applications.
- Avoid repeated pumping and recirculating, as the viscosity may drop and air may become entrained, causing the emulsion to be unstable and fail.
- Agitate emulsions that have been in prolonged storage. This may be done by recirculation

16

Handling Asphalt Emulsion

- **DO NOT** mix different classes, types, and grades of emulsified asphalt in storage tanks, transports, or distributors. See Table *Guide for Condition of Emptied Tanks Before Loading Asphalt Emulsions* for recommendations.

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Guide for Condition of Emptied Tanks Before Loading Asphalt Emulsions

Product to be Loaded	Last Product in Tank					
	Asphalt Cement	Cutback Asphalt and Residual Oils	Cationic Emulsion	Anionic Emulsion	Crude Petroleum	Any Product Not Listed
Cationic Emulsion	Empty	Empty to no measurable quantity	OK to load	Empty to no measurable quantity	Empty to no measurable quantity	Tank must be cleaned
Anionic Emulsion	Empty	Empty to no measurable quantity	Empty to no measurable quantity	OK to load	Empty to no measurable quantity	Tank must be cleaned

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Proper Tack Coat Application

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- *While the surface is still clean, place the tack coat.*
- *The tack coat ensures a bond between the existing pavement and the overlay.*
- *Start with the application rate shown in the Paving Schedule on the PROJECT PLANS*
- *Place a test strip in accordance with section 403.05 of the TDOT specs.*
- *Even if the rate is correct, the material MUST be distributed EVENLY.*

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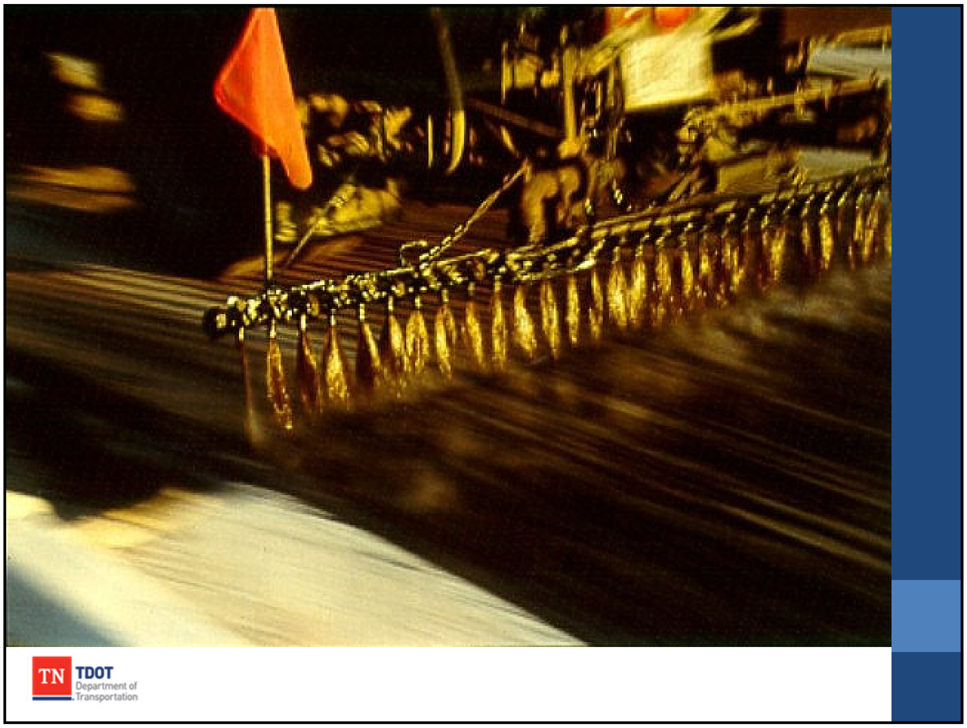
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How much
is enough?
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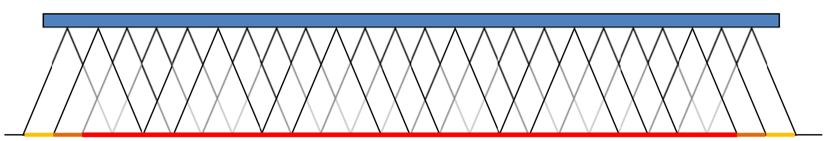
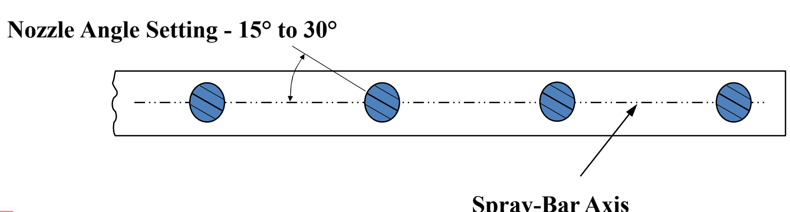
Correct Spray with Triple Overlap



Proper Settings of Nozzles



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- Nozzles must be relatively clean and positioned correctly to achieve a triple overlap.

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- *Asphalt emulsions are applied brown, and then turn black after they break.*
- *The emulsion must be allowed break before placing the HMA.*
- *Typical tack coat application rate not to exceed 0.1 gallons per square yard.*
- *Tack coat application rate on milled surface not to exceed 0.12 gallons per square yard.*
- ***The actual application rate for your project will be shown on the plans.***

29

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- *Make sure the tack coat goes where it is supposed to go….*

31

Tack Coat Application Rate Example

- **Initial Reading on Tack Truck: 500 gallons**
- **Final Reading on Tack Truck: 320 gallons**
- **Tack applied to 2,500’ of a 12’ wide lane**
- **Roadway Surface is not milled**

A) What is the application rate?

B) Does it pass TDOT specifications?

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Tack Coat Application Rate Example

- Initial Reading on Tack Truck: 500 gallons
- Final Reading on Tack Truck: 320 gallons
- Tack applied to 2,500’ of a 12’ wide lane
- Roadway Surface is not milled

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Tack Coat Application Rate Example

- **Initial Reading on Tack Truck: 400 gallons**
- **Final Reading on Tack Truck: 35 gallons**
- **Tack applied to one mile of a 12’ wide lane**
- **Roadway Surface is milled**

A) What is the application rate?

B) Does it pass TDOT specifications?

34

Tack Coat Application Rate Example

- Initial Reading on Tack Truck: 400 gallons
- Final Reading on Tack Truck: 35 gallons
- Tack applied to one mile of a 12’ wide lane
- Roadway Surface is milled

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Sampling Asphalt Emulsions

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TDOT Requires Emulsion Samples

- Requirements listed in TDOT's **S**tandard **O**perating **P**rocedures (SOP 1-1) state that samples of emulsions should be taken from asphalt emulsion terminals and from TDOT projects using emulsion to verify the quality of these materials.

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SOP 1-1

- *Emulsions for prime coats, tack coats, and sealers (aka. fog seals)* – Sampled by the project inspector and once per week thereafter.
- *Emulsions from Surface Treatments (aka chip seals), Microsurfacing, Slurry sealing and related similar processes* - Sampled by the project inspector and once per week thereafter.

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SOP 1-1

- Basically, if there is emulsion on the project, a sample needs to be taken from the field <u>once per week.</u>

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Bad EMULSION samples

- Improperly collected emulsion samples can cause them to be contaminated and useless for testing

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Common Sampling Errors

- Samples taken from distributor spray bars can easily become contaminated.

41

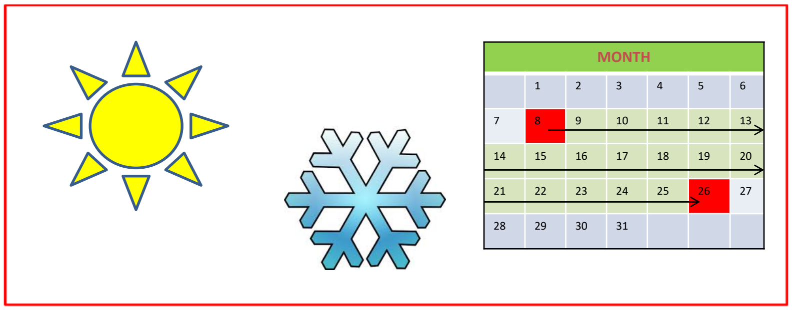
Common Sampling Errors

- Emulsion samples cannot be taken in containers that have been previously used or in metal containers.

42

Common Sampling Errors

- The sooner samples can be tested the better. Emulsion samples can go bad if too much time has passed since sampling or if they have been exposed to extreme heat or cold.



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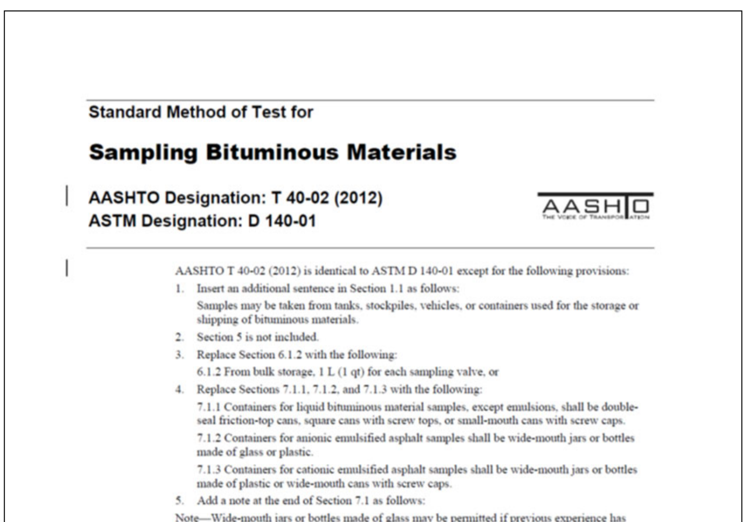
Proper Sampling



Standard Method of Test for

Sampling Bituminous Materials

AASHTO Designation: T 40-02 (2012)
ASTM Designation: D 140-01

AASHTO

AASHTO T 40-02 (2012) is identical to ASTM D 140-01 except for the following provisions:

1. Insert an additional sentence in Section 1.1 as follows:
   Samples may be taken from tanks, stockpiles, vehicles, or containers used for the storage or shipping of bituminous materials.
2. Section 5 is not included.
3. Replace Section 6.1.2 with the following:
   6.1.2 From bulk storage, 1 L (1 qt) for each sampling valve, or
4. Replace Sections 7.1.1, 7.1.2, and 7.1.3 with the following:
   7.1.1 Containers for liquid bituminous material samples, except emulsions, shall be double-seal friction-top cans, square cans with screw tops, or small-mouth cans with screw caps.
   7.1.2 Containers for anionic emulsified asphalt samples shall be wide-mouth jars or bottles made of glass or plastic.
   7.1.3 Containers for cationic emulsified asphalt samples shall be wide-mouth jars or bottles made of plastic or wide-mouth cans with screw caps.
5. Add a note at the end of Section 7.1 as follows:

Note—Wide-mouth jars or bottles made of glass may be permitted if previous experience has

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Proper Sampling

Designation: D140/D140M – 09

Standard Practice for Sampling Bituminous Materials[1]

This standard is issued under the fixed designation D140/D140M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This practice applies to the sampling of bituminous materials at points of manufacture, storage, or delivery.

1.2 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

4. Precautions

4.1 Because of the numerous types and grades of bituminous materials that are alternately shipped and stored in the same or similar containers, the opportunity for contaminating these containers with residues, precipitates, or cleaning solvents is ever present. Numerous opportunities also exist for obtaining samples which are not strictly representative of the material or are contaminated after removal. Therefore it is incumbent upon the producer, transporter, user, and sampler to exercise continuous precaution in the sampling and handling of these materials.

5. Selection of Samples

5.1 Whenever practicable, bituminous materials shall be sampled at the point of manufacture or storage, and at such time as to allow the tests controlling acceptance or rejection to be made in advance of shipment.

5.2 When the samples cannot be taken at the point of

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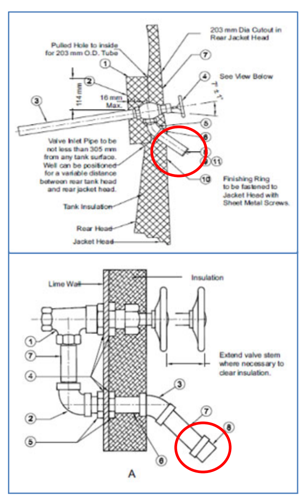
Proper Sampling

The best place to sample emulsions in the field is from the sample valve.



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Proper Sampling

- Samples should be ***PROPERLY LABELED*** and accompanied by a T-2 (DT-0044) sample form. Identify:
  - The material classification (SS-1, CRS-2p, etc),
  - Contract number,
  - Date sampled,
  - Sampler,
  - Where the sample was taken from (distributor, contractor's storage tank, etc.)
- All samples should be taken from the sample valve, and a MINIMUM of 1-gallon of material should be run through the sample valve and wasted prior to collecting the sample.

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Proper Sampling

- For materials where dilution is permitted (shoulder fog seals or tack coat from microsurfacing projects) note whether the sample was taken before or after dilution.
- Dilution is not permitted for tack coats on HMA projects.
- All samples should be taken by contractor, observed by TDOT employee, either from the contractor's storage tank or directly from the distributor.

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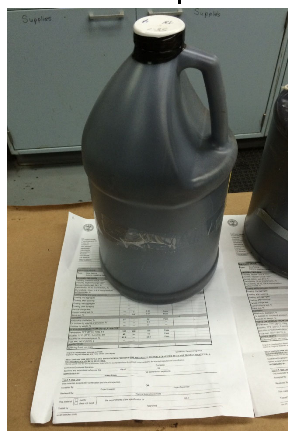
Proper Sampling

- All emulsion samples should be collected in wide-mouth jars or bottles made of plastic or wide-mouth plastic-lined cans with lined screw caps.



Sample containers can be received from Regional or HQ M&T

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Role of the TDOT Inspector

- Circular Letter 407.14-01: “Hot Mix Asphalt Roadway Inspector Checklist”
  - Tack Coat

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6.

HMA Delivery

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Hot Mix Asphalt Delivery

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1

- *Delivery is the start of the HMA construction process.*
- *Like any process, if it is planned properly, it will go smoothly.*
- *The smoother the process, the better the product.*

2

Objectives

- TDOT Specifications for Trucks
- Proper Loading of Haul Trucks
- Proper Haul Truck Operating Techniques
- Role of the Inspector

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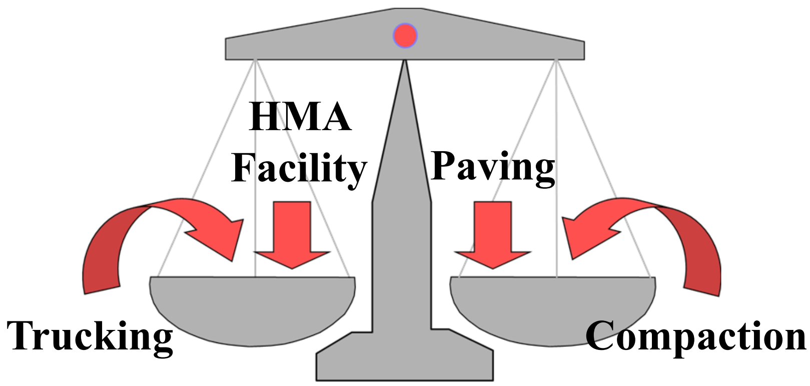
3

- *The theme to this module is looking at HMA construction as a process, and how keeping the process running smoothly lessens problems and improves the product.*
- *<u>Balance</u> the haul rate with the others to produce the best job possible.*
- *Why is consistent HMA delivery so important?*
- *What works against keeping a steady supply of mix coming to the paver?*

4

Balancing Production



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- *Paving is a constant balancing act.*
- *Mix production and delivery must be balanced with lay down and compaction to ensure a smooth operation and a high quality mat. Mix production:*
- *Haul trucks: Adequate numbers (and no pack driving!)*
  - *Lay down production: dependent on width and depth*
  - *Compaction: How many rollers do you need?*

6

Dump Trucks

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7

- *Each are loaded at the plant in the same manner from the silo or pugmill. The difference is in how they unload the mix at the paver.*
- *End dump truck delivers mix directly to the paver hopper, 3 to 6 axles,*
- *Capacity: 15-22 tons (more axles, more capacity)*
- *Advantage: Shortest wheel base, easiest to maneuver*
- *Disadvantage: Limited capacity*

8

Truck Weight Limits-TDOT Spec

- Legal limits found in TDOT Circular Letter 109.01-02*
  - Example (Interstate)
    - End dump 4-axle-
    - Legal Limit- 68,000 lbs.
- TDOT Spec 107.02 – "Conspicuously display the tare weight, the allowable gross weight for State Highways, and the allowable gross weight for the Interstate System on the side of all delivery trucks."
- *Back of this book

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Additional axles to raise weight limit

10

Truck Maintenance

- Trucks must be in mechanically sound condition
- Items to maintain include engine, drive train, hydraulic system, brakes, and lights
- Back-up warning devices
- Driver is responsible for maintenance

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11

- Fuel leaks must be checked and repaired
- Diesel is a solvent of asphalt!

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TDOT Truck Requirements

- **407.05-Hauling Equipment.** Trucks used for hauling bituminous mixtures shall have …

…tight, clean, smooth metal beds which 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.

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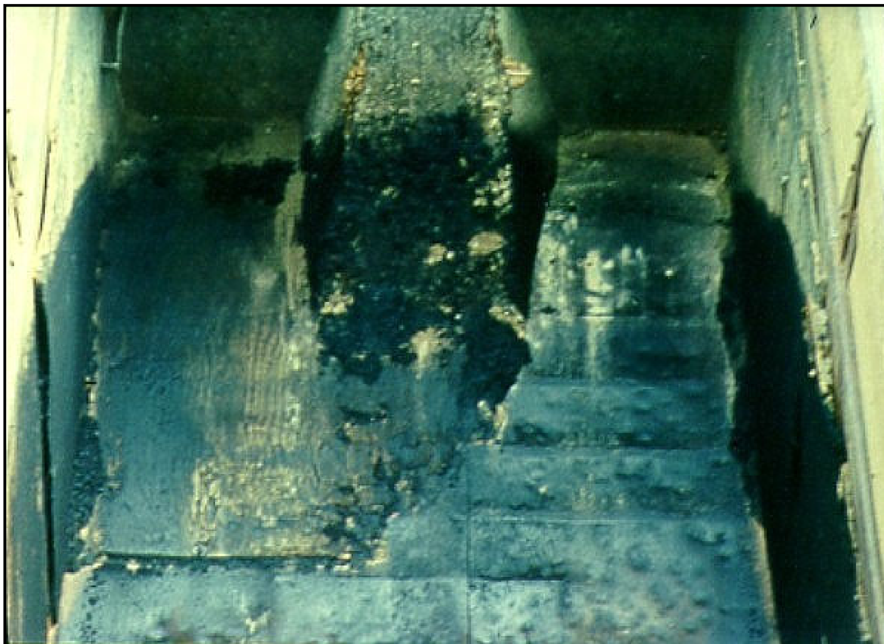

NOT ACCEPTABLE!

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- *The truck bed must be inspected and properly cleaned prior to loading the HMA.*
- *Free from old mix, extraneous materials, debris.*
- *No dents or depressions.*
- *Modified asphalts can cause greater sticking problems in the bed.*

16

- *The outside of the truck should also be kept clean and free of extraneous materials.*
- *Look for loose rock and dirt near the truck's tail lights.*

17

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- *There should be a designated clean up area for the drivers to clean any remaining mix from the rear of the truck, the apron, and the tailgate.*
- *The clean up area is <u>not</u> the paving site.*
- *Again, modified asphalt can make this a more troublesome task.*

19

Truck Loading Operations

- Applying APPROVED release agents
- Proper loading at the plant
  - Multiple Dumps
- Covering Mix with tarps

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- *Drivers must be made part of the paving team from the beginning. They should understand their role and purpose in the team.*
- *Safety is paramount around the jobsite. Drivers must act responsibly, and adequate traffic control must be available to ensure safe passage.*
- *Truck tracking systems are now available using GPS .*

21

TDOT QPL #21- 10+ Approved Release agents!!!

22

- *Once the bed is clean, apply an approved release agent.*
- *Non-petroleum materials sprayed uniformly on the sides and bottom–just enough to coat the bed without runoff.*
- *Diesel fuel can cause problems with the mix, and is hazardous to the environment.*
- *Local agencies have different approved material lists.*

23

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- *Next we are going to look at truck loading practices.*
- *This photo shows silo gates discharging mix into the truck.*
- *This subject may seem to be fairly simple, but improper loading is a prime source for mix segregation.*
- *Proper loading can help eliminate a segregation problem.*
- *The loading plan should be discussed and agreed upon at the preconstruction conference.*

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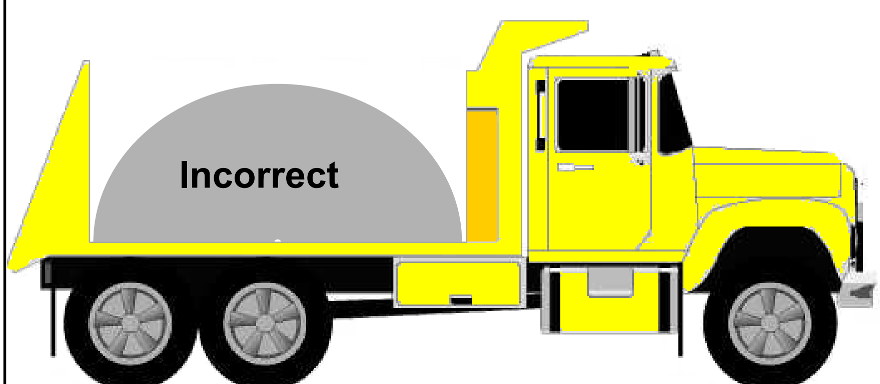

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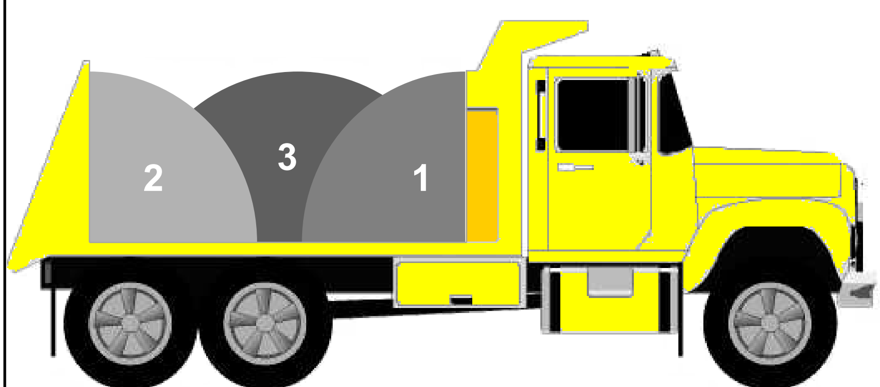
- *Most trucks need to have the load slightly forward in the truck bed to comply with axle weights and load distribution regulations.*
- *This load is centered too much in the truck bed.*
- *This load is more properly placed–slightly forward of the center of the bed.*

27



28

- *The objective of truck loading is to get the mix loaded into the truck as uniformly as possible.*
- *The greatest concern in uniformity is segregating the mix as it is loaded into the truck.*
- *Getting the HMA against the front and back is an important consideration in preventing segregation. If the mix is not crowded to the ends, the larger rocks in the mix can roll down the slopes and gather in one place.*
- *Especially for segregation-prone mixes, multiple drop procedures are recommended.*
- *With multiple drops, end dump trucks are loaded at the front and rear of the bed, and then in the middle.*

29

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- *Haul trucks should be equipped with tarps.*
- *Tarps protect the mix during inclement weather and prevent wind drafts from cooling the mix*
- *Water-repellent, resist tearing, without holes.*
- *Once Loaded, tarped, pick up ticket and go directly to jobsite*

31

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TDOT Truck Requirements

- **407.05-Hauling Equipment.**

Trucks used for hauling bituminous mixtures shall be covered immediately after loading at the plant with a cover of canvas or other suitable material. The covers shall be of sufficient size to protect the mixture from the weather. The cover shall lap down along the sides and rear of the truck bed a minimum of 6 inches (150 millimeters) and be secured by tie downs at a maximum of 5 ft. (1.5 m) spacing along the sides and rear of the truck bed.

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Role of the TDOT Inspector

- Temperature check every **5th load**.
- Spec. 407.05, Hauling Equipment:
  - Insulate truck beds and securely fasten covers over the asphalt mixture.
  - Provide a 3/8-inch hole in **both sides** of each truck bed for inserting a thermometer.
- Check for segregation and contamination.

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Mix Delivery Temperatures

- 407.14- The temperature of the mixture at the time of depositing in the paver hopper shall be in accordance with section 407.11, Table B.

PG Binder Grade	Min. Temp.	Max 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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- *Haul trucks should park in designated areas, and minimize the tracking of tack coats.*
- *Here, one truck has just finished loading the paver, and it pulls away as another truck waits.*
- *The waiting truck was far enough ahead so not to interfere, but close enough to get to the paver and keep the operation moving smoothly.*
- *Again, communication is the key–the drivers should be informed about the paving plan.*

37

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- *The next truck slowly backs toward the paver, while the paver lowers its wings (to give the truck access to the hopper) and continues to move forward.*

39

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- *The truck brakes to a halt in front of paver, ready to be picked up on the fly.*
- *It is important that the truck be centered on the paver before the paver makes contact. Damage to the mat and the paver can result from off-center positioning.*
- *The area between the truck and paver is off limits to personnel. Too many accidents occur in this area.*

41

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- *Once the truck has stopped, the driver releases the brakes and the paver "picks up" the stopped truck. In this photo, the truck is also beginning to lift the bed.*
- *The key is that the truck does not back into the paver and bump it. Bumping the paver can leave a screed mark and roughen the mat.*
- *Once the paver picks up the truck, it pushes the truck forward. A light touch on the brakes keep the truck against the paver.*

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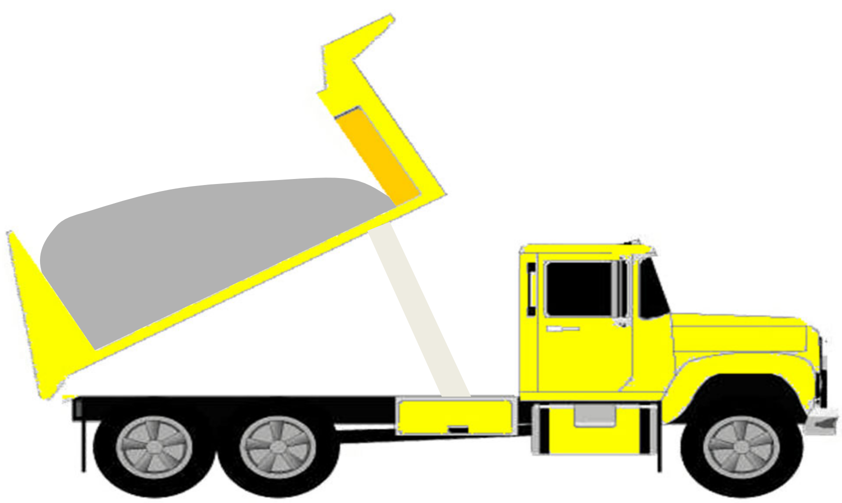

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- *With end dump trucks, the proper procedure for dumping the mix into the hopper is to raise the truck bed slightly and allow the mix to slide against the tailgate before it is released.*
- *This procedure will allow the mix to flood the hopper–not allowing mix to dribble from the truck into the hopper before the bed is raised.*
- *With live bottom trucks, try to use the same procedure to flood the hopper from the truck.*

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- *After the hopper is filled, the truck bed is gradually raised, continually charging the hopper and maintaining a smooth operation.*

47

Crusted Mix

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48

- *No set distance limit for hauling HMA.*
- *Any crust that does form during transport should break up completely as the mix is dumped into the paver and carried back to the screed provide the mix temperature is adequate and especially with the MTD.*
- *The crust must not affect the mat behind the paver.*

49

50

- *While paving, the truck driver must concentrate both ahead and behind.*
- *The driver must steer between the "pull" of the paver, and keep slight pressure on the brakes to maintain contact with the paver.*
- *Too much braking force may make the paver slip and affect the mat.*

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CONSIDER POSSIBLE OBSTRUCTIONS

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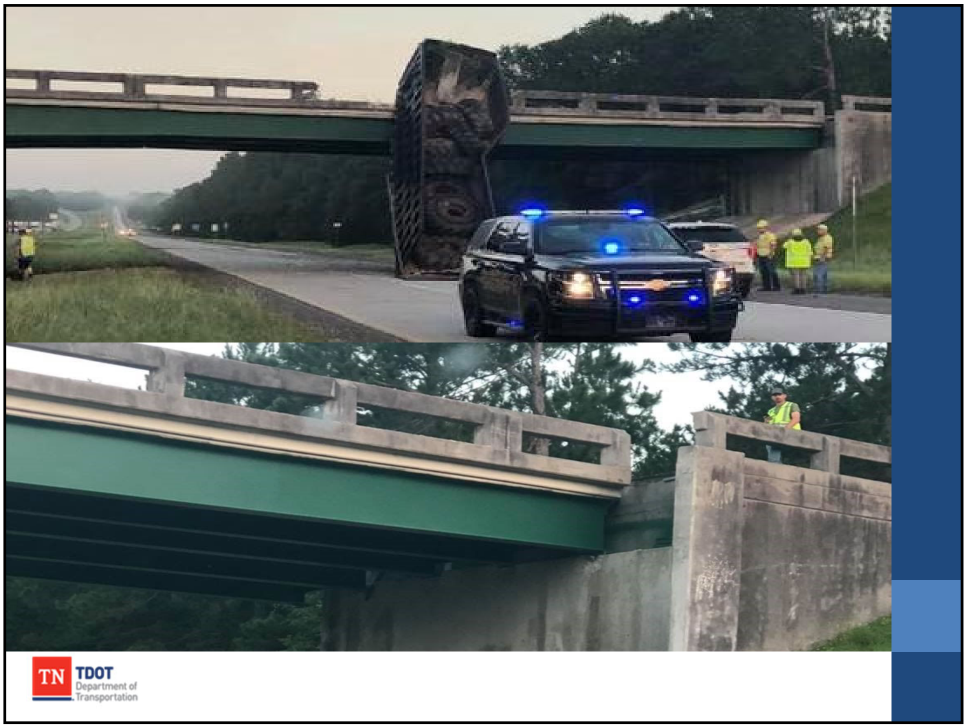
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55

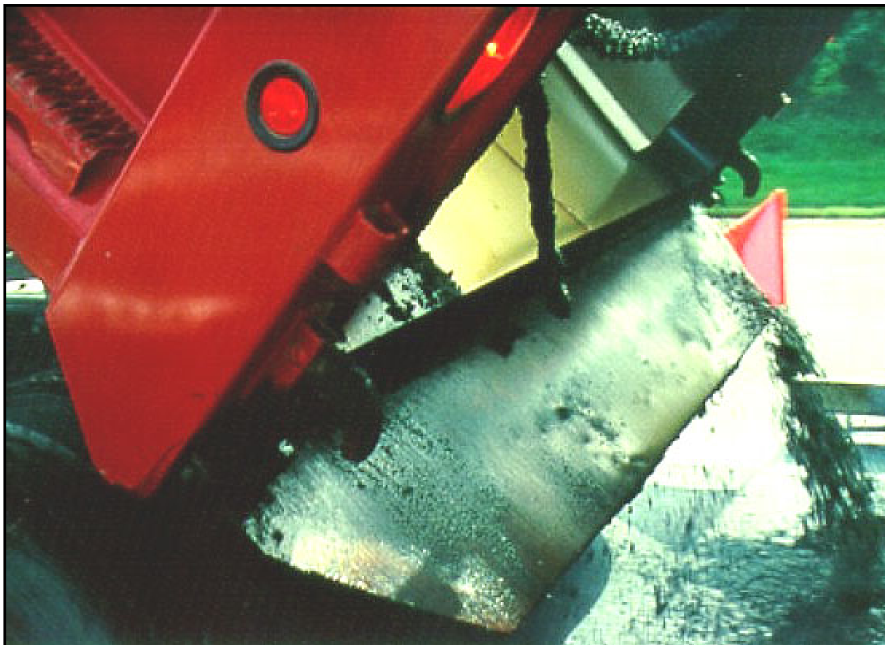
- *Once the truck is empty, the bed has to be lowered before pulling away.*
- *Lowering the bed will allow the truck apron to clear the hopper guards.*
- *Once the truck has cleared the paver, it should immediately depart from the area to a clean up station, and let the next truck back up.*

56

57

- *And we're back to the beginning of the cycle.*
- *The cycle is continuous in nature.*
  - *One truck waiting as the finished one departs for another load of mix.*

58



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- *Aside from catching the paver hopper, another problem with not lowering the truck bed before pulling away is spilling mix onto the paving surface.*
- *Any practice that spills mix onto the paving surface should be discouraged.*

60

61

- *"Banging the gate" (leaving the truck bed up, speeding up, and then stopping quickly to allow the tail gate to bang the truck) should be discouraged.*
- *"Flying Rock"*

62

63

- *If this does occur, the mix must be cleaned off the surface, not just paved over.*
- *What could happen if this mix is allowed to stay on the pavement?*

64

65

- *This truck is ready to leave the jobsite for another load. The back of the truck is clean. No mix is left to spill from the truck.*
- *Once the truck has completed on-site cleanup, is should proceed immediately back to the asphalt plant.*
- *The trucks should not delay departure, or the smooth, continuous nature of the entire operation could be affected.*

66

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Material Transfer Device or Material Transfer Vehicle

- Eliminate physical segregation
- Re-Mix asphalt mixture
- Stop Truck delays
- Eliminate paver Stop and Go
- Provide Smoother road
  - Provides better ride quality and safer road to users
  - Last longer and Requires less maintenance (save money)

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TDOT MTD Requirements: 407.06

- An MTD shall be utilized for all mixes (Except CS)
- The MTD shall have a capacity of 15 Tons, and be capable of remixing the material
- The paver shall have a surge hopper with sloping sides (60°) and a capacity of 15 tons

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TDOT MTD Requirements: 407.06

- Model/Manufacture Must be preapproved by TDOT.
- If another brand/model is present check with HQ Materials and Tests

Approved Material Transfer Device (MTD) List

Astec/Roadtec Shutte Buggy

- SB2500
- SB3000

Weiler Products

- E2850C
- E2860C
- E1650A

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ROADTEC
SB2500D
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WEILER
E2850
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72


Surge Hopper
ROADTEC
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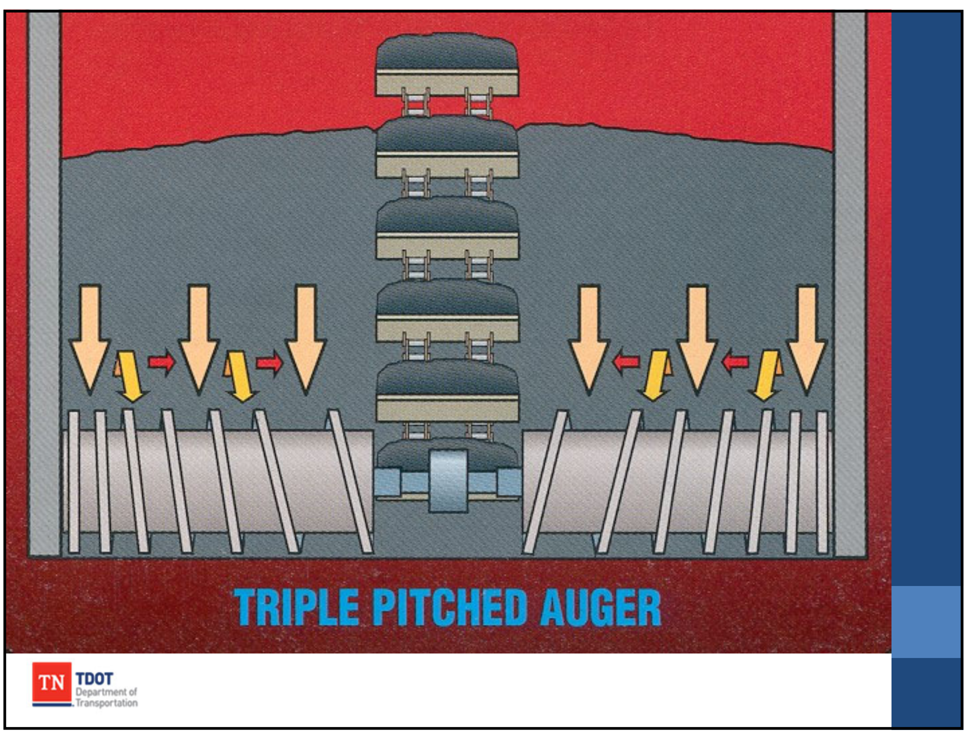
73


TRIPLE PITCHED AUGER
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Why use a MTD?

- To stabilize a paving operation so the paver can maintain a constant unchanging paving speed, eliminating the stops and starts traditionally associated with trucks dumping directly into the paver
- Eliminate aggregate and temperature segregation which will provide for more uniform compaction and eliminate high air void areas associated with truck end segregation.

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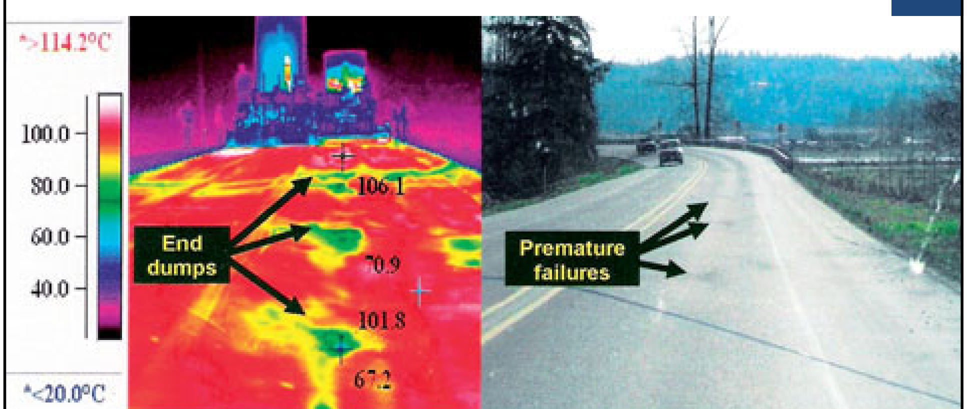

Mat <u>without</u> using transfer device

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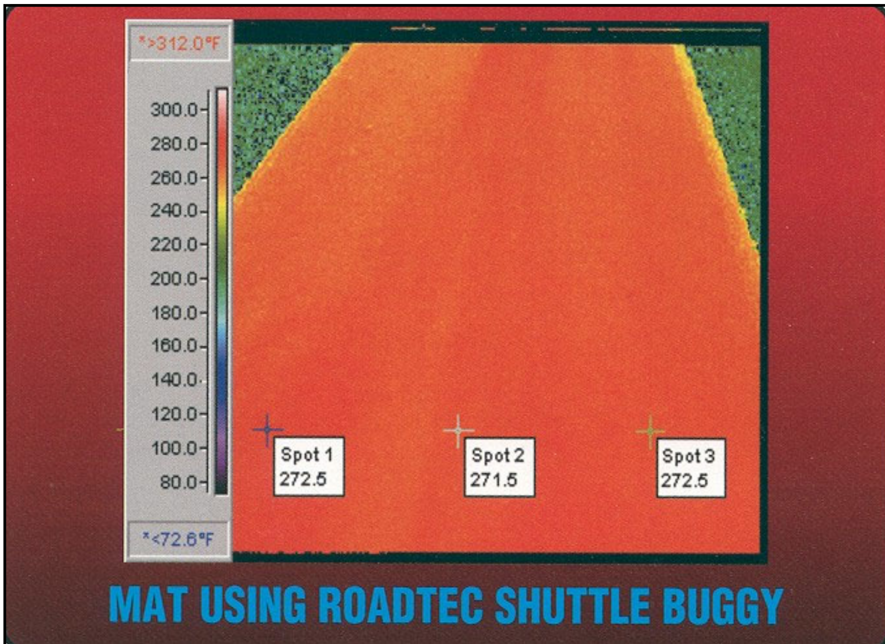

Mat using transfer device

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Paving Quality with MTD

- 1. MTD's will not correct for improper paving techniques. Nothing replaces a well trained and conscientious crew.
  2. Use the MTD to allow the paving crew to match the paver speed to plant output.

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Paving Quality with MTD

- 3. Use the storage capacity of the MTD and hopper insert to ensure a constant paver speed and eliminate the need to start and stop the laydown operation. If you allow the paver to run too fast, you will still run out of material and will be forced to stop. As a rule, with MTD's you can pave slower and still lay more tons per day since you are eliminating the starts and stops between trucks.

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Paving Quality with MTD

- 4. Keep the MTD hopper and the paver hopper insert 1/3 full at all times to allow for sufficient heat transfer with each new load and to eliminate any aggregate segregation.

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Paving Quality with MTD

- 5. At the beginning of the day, take the first truck from the plant and move it back to third or fourth in line. Then take the second and third loads from the plant and run them straight through the MTD and into the paver. This will preheat the metal surfaces of the MTD and will insure the paver starts with hot material in the hopper.

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Paving Quality with MTD

- 6. Remember that the MTD does not need to be physically tied to the paver. To make better use of the MTD, use it to unload trucks where safest (away from overpasses and power lines) and shuttle back to the paver to keep the hopper insert charged.

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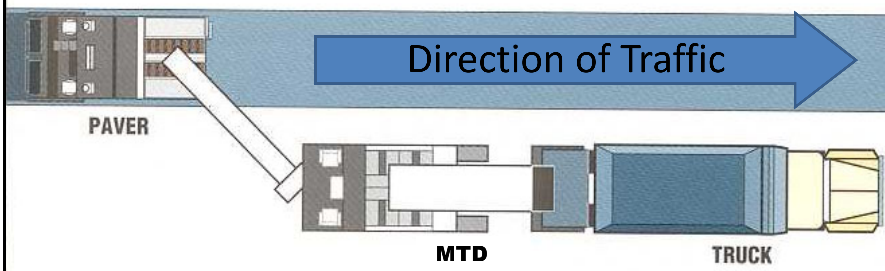
Paving Quality with MTD



- Feeding the paver from the adjacent lane.
  - For most projects the trucks, material transfer device, and paver will be in the same lane.

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Weigh Tickets

- Each load must have a stamped and signed Weight Ticket- "Copy of Record."
- Ticket Number, time, gross, tare, and net weights, running total, legal limit and check legal limit.
- Inspector shall sign each ticket at point and time of delivery.

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Role of the TDOT Inspector

- Circular Letter 407.14-01: “Hot Mix Asphalt Roadway Inspector Checklist”
  - Material Transfer Device
  - Delivery

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7.

HMA Placement

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HMA Placement

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1

- *This module will cover all the aspects of placing HMA.*
- *Again, focus on the balance aspects of the paving operation–forces on the paver must be in balance to produce a uniform, dense, and smooth mat.*
- *Principles of paver operation are applicable to a variety of HMA mix types, including dense-graded, Open-Grade Friction Courses (OGFC), and Stone Matrix Asphalt (SMA).*

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2

Objectives

- Components and Function
  - Tractor and Screed Unit
- Grade and Slope Control Systems
- Yield-Thickness-Smoothness Relationship
- Types of Paving and When to Use Them
- Night Paving
- Paver Maintenance
- Operating Techniques

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3

Objectives (Contd.)

- Paver Maintenance
- Operating Techniques

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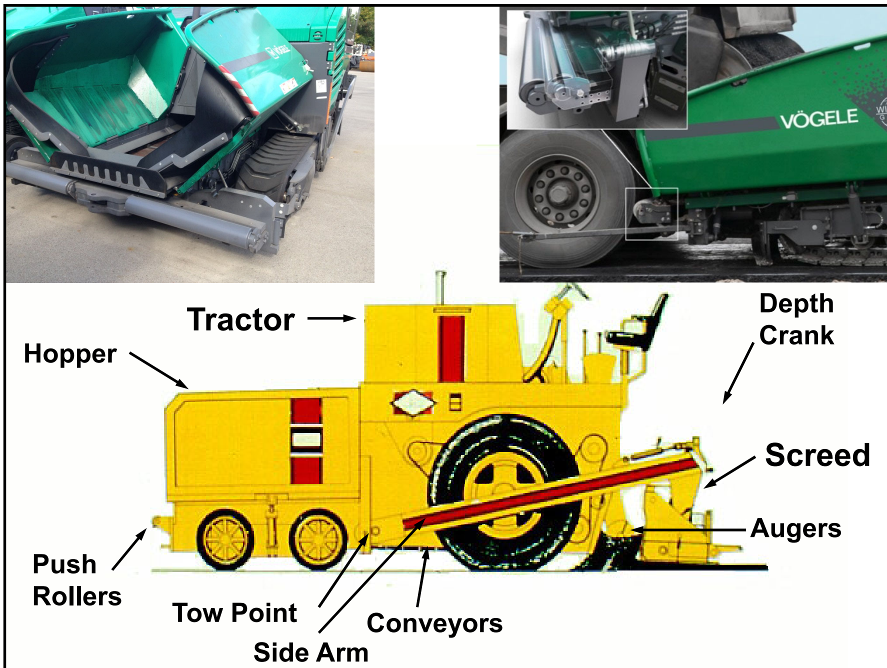

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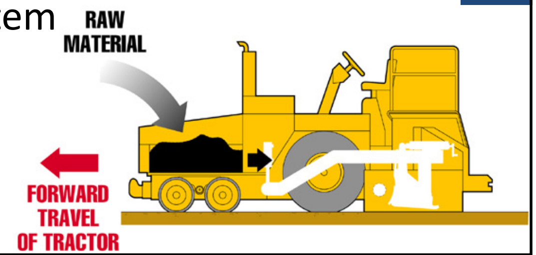
- *The purpose of the paver is to place the HMA to the desired width and thickness and to produce a satisfactory mat texture.*
- *The paver consists of two primary components: the tractor unit and the screed.*
- *The tractor unit provides all of the power for the paver, and carries the mix from the hopper back to the screed.*
- *The screed is towed by the tractor unit, and provides the initial density and smoothness to the mat.*

6

Tractor Unit

- Drive Systems
- Push Rollers and Truck Hitches
- Hopper
- Slat Conveyer
- Conveyer Flow Gates
- Augers
- Materials Feed System
- Tow Points
- Maintenance



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7

- *This list gives the major components of the tractor unit and the subject areas that will be covered during this part of the module.*

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Rubber Tire Paver

9

- *The tractor unit has its own engine that provides the power to move the pave forward.*
- *Pavers travel on either rubber tires or tracks.*
- *Rubber-tired pavers can be moved around more readily. Rubber-tired pavers have a faster travel speed than track pavers.*
- *The rubber tires are inflated to between 240 and 585 kPa. The tires are also ballasted with a calcium chloride solution to reduce bounce in the paver.*

10

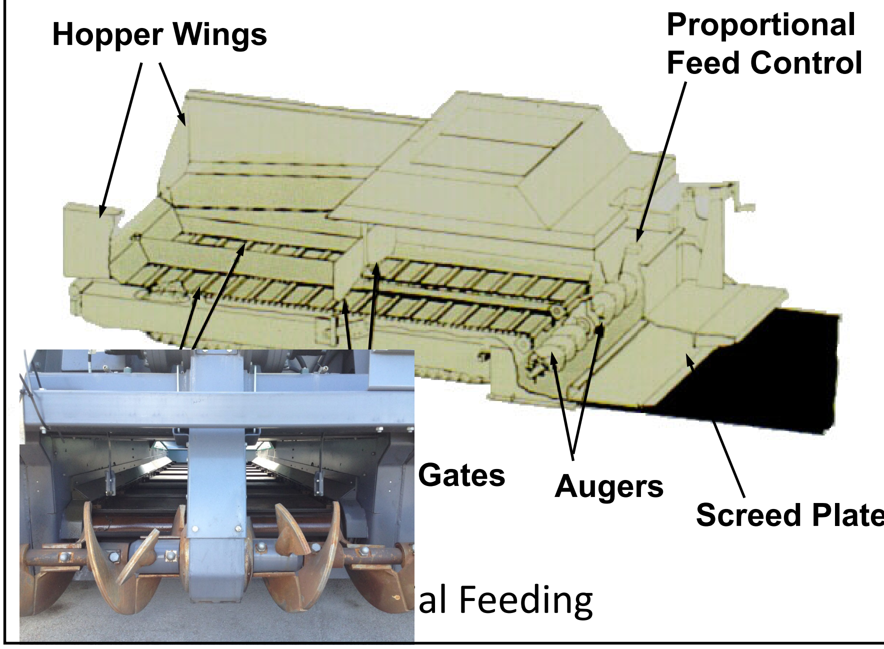
Track Paver

11

- *Pavers also come with track drive systems.*
- *The tracks spread the weight of the paver over a larger area.*
- *These types can be more effective on paving grades.*
- *The tracks can be all steel, steel with rubber pads, or flexible bands with steel shoes and rubber pads.*
- *QUESTION: Who has a preference between rubber tired and track pavers? Why?*

12

Material Flow



al Feeding

13

- *The goal of the material feed system is to get a constant head of material in front of the screed.*
- *If the material feed system is set and operating properly, the slat conveyors and augers on each side of the paver will rarely shut off.*
- *If the conveyors and augers are constant speed (only on or off), the flow gate settings control the flow.*
- *For variable speed augers and conveyors, material flow is controlled by all three.*

14

Hopper

15

- *The paver hopper is where the mix is received from the truck or pickup machine.*
- *The hopper must be low enough to allow the truck bed to be raised.*
- *What is the actual purpose of the wings being able to fold? How often should the wings be folded? (Minimally, to reduce segregation.)*
- *The wings should be folded while the hopper is relatively full of mix.*

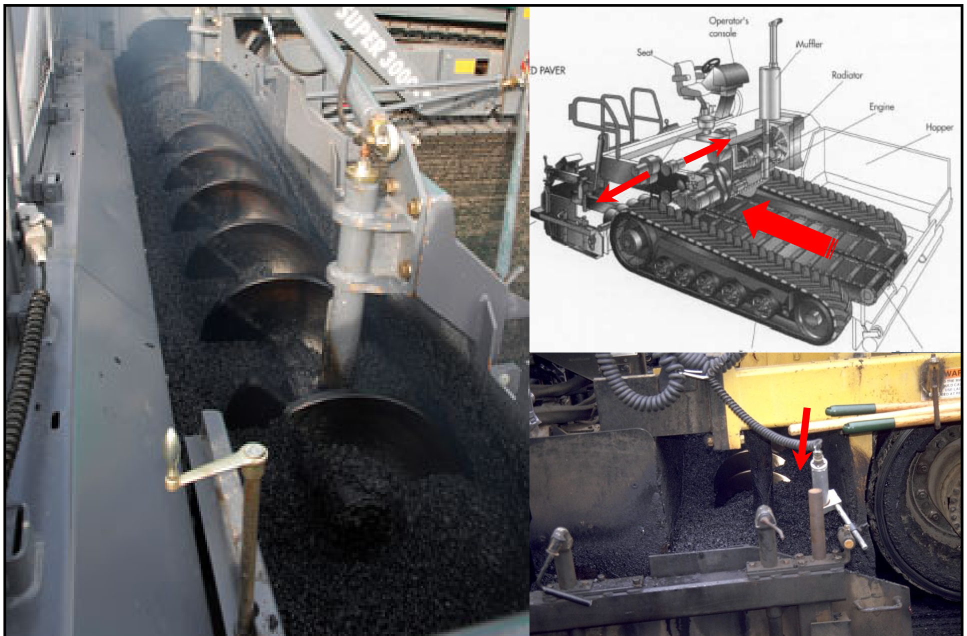
16

Slat Conveyors

17

- *At the bottom of the hopper are slat conveyors.*
- *They transport the mix from the hopper back through the tunnel in the tractor unit to the spreading screws.*
- *The slat conveyors move independently, each of them feeding one side of the screed.*
- *Why would one conveyor need to be moving faster than the other?*
- *Above the slat conveyors at the back wall of the hopper are flow gates.*

18



Auger Chamber

19

- *The augers reside directly between the tractor and screed units, in the auger chamber.*
- *This photo shows the proper head of material in the auger chamber and in front of the screed. <u>The proper head of material is at the center of the auger shaft.</u> The mix should not cover the augers, nor should the bottom of the augers be visible.*
- *It is important that the head of material is consistent across the screed, to keep forces on the screed constant.*

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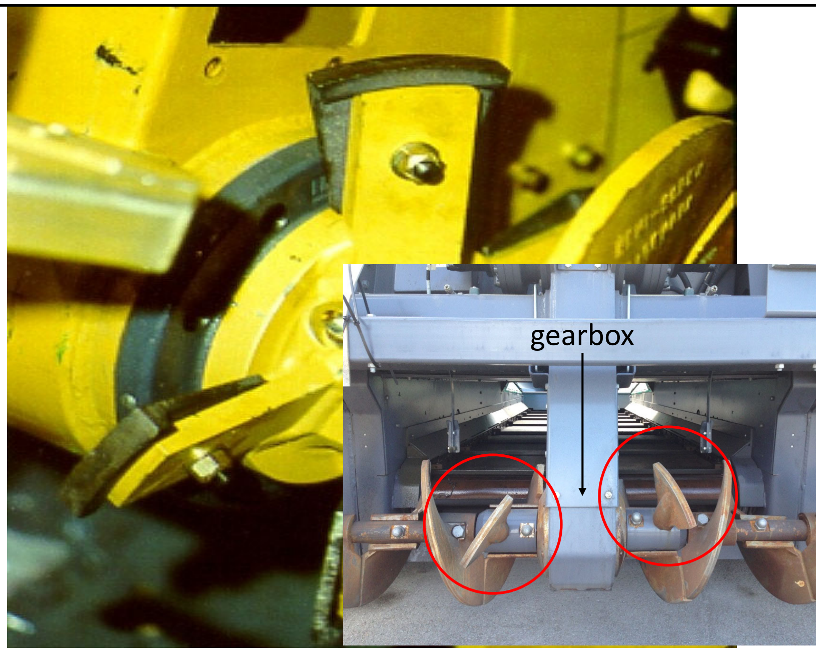

TN TDOT Department of Transportation Kick Back Paddles (Throw-Back Blades)

21

- *In the center of the augers is a gear box. Kick back paddles are used to "tuck" mix under the gear box.*
- *If the paddles were not there, the proper amount of mix would not get under the gear box.*
- *These are a high wear item, and must be replaced when they are worn.*
- *How could the finished mat look if these paddles were either worn or missing?*

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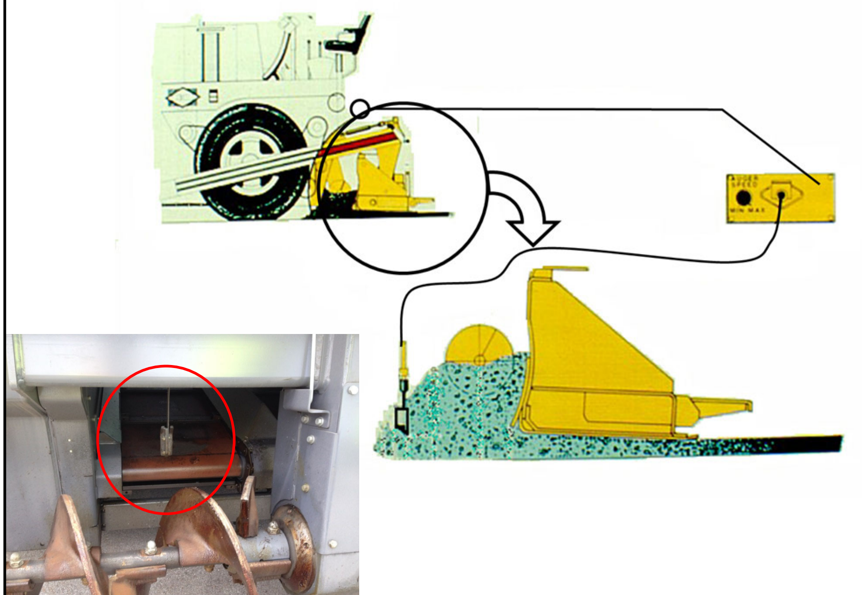
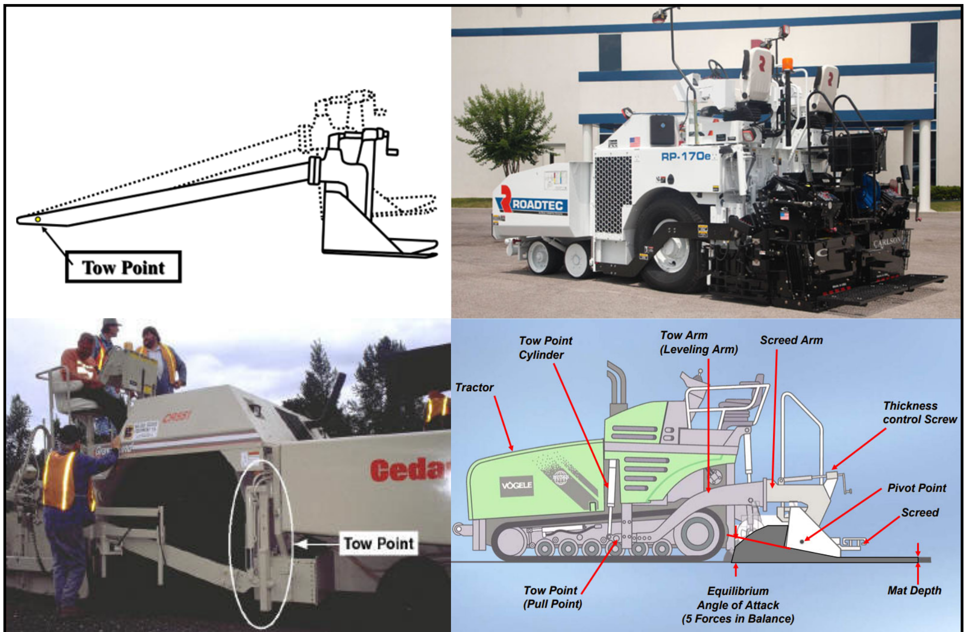


Material Feed Control

23

- *Many material feed systems have automatic feed control.*
- *A sensor measures the head of material and controls the slat conveyors and augers.*

24



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Tow Point

25

- *The last part of the tractor unit is the tow points (or pull points).*
- *The tow points are a pin connection where the screed is attached to the tractor unit.*
- *The tow point is the only place the tractor and screed units are connected together.*
- *The screed pivots around the tow point. (The forces acting on the screed and how the tow point is positioned are discussed later.)*

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Screed Unit

- Screed plate
- Strike-off
- Crown control
- Extensions and end plates
- Thickness Control Screws
- Screed Arm
- Pre-Compaction System
- Heating Systems

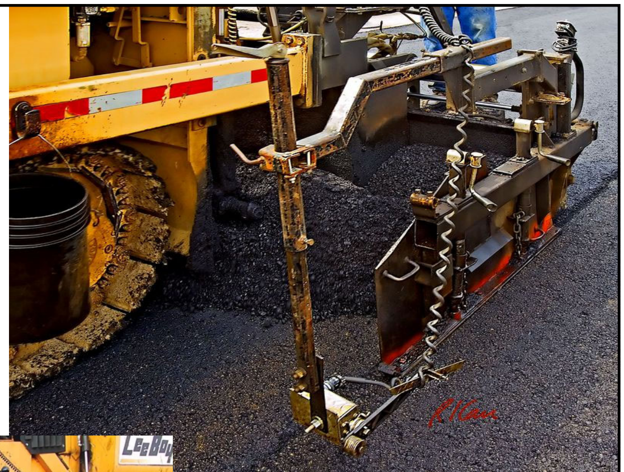
27

- *The second major part of the paver is the screed unit.*
- *The screed unit is towed by the tractor unit and consists of these parts.*

28

Screed Unit

- Establishes the thickness of the layer
- Provides the initial texture of mat surface
- Provides the initial compaction to the mat

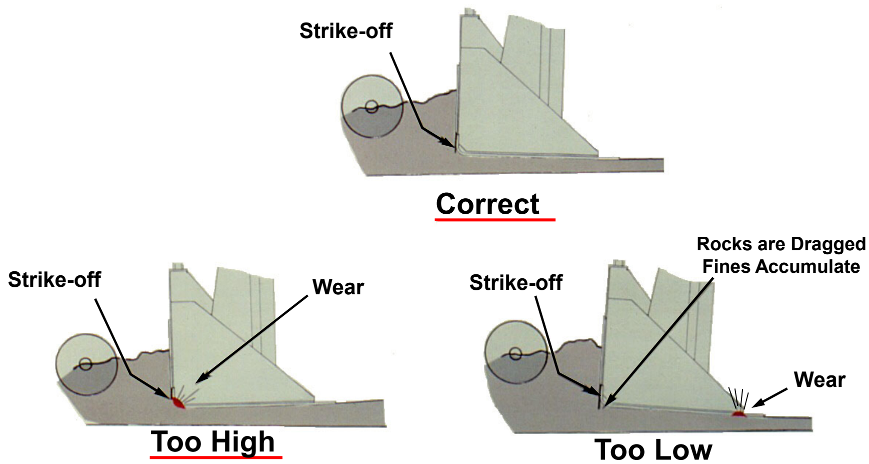


29

- *The screed unit establishes the thickness of the asphalt layer and provides the initial texture of the HMA surface.*
- *The screed also provides the initial compaction to the mat with its weight and through vibratory action or with a combination of vibration and tamping.*
- *The free floating screed was developed in the 1930s. The concept allows the screed to level out the changes in grade experienced by the wheel base of the tractor unit.*

30

Strike-off Plate: The vertical plate just above the leading edge of the screed used to strike off excess asphalt mixture and protect the screed's leading edge from excessive wear.



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- *Typically, a strike-off (or pre-strike-off) plate is mounted in front of the leading edge of the screed.*
- *The strike-off regulates the amount of mix fed under the screed plate. It also reduces wear to the leading edge of the screed.*
- *If the strike-off is too high, too much material is fed under the screed, causing it to rise. If the strike-off is too low, too little material goes under the screed.*

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33

- *The basic width of the screed (2.4 to 3 m) can be increased with rigid screed extensions.*
- *The extensions come in varied widths.*
- *It is important that the extensions be set at the same elevation and angle of attack as the main screed.*
- *Auger and auger tunnel extensions should be added when using rigid extensions.*
- *Not used much in road paving now — replaced by hydraulic screed extensions.*

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34

Screed End Plate

35

- *The end plate is attached to the end of the screed to keep the mix contained behind the screed.*
- *While paving, the end plate is typically positioned tightly to the existing surface to retain the mix and control the width of the mat.*

36

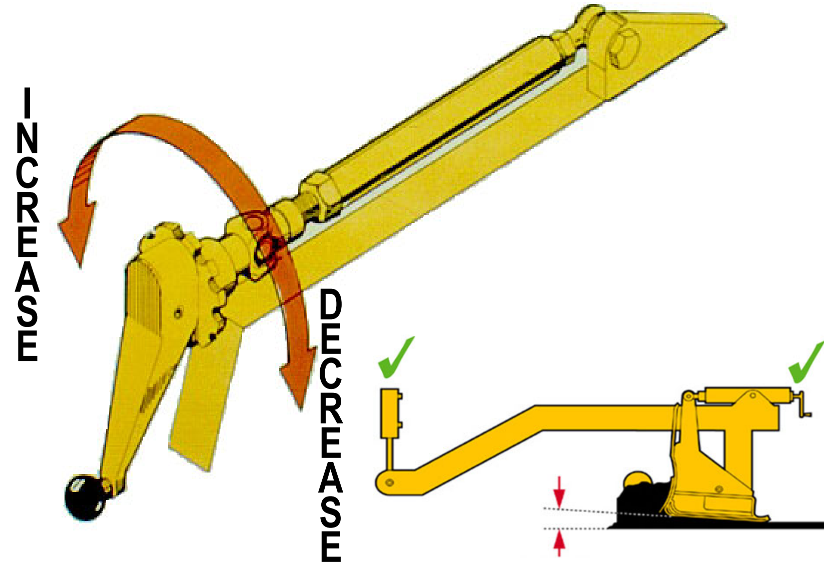
Shaped End Plate

37

- *Various shaped edge plates are also available to form longitudinal joints.*
- *The most common type is a wedge shaped joint.*
- *Many states have been conducting research in the styles and shapes of these edges to try and improve the performance of the longitudinal joints formed between paving lanes.*
- *This is a joint is called the "Safety Edge". Very safe.*

Are wedge shaped joints used locally?

38



Mat Thickness Control

39

- *The thickness of the mat can be controlled one of two ways: with the thickness control screws (or hydraulic lifts), or with the tow points.*
- *The thickness control screws rotate the screed about its pivot point.*
- *The rotation changes the screed's angle of attack; as the angle of attack changes, the screed rises or falls to balance the forces acting on the screed.*

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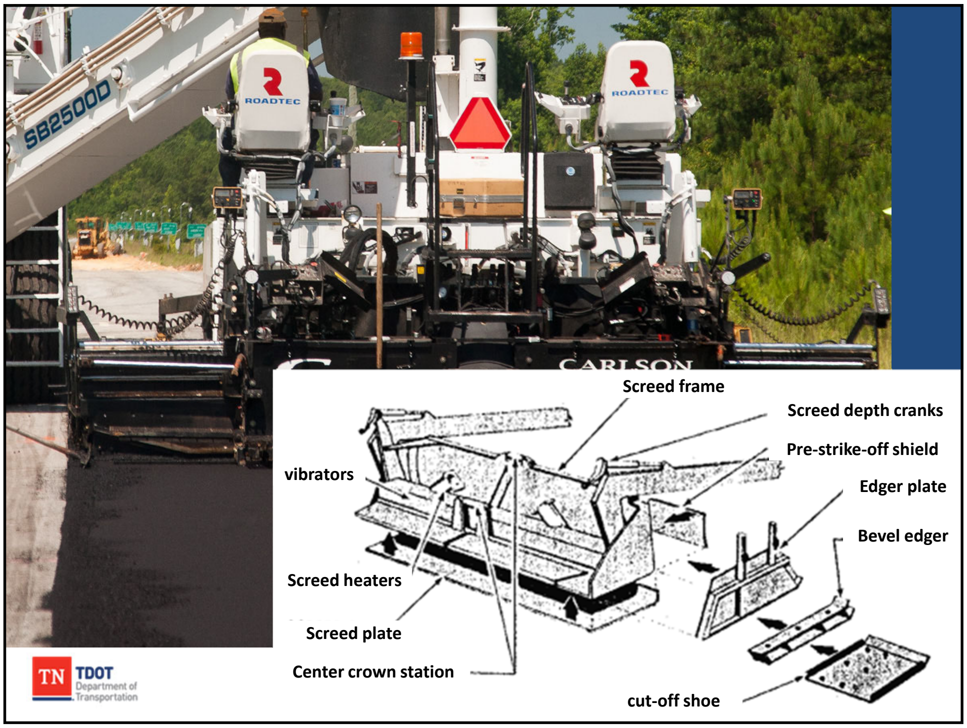

41

- *Screeds also contain a screed heater, to heat a cold screed to about 150 °C (300 ° F) prior to the start of paving.*
- *A properly heated screed, particularly at the start of the day or after a prolonged shutdown, provides for a more uniform mat surface texture.*
- *Heating the screed prevents the mix from sticking to the screed plate and tearing the mat, causing a rough texture.*
- *Screed heaters <u>cannot</u> be used to raise the heat of the mix.*

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Operational Principles of the Screed

- Self-leveling Concepts
- Screed Response
- Forces Acting on a Screed

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43

- *The next item to discuss is the operational principles of the screed.*
- *This topic will cover...*

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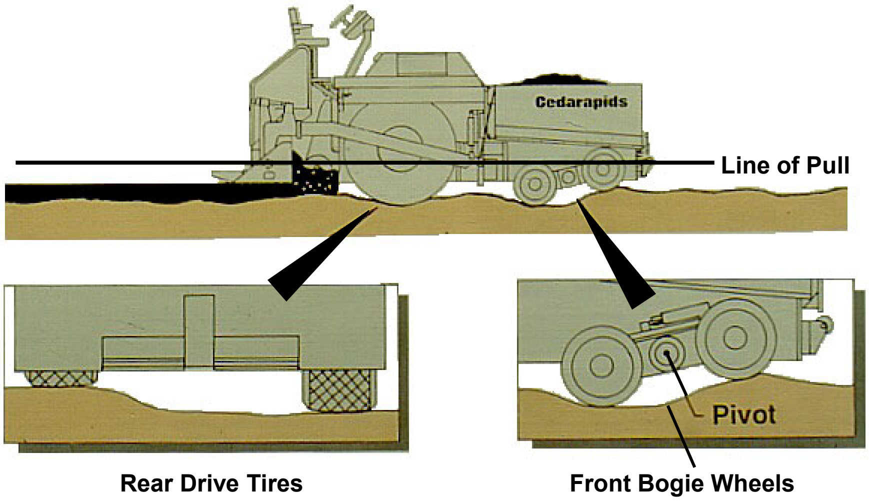
Self Leveling



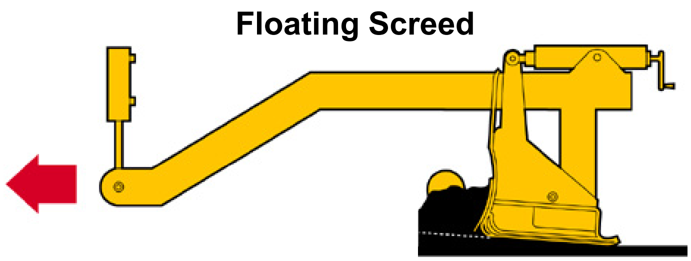
45

- *As the paver moves along the road, the tractor unit follows the ups and downs of the existing surface.*
- *While the tow point moves up and down, the screed reacts slowly to this up and down movement, so it moves along relatively unchanged. One further step toward producing a level surface is setting up a reference unattached to the paver.*
- *The tow point is guided by the reference, instead of the motion of the tractor unit, to keep the screed level. Use of the reference is guided by automatic grade controls.*

46

Self Leveling

- The screed floats on the asphalt as it passes under the screed plate
- The screed will “self-level” and maintain a thickness based on the forces acting on the screed.



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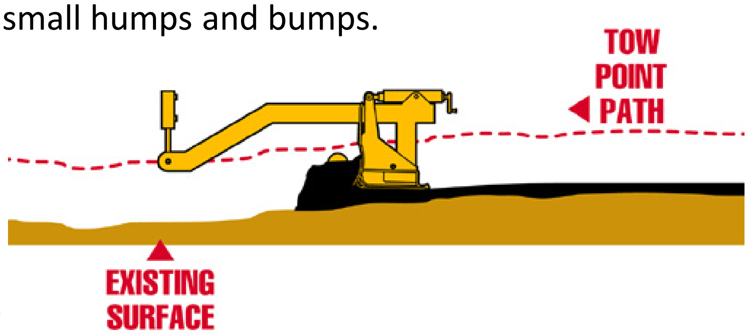
Self Leveling

- The paver tractor, and therefore the screed tow point, travel over the existing “rough” surface
- The floating screed doesn’t react immediately to the variations in the tow point path
- The floating screed seeks it’s own level, smoothing out small humps and bumps.



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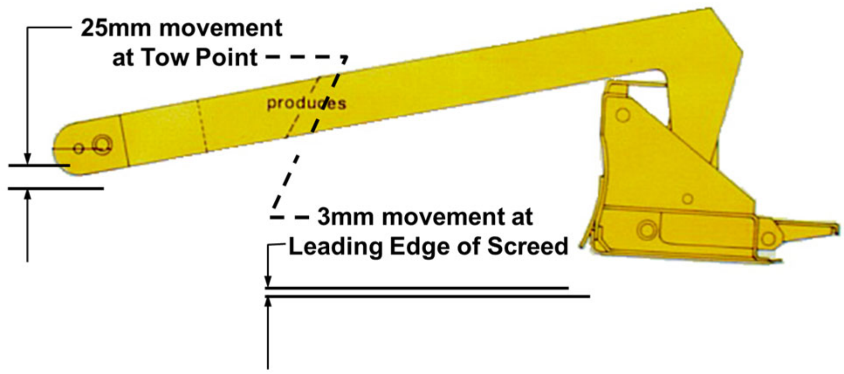
Screed Response



49

- *The change in thickness "command" can be made with the thickness control screw, or can be made by adjusting the tow point.*
- *If the tow point is moved, the paver must still move forward about <u>five lengths of the tow arm</u> before the screed fully reacts to the change.*
- *A 25 mm change in the tow point will produce a 3 mm change in the leading edge of the screed.*

50

Main Forces Acting on Screed

1. Speed of Paver
2. Head of Material
3. Angle of Attack
4. Screed Weight

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- *The self-leveling action of the screed means it will respond to the various forces acting on it to find its balance or equilibrium.*
- *The three main forces acting on the screed and how thick it places the mat are...*

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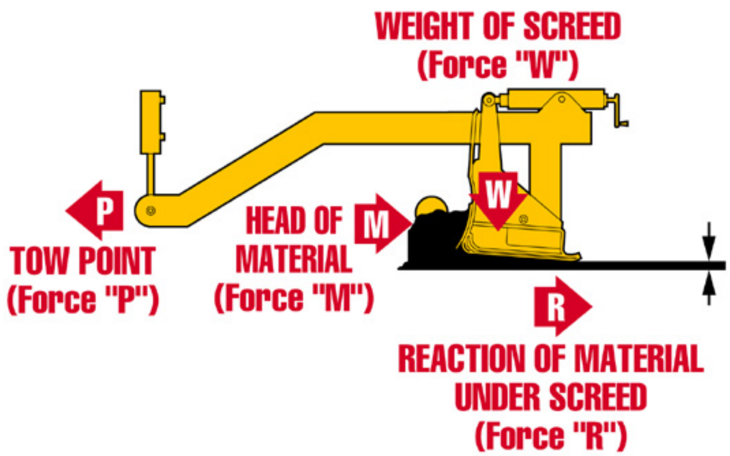
Forces Acting on Screed

If any one of these forces change, the mat thickness will change. But these forces cannot always remain constant.



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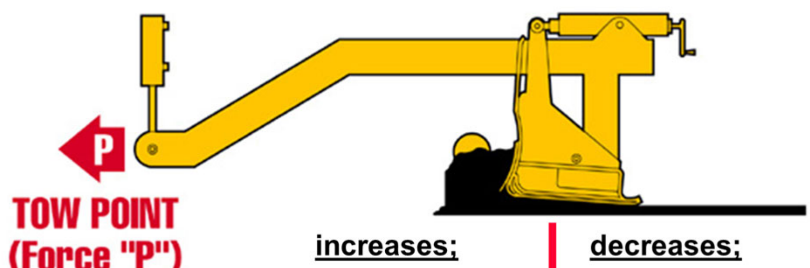
Forces Acting on Screed

1. Paver Speed



increases;	**decreases;**
mat thickness will *decrease*	mat thickness will *increase*

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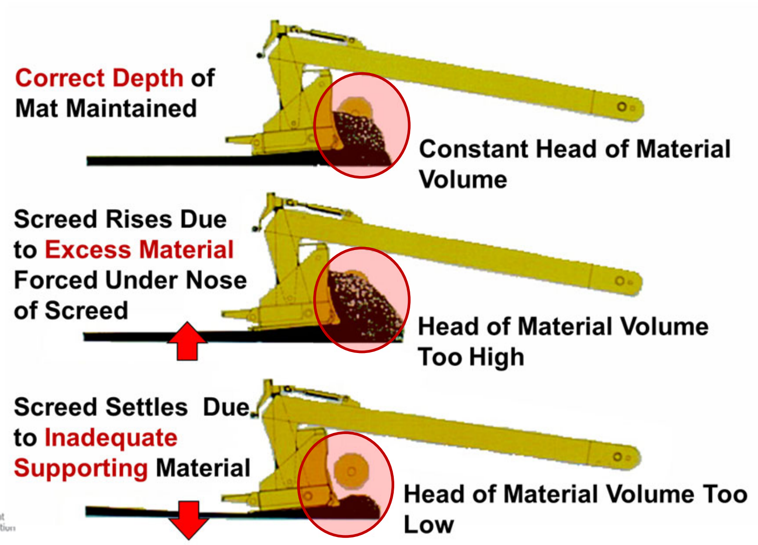
Forces Acting on Screed

2. Head of Material



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55

- *If everything else is constant:*
  - *Faster Paver = thinner mat*
  - *Slower Paver = thicker mat*
- *Speeding up the paver will change the precompactive effort into the mat, requiring more compactive effort from the roller.*
- *If head of material is more than ideal, then the force on the front of the screed increases, and the screed compensates by moving upward.*
- *If head of material is less than ideal, then the force on the screed decreases, and the screed compensates by moving downward.*

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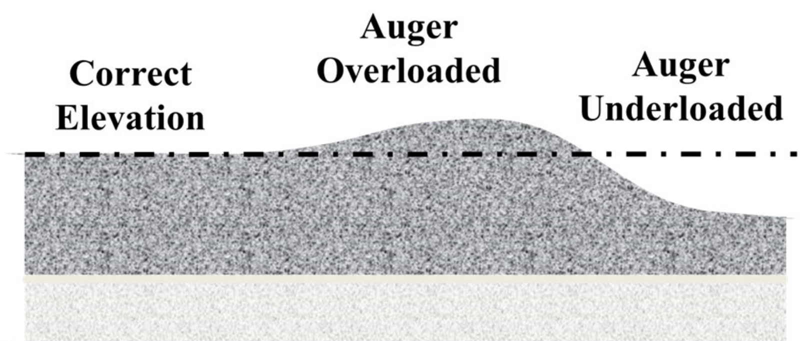
Forces Acting on Screed

2. Head of Material

The Amount of Material is IMPORTANT for the quality final Mat!!!



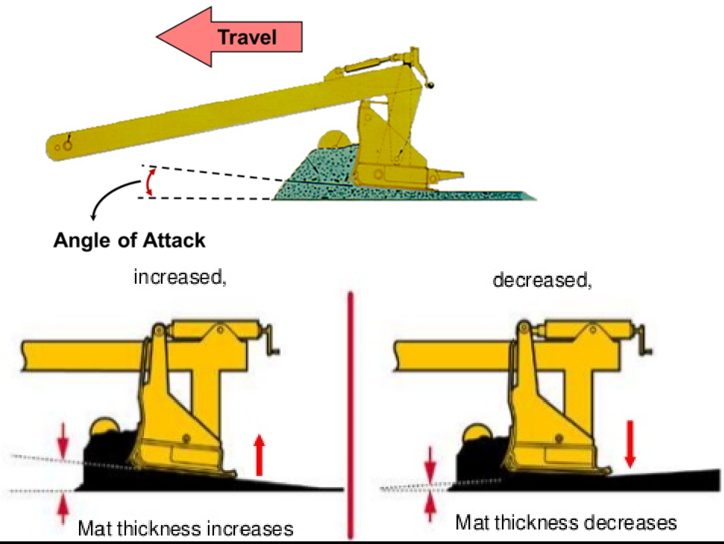
57

- *If the augers are underloaded, the thickness placed is too thin.*
- *If the augers are overloaded, the thickness placed is too thick.*
- *The head of material is the most important force acting on the screed. Some paving experts feel that 90 to 95 percent of paver-related problems can be solved by maintaining a uniform head of material during paving.*

58

Forces Acting on Screed

3. Angle of Attack



59

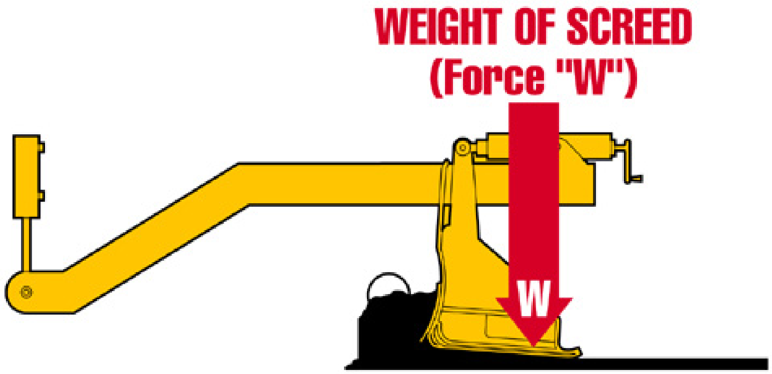
- *We discussed earlier how moving the tow point or thickness control screw (and hence adjusting the angle of attack) changes the thickness.*
- *Increase the angle of attack, increase the thickness.*
- *Decrease the angle of attack, decrease the thickness.*

60

Forces Acting on Screed

4. Screed Weight

Compaction Force = Pounds per square inch



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Forces Acting on Screed

4. Screed Weight

- People climbing on and off the screed can have a small effect on overall screed weight
- Changing screed width changes the compaction force

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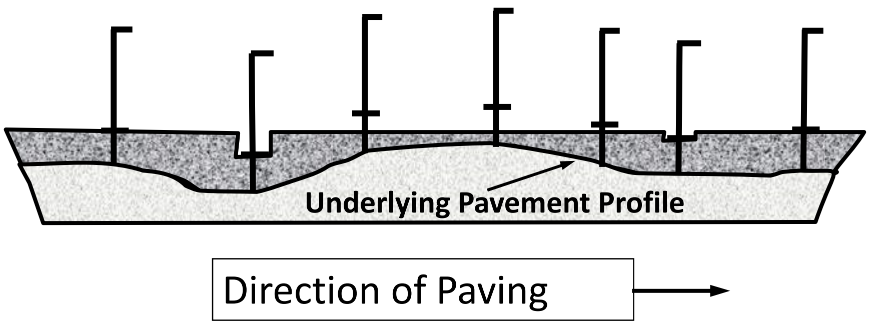
Checking Mat Depth/Thickness



63

- *Ask: If the screed operator stuck the mat this frequently on this project, what would most likely happen?*
- *The mat thickness would be adjusted too frequently.*
- *Ask: What part of the paver is trying to adjust for the unevenness? (The tow point.)*
- *Sticking the mat can be useful during on-the-job training to show how long it takes for the screed to react.*

64

Grade/Slope Control Systems

- Ski Type
- Non-Contact

65

- *These are the two types of grade control references most often used in TN.*
- *Grade references can be used alone on either side of the paver, or on both sides.*
- *One type can be used on one side (e.g. non-contact) and one on another (e.g. ski).*
- *A joint-matching shoe may be used when placing a secondary mat.*

66

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- *A mobile reference system can come in various styles, although they function in the same manner.*
- *This style is a contact ski with a wire stretched between the ends.*
- *The ski rides directly on the surface, and the grade sensor rides on the wire to detect changes in elevation.*
- *The ski is available in several lengths (up to 15 m) to increase the length of the reference.*

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• *Non-contact systems use ultrasonic pulses to determine the roadway's elevation.*

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Paving Process – In Order

1. Determine Projected Paver Speed
2. Warm up Machine
3. Position on Joint
4. Null the Screed
5. Input Initial Settings
6. Charge the Hopper, Tunnels, Screed

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Paving Process – In Order (cont.)

7. Pull off Joint
8. Re-checking Settings
9. Check Yield
10. Manage Truck Exchanges
11. Fold Hopper Wings

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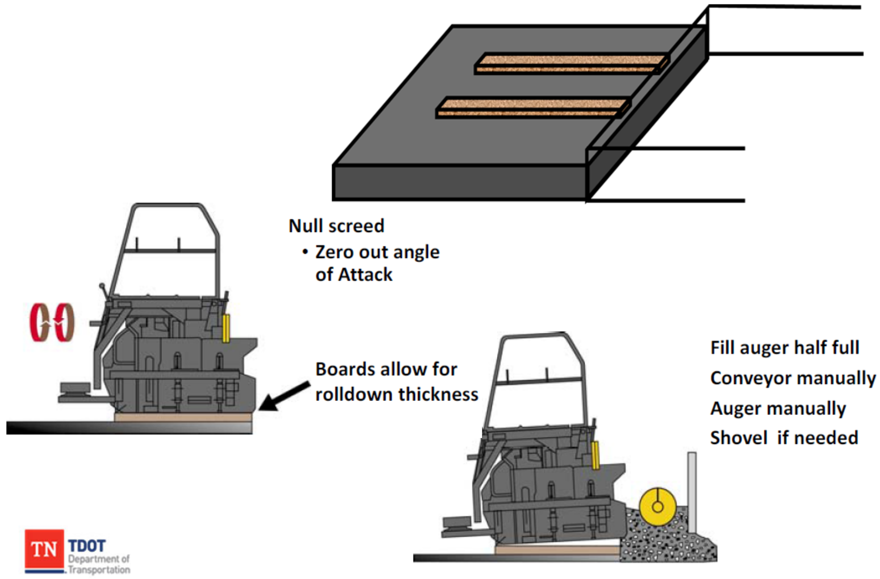
72

A good rule of thumb is to raise the screed 25 percent more than the compacted thickness.



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- *A good rule of thumb is to raise the screed 25 percent more than the compacted mat thickness.*
- *SMA mixes will have only about half as much "roll down" change in height between compacted and uncompacted thickness as conventional HMA.*

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Re-Checking Settings

- Is thickness okay?
- Is cross slope okay?
- Is mat texture okay?

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- *Once you get moving, recheck all the settings, and adjust if necessary.*
- *Mat texture with SMA and Superpave mixes will look much more open than conventional mixes. However, still look for a uniform appearance.*
- *(The next few slides provide opportunities for discussion of these points.)*

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- *Cross slope (also known as "crown" or "crossfall) should be between 1.5 and 2.0 percent.*
- *Cross slope can either be checked with a level and ruler, or by using a "smart level".*
- *How is the mat texture? Some screed adjustments may be needed in this photo.*

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Feet Per Minutes = ft./min

79

- *Before you began paving, you calculated an ideal paver speed.*
- *This speed should be checked and maintained.*
- *Remember, balance of all the production rates is the key to quality pavement.*
- *Rates of placement for specialty mixes do not typically have to be any different than those for conventional HMA.*

80

Section 407.06 - Bituminous Pavers

- "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. <u>Auger extensions shall be incorporated in a manner such that the maximum distance from the augers to the end plate shall be 18 inches</u>. 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."

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Section 407.09- Weather Limitations

- The surface upon which the mix is to be placed **<u>SHALL BE FREE OF EXCESSIVE MOISTURE</u>**
- Only when **<u>weather conditions permit</u>** the pavement to be properly placed, compacted, and finished and in accordance with the following temperature limitations:

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Section 407.09- Weather Limitations

Compacted Thickness	Minimum Air or Surface Temp.	
	Unmodified Mix	Modified Mix
< 2 in.	45°F	55°F
2.0 in. and greater	35°F	35°F [1]
OGFC/Thin Lifts[2]	55°F	55°F

1. **If compacted thickness < 3 in. and Temperature is < 55°F, an approved Warm Mix Additive is required in the mix.**
2. **OGFC/TL/TLD: Not between Nov 1 and April 1**

83

Section 407.09- Weather Limitations

A day after construction under NO Cold Weather Paving Plan in West Virginia

84

Section 407.14 -Spreading and Finishing

- Paver shall be fed from **1** plant
- **Plant production and paving operations shall be coordinated** such that **constant** forward movement
- Repetitive interruptions or stopping the paver shall be cause to **STOP** the work

85

Section 407.14 -Spreading and Finishing

- Unevenness in texture, segregation, tearing, or shoving that occurs during paving shall be reason to **STOP** the paving
- Unacceptable mix shall be removed and replaced at the Contractors expense

86

Section 407.14 -Spreading and Finishing

- Automatic screed controls using either string line, ski type grade reference, or non-contact averaging system is required
- If ski type is used, it shall be 40’ minimum
- Longitudinal joint offset by 1’ of preceding layers, top on Center
- Contractor **SHALL be required to pave in the direction of Traffic**

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Section 407.18 - Surface Requirements

- The surface shall be tested with a 12 foot straightedge parallel with the centerline, maximum deviation
  - D-mix - 1/4 inch
  - B and C mixes - 3/8 inch
  - A mixes - 1/2 inch
- The transverse slope shall be checked with straightedge, shall not deviated by more than 0.5% of the plans

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Spread Rate Example

Given:

The contractor has managed to put down 1.5 miles of surface mix. The gross weight for the day is 643 tons. The TDOT project plans call for a spread rate of 132.5 lbs/SY.

89

Spread Rate Example

A: Assuming the paver width is 12 feet, calculate the actual spread rate of the mix.

B: According to the plans, is this rate OK?

C: If not, what should we do?

90

Spread Rate Example

A: Spread Rate is Calculated in pounds per square yard. This requires us to convert tons into pounds and square feet into square yards.

91

Spread Rate Example

A: therefore…

$$7920\,feet * 12\,feet$$

A: and…

$$\underline{1{,}286{,}000 lbs}$$

92

Spread Rate Example

A: Assuming the paver width is 12 feet, calculate the actual spread rate of the mix.

B: According to the plans, is this rate OK?

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Role of the TDOT Inspector

- Circular Letter 407.14-01: "Hot Mix Asphalt Roadway Inspector Checklist"
  - Paver
- Circular Letter 407.09-01: "Cold Weather Paving Plan"

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8.

Joint Construction

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Joint Construction

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1

- All pavements have one internal weakness–joints
- Joints probably cause more problems than any other area.
- The final appearance and quality of the joints determines the overall appearance and quality of the finished mat.
- Fortunately, it is easier and quicker to construct a good joint than a bad one. It just requires teamwork.
- Good joints are a measure of a construction crew's skill.
- Corps and FAA have always had joint specifications.
- Many state DOT's (including TDOT) also have joint specs.

2

Objectives

- What is Joint?
- Types of Transverse Joint Construction Methods
- Types of Longitudinal Joint Construction Methods
- Proper Joint Luting/Raking

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3

After introducing objectives,

Ask:

- What is your biggest problem with constructing joints?
- Which is easier to build, longitudinal or transverse?

- It may be beneficial to write any problems down, and address how to improve upon them at the appropriate time during the module.

4

HMA Joint construction

What is Asphalt Joint?

An asphalt joint is formed when a fresh mixture is laid and compacted next to an existing layer.

Why Joint construction is important?

- Crack Propagation
- Loss of particles (segregation)
- Accident for 2-wheel vehicles due to unevenness
- Water infiltration
- Pot Holes

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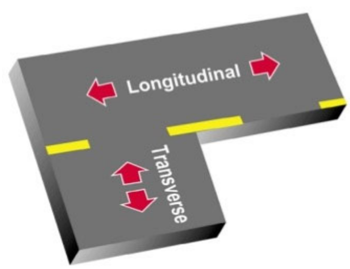
5

Classify Joints

Based on traffic direction

- Longitudinal Joint
- Transverse Joint



Based on the Temperature of existing layer when the new layer is placed

- Close to new layer temperature: Hot Joint
- 50~70°C (122-159°F): Warm Joint
- 50°C (122°F): Cold Joint

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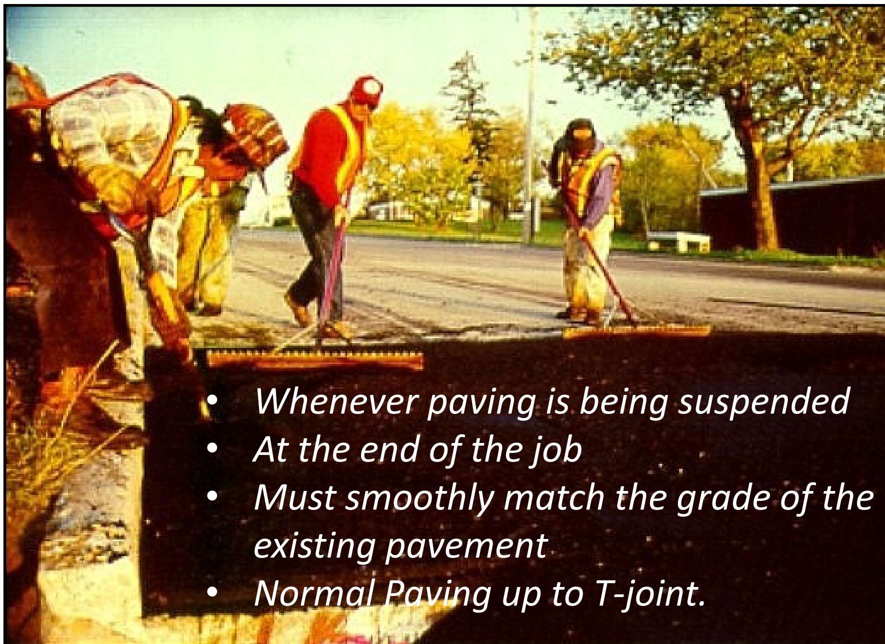

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7

- *A transverse joint must be constructed across the pavement whenever paving is being suspended*
- *This joint is being constructed at the end of the job, and must smoothly match the grade of the existing pavement.*
- *When ending paving (for the day or the job), run the paver in normal fashion right up to where the transverse joint is being constructed.*
- *While commonly done, do not run the paver dry right at the joint. Keep a full head of material in front of the screed to the end. (This practice can be seen in this photo–a smooth mat to the end.)*

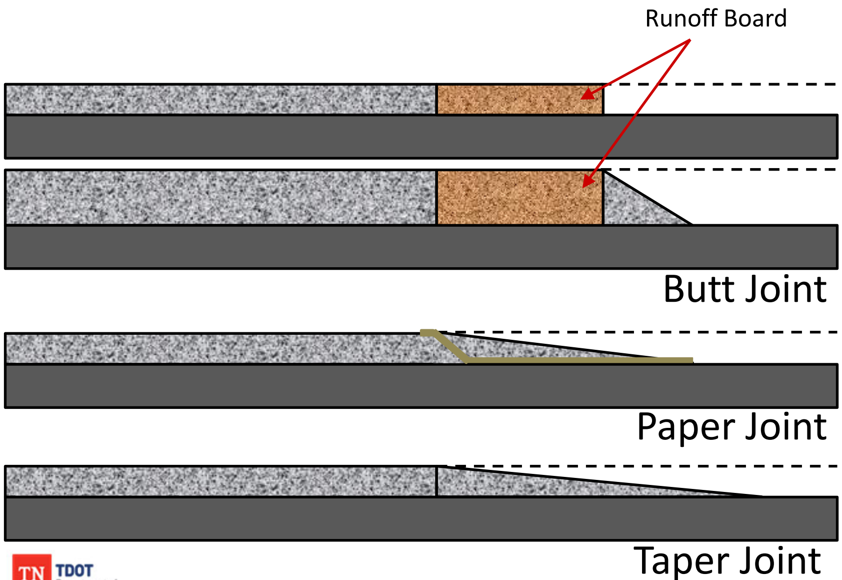
8

9

- *Tying into the existing pavement requires skill to ensure a smooth transition.*
- *There will almost always be some handwork necessary to complete the joint. Do not get carried away with overworking the mix.*
- *Notice how the paver finish comes right up to the joint.*
- *When handworking mix, "leave the mix high" to allow compaction. Handworked mix is looser than paver-laid mix. Leave about 0.25" per 1" of mix laid.*
- *Compact this immediately. Handworking (and the time to do it) results in a cooler mix.*

10

Types of T-Joints



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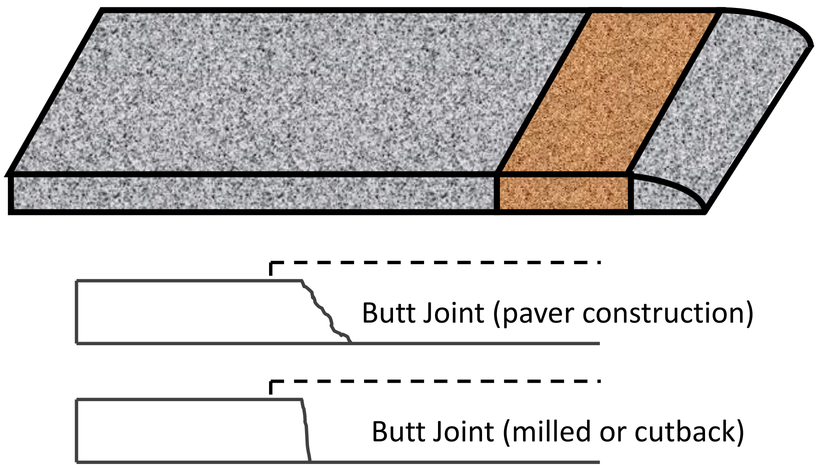
- *Several types of temporary transverse joints are used. Terms may vary locally, and there are pros and cons to each.*
- *A butt joint can be used when traffic will not be passing over the joint. There are several ways to construct this.*
- *A joint location is selected, and the upstream side is not touched. The downstream side is raked away, and boards are laid lengthwise to allow the roller to compact the edge without rolling it over.*
- *This style places a board at the end of the mat, and then builds a small ramp for getting equipment off of the mat.*

12

Butt Joint



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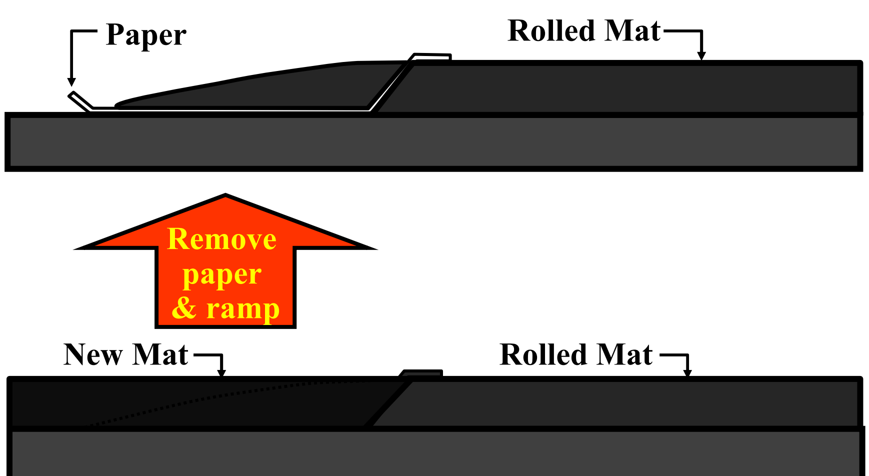
Papered T-Joint



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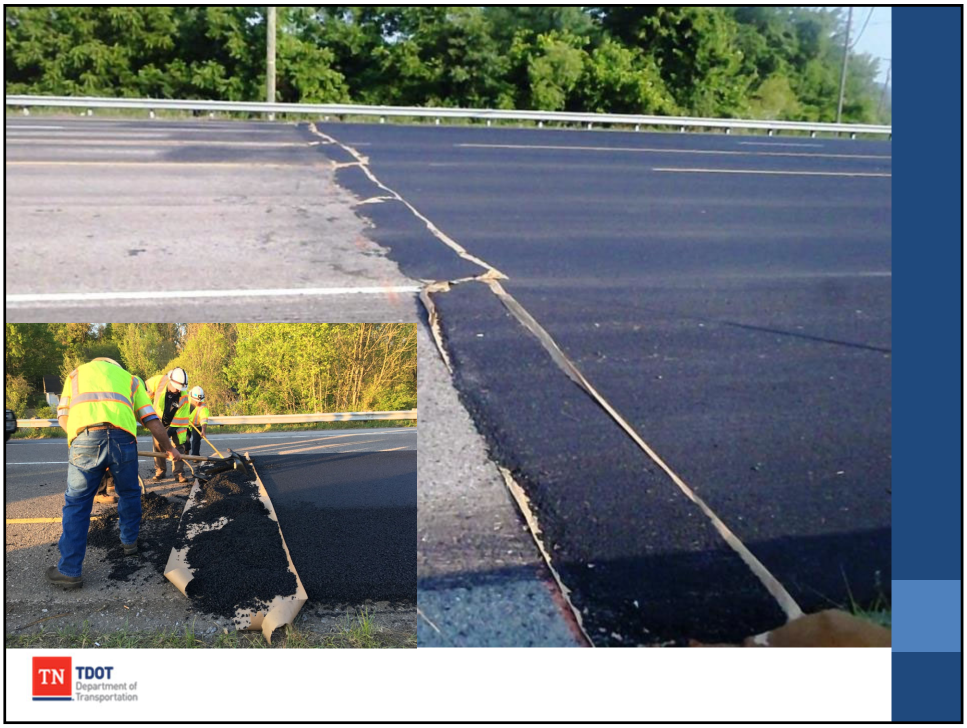

15

- *Instead of a board, a paper transition can be used.*
- *Again, at a point where the mat is still uniform in thickness and density, the paver is stopped and pulled away.*
- *Mix is shoveled away from the joint location, and treated paper is placed downstream of the joint.*
- *Mix is shoveled onto the paper, formed into a ramp, and then the mat and the transition are compacted.*
- *This is the most commonly seen joint in TN.*
- *Paper joints are often left open to traffic. This should only be done when vehicle speeds are less than 40 mph.*
- *Paper joints may not hold up well during wet weather conditions.*

16

Taper T-Joint Removal

17

- *Another option is to run out the paver, and feather the joint into the existing mat.*
- *The joint location will be upstream of the taper, where the mat thickness and density match the specs.*
- *When starting up again, the transition point must be found, if a butt or paper joint was not used.*
- *Use a straightedge to determine where the pavement thickness began decreasing and mark the joint location.*
- *Even if using a butt or papered joint, it must be straightedged to ensure that it was smooth up to the transition. If the mat is not level at the formed transition, the joint must be moved back*

18

19

- *Once the joint location is determined, the material downstream of the joint is removed.*
- *For a papered joint, there is no bond between the paper and pavement, and the taper is easily removed.*
- *For a butt or nonformed taper joint, the mix will have bonded to the existing pavement, so a mechanical device must be used to remove the mix.*

20

21

- *This contractor is using a small milling machine to remove the taper. The milling machine could also have been used to create the vertical edge.*
- *A front-end loader can also be used to pry loose the mix.*
- *Care must be taken to create a clean, vertical transition for re-starting the paving operation.*

22

23

- *After the transition has been removed, the exposed joint area must be thoroughly cleaned, removing any mix and dust.*

24

- All transverse joints must be properly tack coated to ensure a good bond between the mix and the existing pavement.
  - See section 407.16 in TDOT specs.

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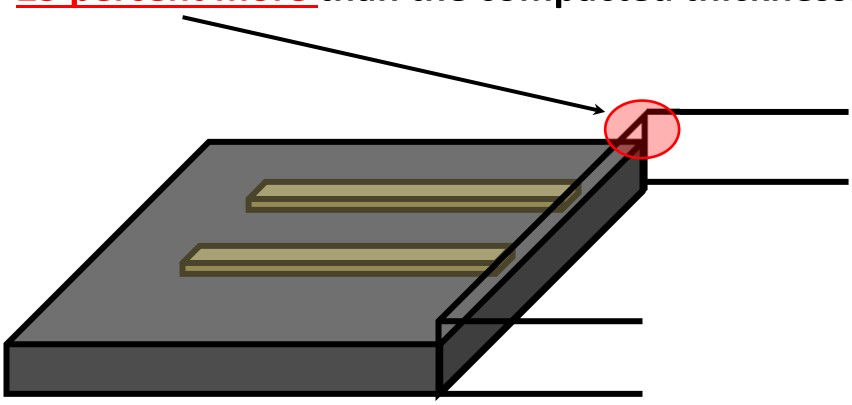
25

A good rule of thumb is to raise the screed <u>25 percent more</u> than the compacted thickness.



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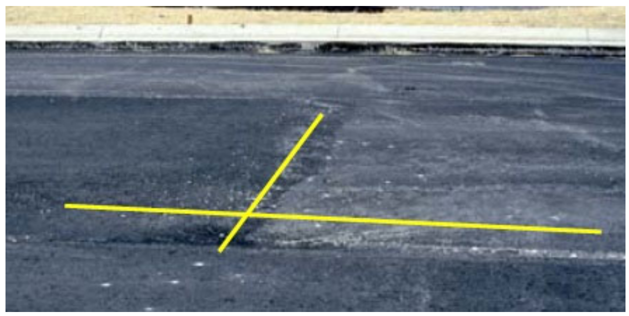

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27

- *Remember that boards must be placed on the upstream side of the joint to raise the screed to allow for mix compaction at the joint.*
- *Rolldown will typically range from 0.25" per inch of mix placed, depending on the mix.*
- *After the screed is set on the blocks, remember all of the paver start-up procedures:*
  - *Null the screed,*
  - *induce the angle of attack,*
  - *flood the hopper with mix,*
  - *fill the auger chamber with a full head of material,*
  - *turn on any automatic material, grade, and slope sensors, and*
  - *pull off the blocks and bring the paver up to the laydown speed.*

28

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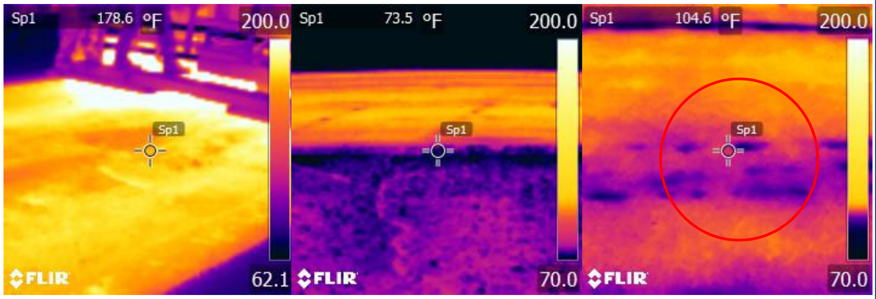
- *If the transverse joint is constructed properly up to this point, there should be minimal luting necessary.*
- *If the paver starts out on the blocks and the screed begins with a full head of material, the thickness of the downstream mat will be correct.*
- *There is never a reason to lute a transverse joint excessively.*
- *Remove and recycle any excess coarse aggregate left from luting the joint. Shouldn't broadcast material back onto the mat.*

30

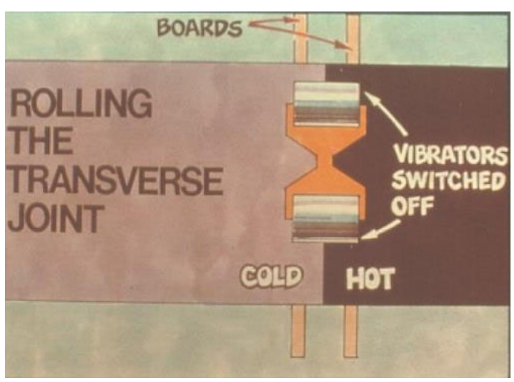
Infrared Camera Photos



Casted materials showing low temperature

31

- Ideally, a transverse joint should be compacted in the transverse direction.
- If traffic allows, use boards to allow the roller to make the first pass in the transverse direction.



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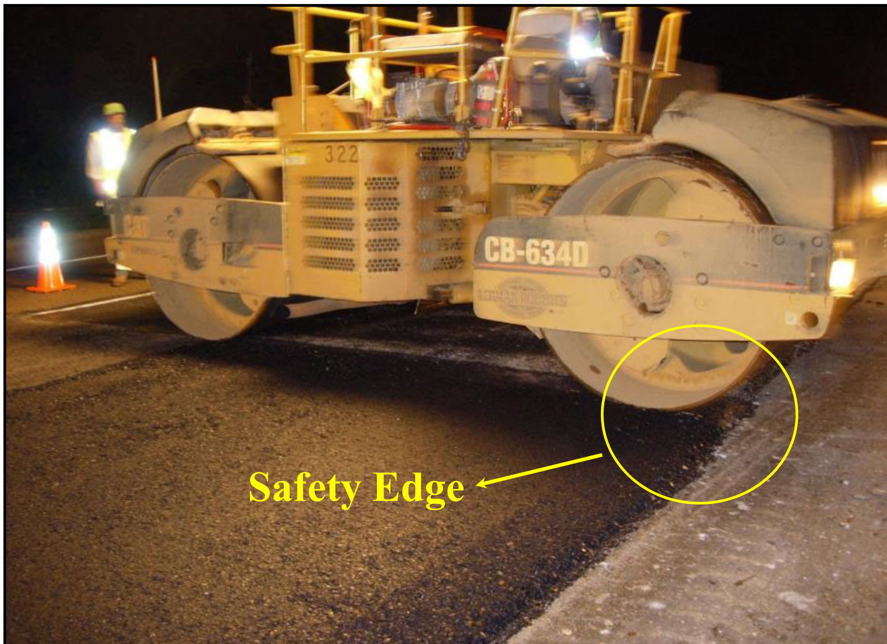

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TDOT Requires Contractors to have
a **12’ Straightedge**

(TDOT Spec. 407.18)

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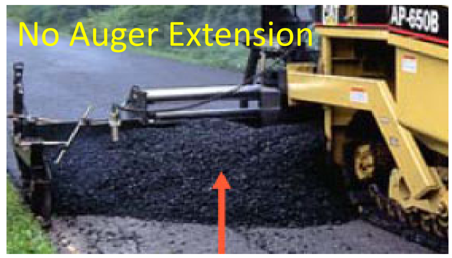
34

Longitudinal Joint

35

- *A longitudinal joint is formed when a new mat is placed against an existing mat.*
- *The first pull of the paver almost always leaves an unsupported longitudinal edge in the mat. This joint will be a potential weakness in the finished pavement, and it must be handled carefully to minimize problems.*
- *Construction of good longitudinal joints is especially important with coarse mixes and SMA.*

36



The joint is formed by mix extruded under the screed and restrained by the edge plate.

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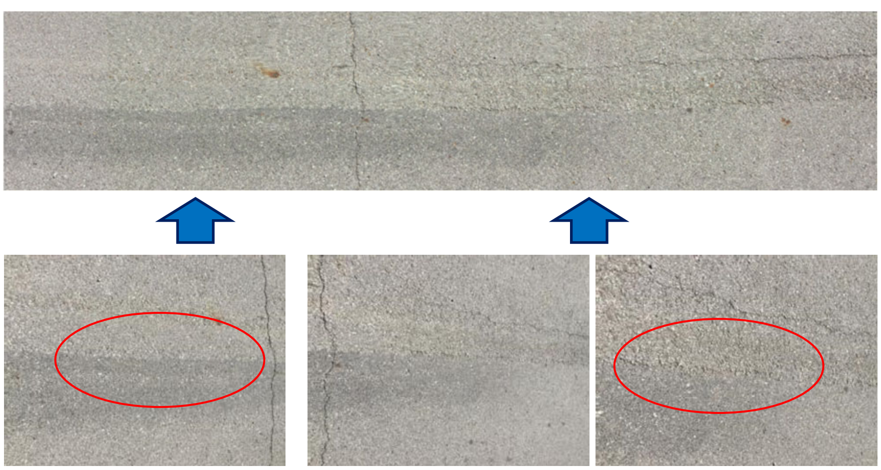
Aggregates Segregation



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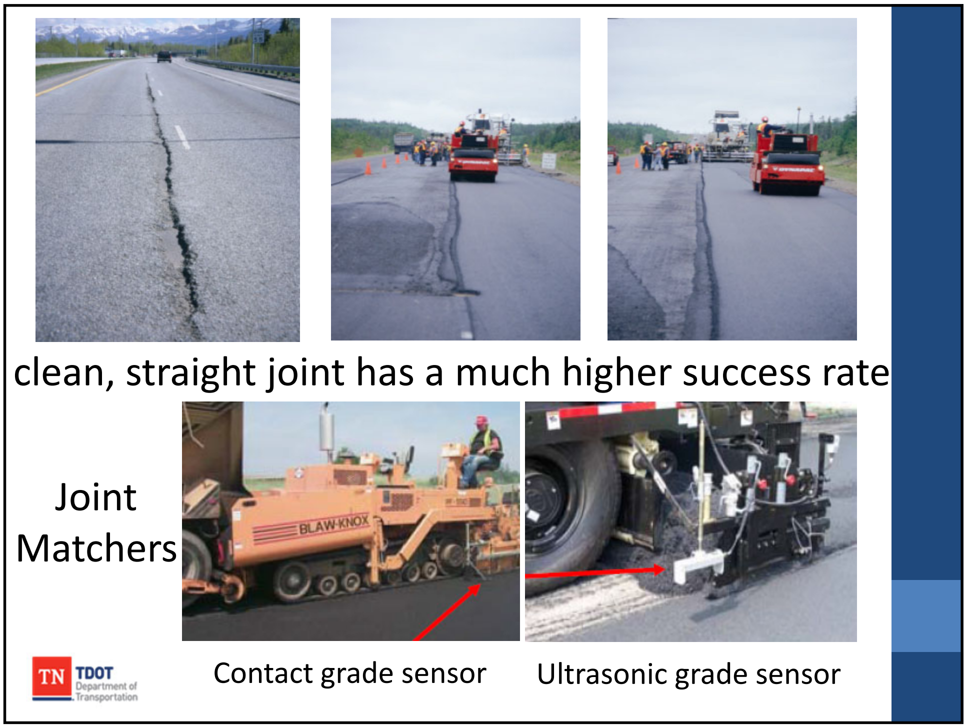
clean, straight joint has a much higher success rate
Joint
Matchers
BLAW-KNOX
Contact grade sensor
Ultrasonic grade sensor
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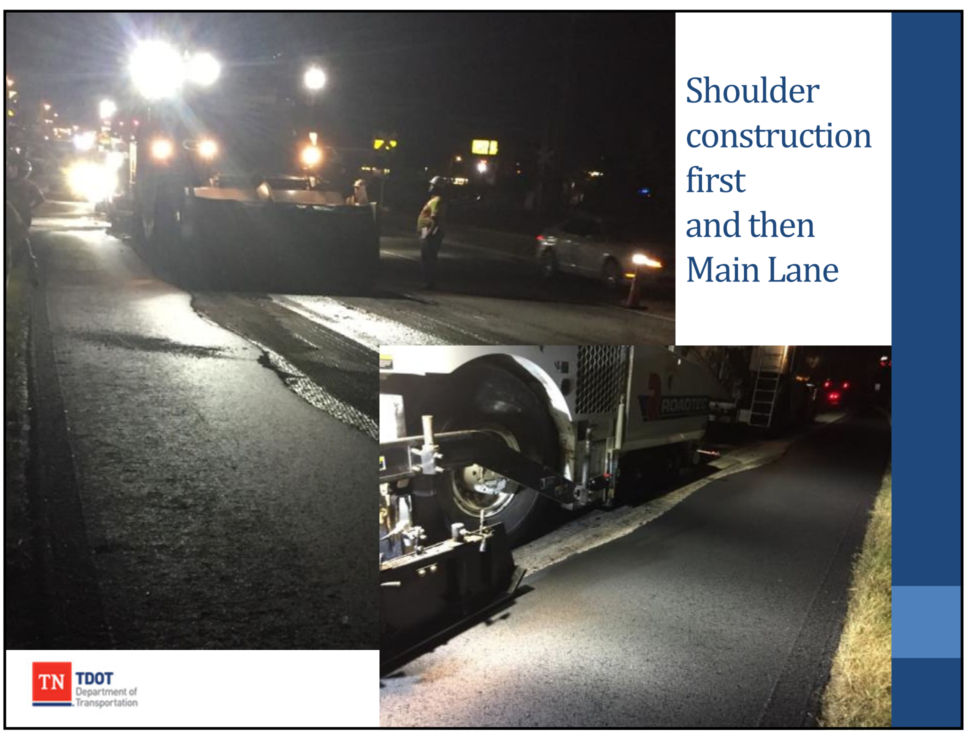
39


Shoulder
construction
first
and then
Main Lane
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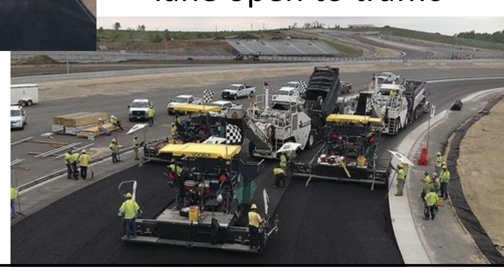
40

41

Echelon Paving

- Best results would be obtained
- Consistent HMA feed more than one paver
- Difficulties in highways, which require at least one lane open to traffic



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Echelon Paving

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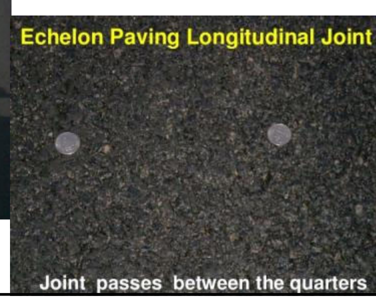
43

- I-24 in Davidson County.
- Cores taken on the joint revealed densities of 94%



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- Longitudinal joint was eliminated at the shoulder.
- TDOT requires special small shoulder roller

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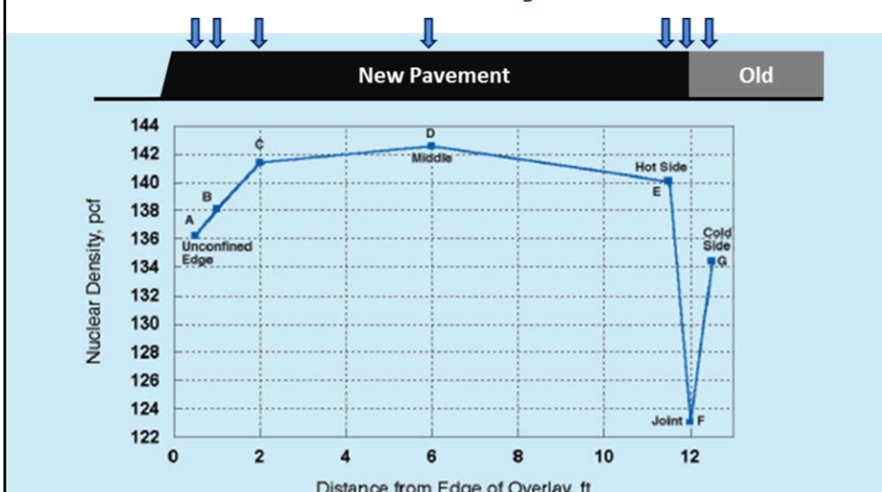
45

Transversal Density Profile



The tendency is for this edge to have less density than the middle of the mat, which has adequate confinement from all directions.

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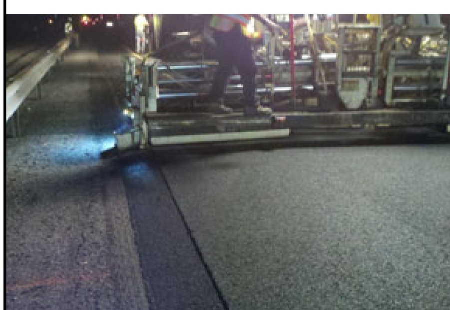
L-Joint Edge

Without Safety Edge

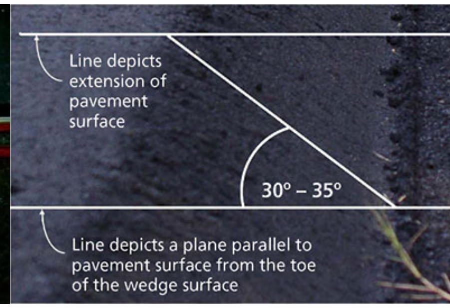
With Safety Edge

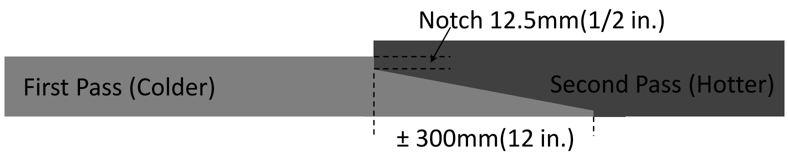
47



Sharp, steep pavement edge drop-offs can contribute to crashes

48





Rate of taper depends on traffic speed

49

- *States have been researching whether performance and increased safety can be derived from tapered joints.*
- *This style of taper is excellent for fine mixes.*
- *Michigan wedge—allows traffic to run on it.*
- *The problem is coming back to pave up against it.*
- *NCAT's study showed the cut joint was best, but that this is the next best. Cut joints cost more.*

50

Cut Joints

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51

Joints Treatment Technologies

Longitudinal joint heater

Overbending longitudinal joints 4” wide with PG binder

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52

Joints Treatment Technologies

- Typical overlap on L-Joint is 1-1.5inches.
- Excessive overlap requires removal of extra materials from the cold lane to hot lane which may cause premature cracking near joint.

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53

Here is a crew creating a very tight joint, such that it does not need any luting.

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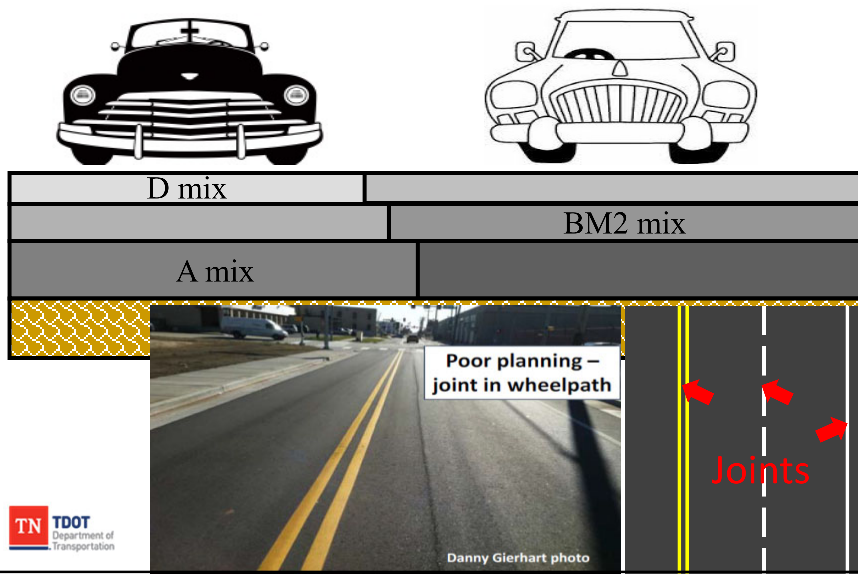
Staggered Paving Joints



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- *When building multiple layers of HMA, longitudinal joints must be staggered so a single vertical joint does not run the full depth of the pavement.*
- *Should be greater than 1 ft.*
- *See TDOT Spec., 407.14, 2nd Paragraph*

56

Luting and Raking

- Excessive raking is NOT necessary at all times.
- The mix material that is pushed off the L-joint and deposited on the new asphalt mat changes the surface texture and cause segregation on L-joint.
- Raking of the longitudinal joint can be eliminated with proper overlapping of the new mix on the previously placed mat.
- Raking or luting at the longitudinal joint can be eliminated if the materials are properly overlapped.
- Overlapped material should be bumped with a lute onto the hot mat just across the joint.

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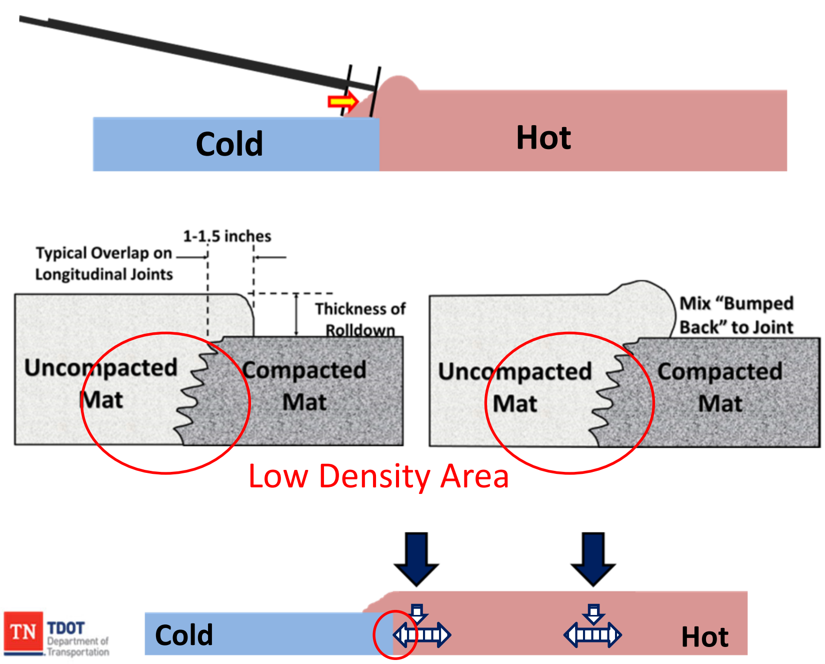
- *Provide enough overlap to provide a tight joint and allow for the steering tolerance of the paver.*
- *1-1½ inches is successful in most cases.*
- *The end gate should be in contact with the surface and leave a tight edge.*
- *If the amount of material is properly placed, a simple bump of the mix with the lute will prepare the joint for compaction.*
- ***Do not cast mix across the mat.***

58



59

This luter is flattening out the joint, pushing all of the coarse aggregate away from the joint and onto the mat.

60

TDOT Joint Specs 407.16

Placing of the bituminous paving shall be as continuous as possible. Rollers shall not pass over the unprotected end of a freshly laid mixture unless authorized by the Engineer. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. A brush coat of bituminous material shall be used on contact surfaces of longitudinal and transverse joints just before additional mixture is placed against the previously rolled material.

61

Role of the TDOT Inspector

- Circular Letter 407.14-01: "Hot Mix Asphalt Roadway Inspector Checklist"
  - Longitudinal Joint
  - Transverse Joint

62

9.

HMA Compaction

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HMA Compaction

1

- *The last chance to make a job is during the compaction process, which must be closely controlled to achieve a quality pavement.*
- *Compaction determines the ultimate performance of the mix and pavement.*
- *Compaction is often very difficult to achieve in the field because of a number of variables.*
- *You must manage these variables and control them, in order to ensure that you achieve density.*
- *The key is to recognize the advantages and disadvantages of each type of roller per project.*
- *Setting up and maintaining the rolling pattern involves much effort on the part of the operator.*

2

Objectives

- Factors Affecting Compaction
- Types of Rollers
- Compaction Variables
- Roller Maintenance
- Roller Productivity
- Operating Techniques
- Roller Patterns
- Joint Compaction

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3

- *During this unit, we will look specifically at what compaction does for a mix design and for a pavement.*
- *We will look at the variables and factors that affect the compaction process.*
- *We will look specifically at the types of rollers or compaction equipment available and how to pick the best roller for the job.*
- *We will look specifically at the variables facing the compaction process and the importance of keeping rollers maintained.*
- *Slow and steady is the right way to do it!*

4

Why Compact?

- REDUCE AIR VOIDS!
- Reduce Moisture Penetration
- Improve Mechanical Stability
- Improve Resistance to Permanent Deformation
- Improve Fatigue Cracking Resistance
- Reduce Low-Temperature Cracking Potential

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5

- *Compaction is the single most important factor that affects the ultimate performance of a hot-mix asphalt pavement.*
- *An asphalt mixture that has all the desirable mix design characteristics will perform poorly under traffic if that mix is not compacted to the proper density level.*

6

Time Available for Compaction

Compaction must be accomplished before the mat cools to a temperature below 185°F.

- Below that temperature, the mix is still warm enough for the compaction, but the mix is generally too stiff to increase in density any significant amount with continued rolling

7

Factors Affecting Compaction

- Properties of the Materials
  - *the surface texture, porosity and particle shape of the aggregate and the viscosity of the liquid asphalt.*
- Environmental Variables
  - *temperature, wind, solar effects on climate*
- Laydown Site Conditions
  - *existing road surface texture, lift thickness and profile or the sub-base stability.*

8

Properties of the Materials

- Aggregate
  - Source Material, Pros/Cons.
- Asphalt Cement
  - Graded based on climate performance.
- Mixture Properties
  - Dependent on mix type and traffic.
  - Virgin Mixture vs. RAP/RAS Mixture.

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- Aggregates vary greatly across the nation from sedimentary to metamorphic and igneous.
- Aggregates may be natural deposits with little to no processing, processed aggregates such as limestone, dolomite, expanded shale, quartzite, and granite, and synthetic aggregates such as steel and blast furnace slags.
- Asphalt is graded by performance, and varies in hardness based on climate. IE PG 64-22, PG 76-22
- Mixture properties vary based on type of mixture specified.
- Type of mixture specified varies directly with traffic loading.

10

Non-Crushed Aggregates

- While most gravels are crushed, not all of their particles are fractured. Some may still remain round.
- Most natural sands, especially those dredged from a body of water are also quite round.
- These round aggregate particles act as ball bearings and aid in the compaction of HMA

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11

100% Crushed Aggregates

- Angular, 100% crushed particles offer more compactive resistance than rounded particles.
- Other factors affecting compaction may be the surface texture of an aggregate or the nominal maximum aggregate size of the mix.

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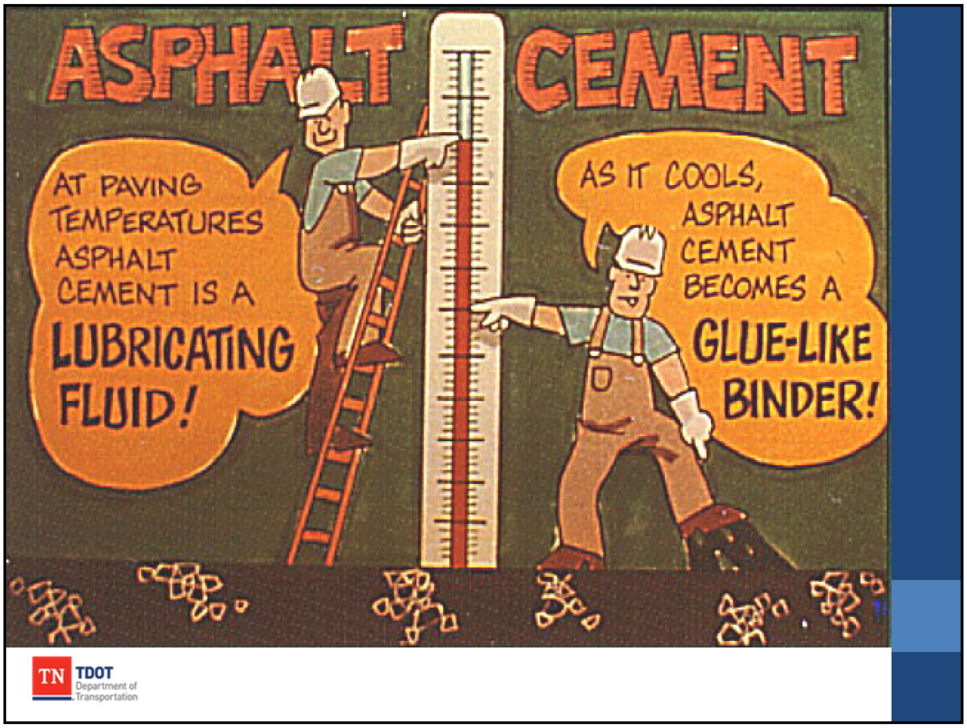

13

- The grade and amount of asphalt cement used in the mix affects the ability to compact the mix.
- Modifying the asphalt increases the compactive effort needed to obtain density. (PG 70, 76, 82-22)
- In general, a mix with too little AC may be stiff and require an increase in compactive effort, whereas a mix with too much AC may shove under the rollers.
- As the temperature of liquid AC increases, it's viscosity *decreases*. In general, the lower the viscosity of the AC, the easier it will be to compact a mix.

14

Environmental Variables

- Layer thickness
- Air and base temperature
- Mix laydown temperature
- Wind velocity

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15

- *Research work and field experience show that once a pavement cools to 175 ^{o} F, the internal friction and cohesion of the mix increases to the point that little density gain is achievable.*

- *Layer thickness, air temperature, base temperature, mix temperature, wind velocity, and solar flux have an effect on the rate of cooling a layer of asphalt placed on top of another existing layer of the same material.*

16

Major Factors affecting rolling time

Major Factors	Allows MORE time	Allows LESS time
Mat Thickness	Thick	Thin
Mix Temperature	High	Low
Base Temperature	High	Low

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- *Layer thickness is the thickness of an asphalt pavement layer, and it is the most important variable in the rate of cooling of asphalt mixtures.*
- *It is very difficult to obtain the desired density on thin lifts of mix in cool weather because of the rapid loss in temperature in the mix.*
- *Depending on the air and base temperature as well as moisture content, the loss of temperature could be large or small.*

18

What about wind?

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19

- *A thin layer of mix will cool more quickly in a strong wind than when there is little or no wind.*
- *Wind has a greater effect at the surface of the mix than within the mix, and can cause the surface to cool so rapidly that a crust will form and checking of the HMA may occur.*
- *Refer to the section HMA Delivery in which thermometers were discussed.*

20

Types of Rollers

- Vibratory
- Oscillatory
- Pneumatic (Rubber Tire)
- Static Steel Wheel

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Table 407.15 – Roller Requirements

Mix Type	Roller Requirements
307-A, 307-B, 307-BM-2, 307-C, 307-CW (Except Surface)	3 Rollers (Intermidate Roller shall be Pneumatic)
307-AS, 307-ACRL, 411-D, 411-E, 307-CW (surface), 313-Asphalt TPB	3 Rollers (Unspecified)
411-TL, 411-TLD, 411-TLE, 307-CS (Paved as a continous layer)	2 Rollers (Unspecified)
411-OGFC	2 Rollers (Both shall be static steel double-drum, 10 ton minimum)
Any mix used for scratch paving	2 rollers (Breakdown shall be pneumatic)

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Density Tables

- Table 407.15-1: Density Requirements for Bituminous Pavement

Mix Type	% of Maximum Theoretical Density (Lot Average)	No Single Test Less Than, % (Sub-lot)
Travel Lanes ADT < 1,000 A, B, BM, BM2, C, CW, D, E	90.0	87.0
Travel Lanes 1,000<ADT>3,000 A, B, BM, BM2, C, CW, D, E	91.0	89.0
Travel Lanes ADT > 3,000 A, B, BM, BM2, C, CW, D, E	92.0	90.0
Travel Lanes Any ADT CS, TL, TLD, TLE, OGFC	N/A	N/A
Shoulders B, BM, BM2, D, E	88.0	85.0

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23

- The type of equipment used to compact the asphalt mix obviously has a significant effect on the degree of density that can be obtained in a given number of passes of a particular roller.

- Three types of self-propelled compaction equipment are currently being used: static steel wheel rollers, pneumatic tire rollers, and vibratory/oscillatory rollers.

24

Vibratory Rollers

- Amplitude
- Frequency
- Impact Spacing

25

- *Vibratory rollers have two types of compactive forces that are applied to the hot-mix asphalt: static weight, caused by the weight of the rolls and frame; and dynamic (impact) force, produced by a rotating eccentric weight located inside the drum(s), which rotates about the shaft inside the drum.*
- *The operator is in control of more variables when using a vibratory roller and should be well-educated in the selection and interaction of these variables.*

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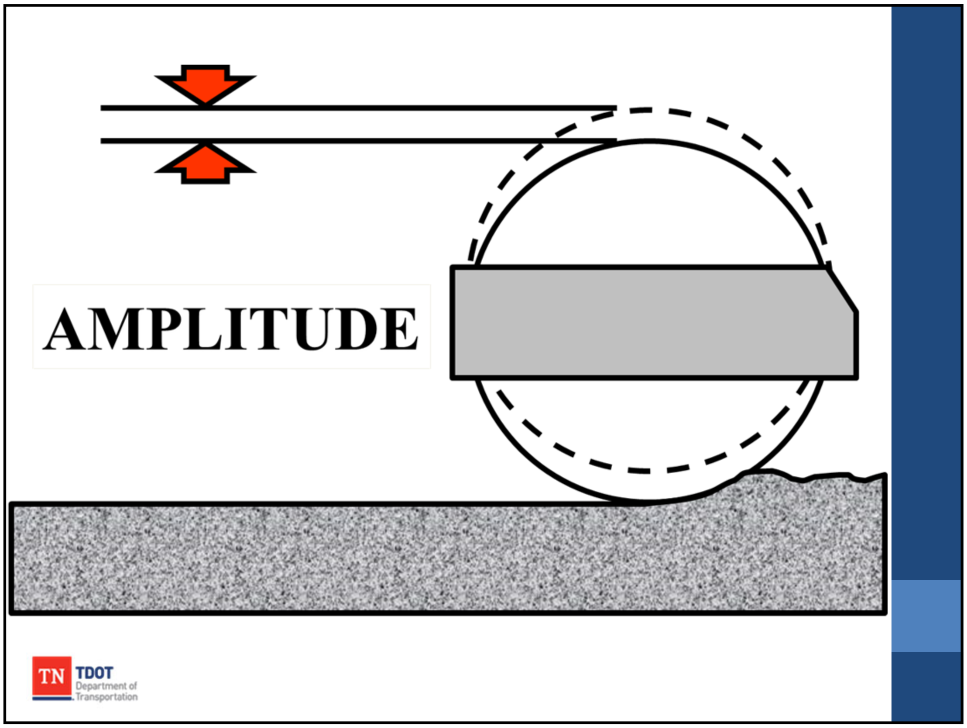

27

- *Amplitude is basically defined how hard the drum hits the mat.*
- *Normal values of nominal amplitude range from 0.01 to 0.04 inches.*
- *Some rollers can operate at only one fixed amplitude, while others have "high" and "low" amplitude positions.*
- *Typically as the layer thickness increases, it is often advantageous to increase the nominal amplitude applied to the asphalt mix.*
- *Unless 'high' amplitude is needed to achieve a particular density level, the vibratory roller should be operated in 'low' amplitude.*

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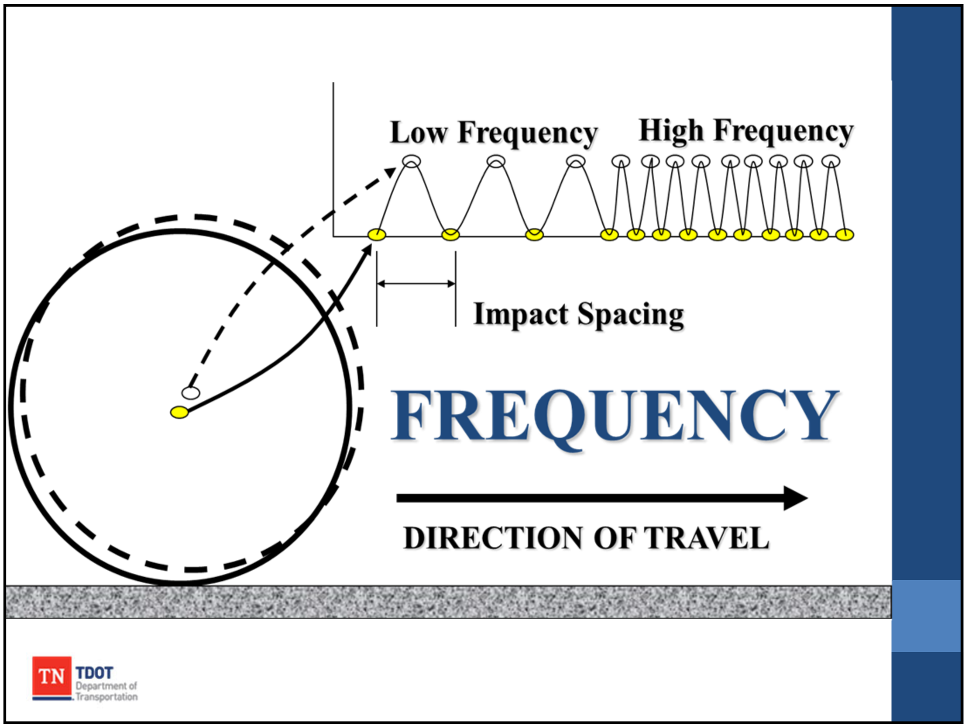

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- *The frequency of vibration is basically the number of cycles that the eccentrics rotate per minute.*
- *Some vibratory rollers can operate at only one frequency or have a very limited selection of frequencies.*
- *Other vibratory rollers can alter the frequency of the applied load between 1600 and 3000 vibrations per minute.*
- *Frequencies below 2000 vibrations per minute are not normally acceptable to compact asphalt mixtures.*

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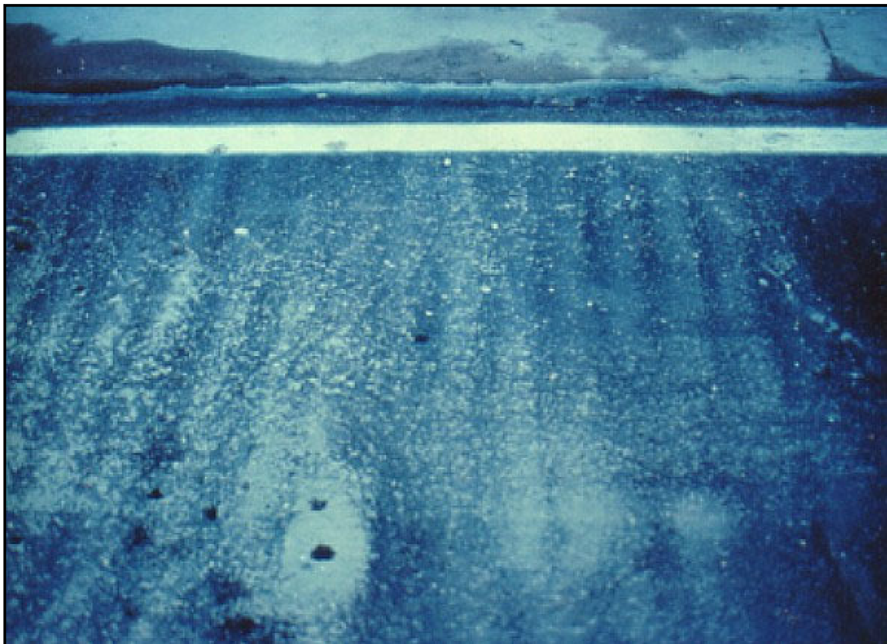

31

- *The spacing of the impacts of the applied force is a function of the frequency of the vibration and the travel speed of the roller.*
- *A smaller impact spacing and thus a greater number of impacts per meter, is usually preferred.*
- *Manufacturers recommended the following impact spacings.*
  - *The impact spacing should be in the range of 10-12 impacts per foot, or 1 to 1.25 in between impacts, to ensure the highest efficiency of the vibratory rollers and reduce the possibility of leaving ripples in the finished pavement.*
- *Proper impact spacing and amplitude are the keys to successful pavement compaction.*

32

Oscillatory Rollers

33

- *Oscillatory rollers, similar to vibratory rollers, also have 2 types of compactive forces that are applied to the hot-mix asphalt.*
- *The difference is that the directional axis of the impact force has effectively been rotated 90°; thus providing more of a side-to-side compactive effort.*
- *This is far less likely to break aggregate, while still providing dynamic compaction.*

34

Pneumatic Tired Rollers

- Wheel load
- Tire design
- Inflation pressure
- Contact area

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35

- *The tire pressure used depends in part on the number of plies used in the tires.*
- *If the mix is tender, a lower tire pressure will displace the mix less than will a higher pressure in the tire.*
- *For a stiff mix, a higher tire pressure can be used, because the mix will be stable enough to support the weight of the roller without the mix shoving laterally under the tires.*
- *Tire pressure is normally kept constant for a particular project, but the level selected should be dependent on the properties of the mix being compacted and the position of the roller on the mat.*

36

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Pneumatic Rollers

37

- *Most pneumatic rollers are operated in the intermediate roller position, behind a vibratory or static steel wheel breakdown roller and in front of a static steel wheel finish roller.*
- *For this type of roller, the compactive effort applied to the mix is a function of the wheel load of the machine, the tire pressure, the tire design, and the depth of penetration of the tires into the mix.*
- *All of the tires on the roller should be the same size, ply, and tire pressure.*
- *The greater the contact pressure between the tire and the mix, the greater the compactive effort applied by the roller.*

38

39

- *Damage like this needs to be avoided.*
- *Although the density of the pavement is probably being achieved, the finished surface is mottled and will most likely have surface blemishes which may hold water.*
- *The key is to get the tires hot and keep them hot by keeping the roller moving.*
- *Modified asphalt may be more of a problem…but it can be done.*

40

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The use of 'skirts'

41

- *Get the tires hot by running the pneumatic roller on existing pavement first and then by slowly getting them hot on the new pavement.*

- *The use of 'skirts' not only helps in getting the tires hot but also ensures that they will stay hot all day by limiting the winds cooling effects.*

42

Typical amount of surface pickup

43

- *This is a typical amount of surface pickup when using the pneumatic tired roller properly.*

- *Once the size of the pneumatic roller and the pressure to be used are selected, the only variables that can be controlled easily by the operator are the rolling speed, the location of the roller with respect to the paver, and the number of roller passes over each point in the pavement surface.*

44

45

- *Many times attempts are made to eliminate the mix pickup problem by spraying water or a release agent on the tires during the rolling process.*
- *A better solution is to allow the tires on the roller to reach the same temperature as the mix being compacted without adding water or release agent to the tires.*
- *This roller was photographed on a project in East TN while compacting a mix with PG 70-22 AC.*

46

Static Steel Wheel Roller

- Contact Pressure
- Operation

47

- *Mass may be increased by adding ballast to static rollers, which in turn increases the contact pressure per linear inch.*
- *Maintenance ensures not only that the equipment will work but that the finished surface will not be blemished.*
- *Poor scraper performance or an overloaded roller both cause blemishes in finished pavement surfaces.*

48

Static Steel Wheel Rollers

49

- *Static steel wheel rollers normally range in weight from 3 to 14 tons and have compression drums that vary in diameter from approximately 3 to 4.5 ft.*
- *The gross weight of the roller can usually be altered by adding ballast to the roller, but this adjustment cannot be made while the roller is operating, and is not normally changed during the term of a project.*
- *Normally used as the finish roller on a paving project, removing any marks left in the mat by previous rollers.*

50

Compaction Rate Variables

- Rolling Zone
- Roller Speed
- Number of Passes (Coverage)
- Rolling Pattern

51

- *The primary compaction variables for all types of rollers that can be controlled during the rolling process are: (a) roller speed, (b) number of roller passes, (c) roller pattern, and (d) rolling zone.*
- *Each of these factors has an effect on the level of density achieved under the compactive effort applied to the mix.*

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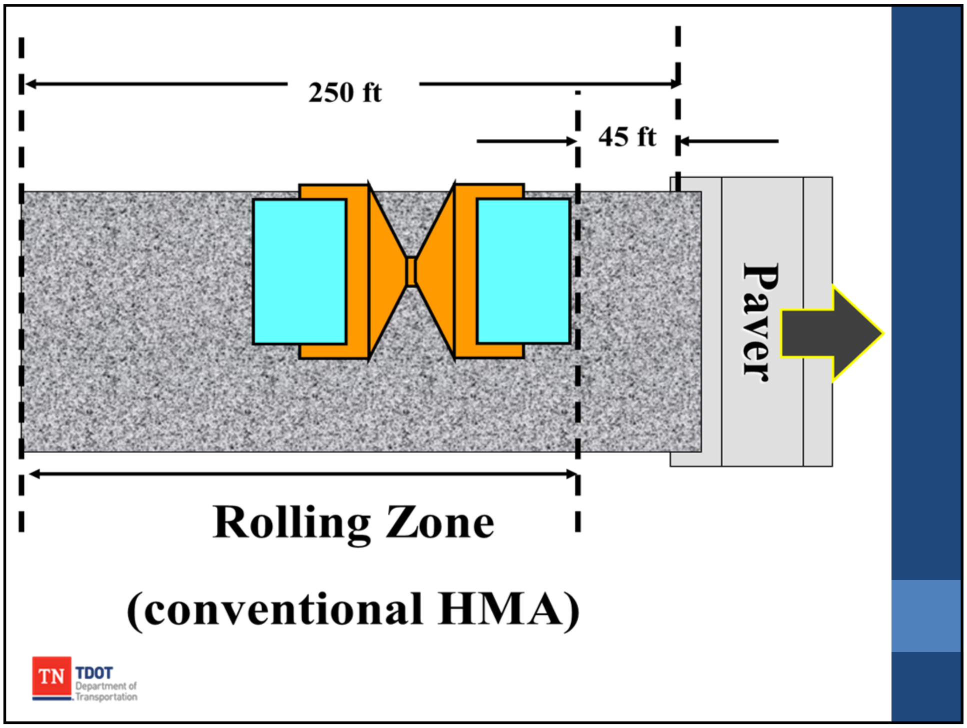

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- *This slide shows a typical rolling zone which ranges from 45 feet behind the paver to 250 feet.*
- *The idea is that the material within 45 feet of the paver is too hot, or "tender".*
- *Once rollers get a certain distance back from the paver, the mat may be too cold for sufficient breakdown compaction.*
- *The values shown here are approximate and will change depending on variables such as air temp, AC grade, mat thickness, etc.*

54

Test Strip Construction
(reasons for)

- Simulating Actual Conditions
- Establishing Roller Patterns
- Calculating Effective Roller Speed
- **CALIBRATING NUCLEAR GAUGES**
- **Finding How to Reach Target Mat Density, this is the Contractor's Responsibility**

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55

- *The actual rolling pattern to be used to compact the mix on a paving project should be determined at the start of the project through the construction of a roller test strip.*
- *The mix should be representative of the material to be produced for the project; generally the plant should produce mix for a short period of time before mix is made for the compaction test section.*
- *The thickness of the layer should be the same as that used for the rest of the project and* ***400 sq. yd.***

56

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Establishing Roller Pattern

57

- *Different mixes may require considerably different levels of compactive effort and thus different compaction equipment and rolling procedures.*

- *An asphalt mix containing large aggregate, for example, may need different types of rollers to achieve a required level of density than an asphalt concrete mix made with smaller size coarse aggregate.*

58

59

- *The most common method for monitoring changes in density with roller passes is through the use of a nuclear density gauge. The count data that are obtained can be related to the relative density of the layer.*
- *Nuclear gauge readings should be taken after each pass of each roller, and the rate of increase in density after each pass determined.*
- *When no appreciable increase in density is obtained with additional roller passes (or if the density reading actually decreases), the maximum relative density for that mix has been obtained.*

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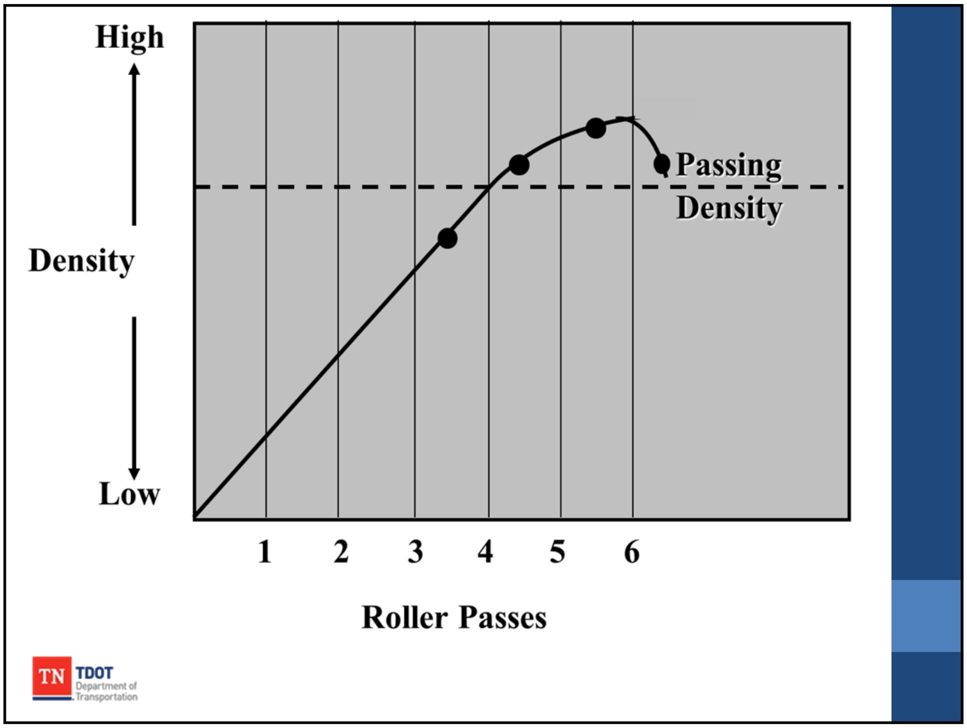


61

- *Nuclear gauge readings should be taken after each pass of each roller, and the rate of increase in density after each pass determined.*

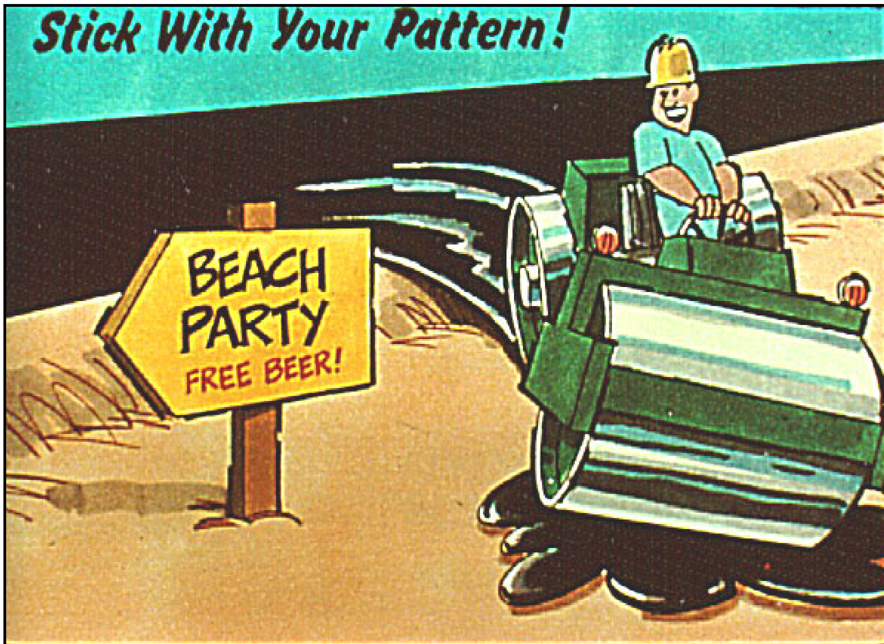
- *When no appreciable increase in density is obtained with additional roller passes (or if the density reading actually decreases), the maximum relative density for that mix has been obtained.*

62

63

- *The density value determined with the nuclear gauge is relative and is generally **<u>not</u>** the same as the density value obtained from cores cut from the pavement.*
- *Thus a correlation must be developed between the nuclear density reading and the actual unit weight of the pavement.*
- *That unit weight must be compared to the maximum theoretical unit weight of the mix in order to calculate the actual in-place air void content of the layer.*

64



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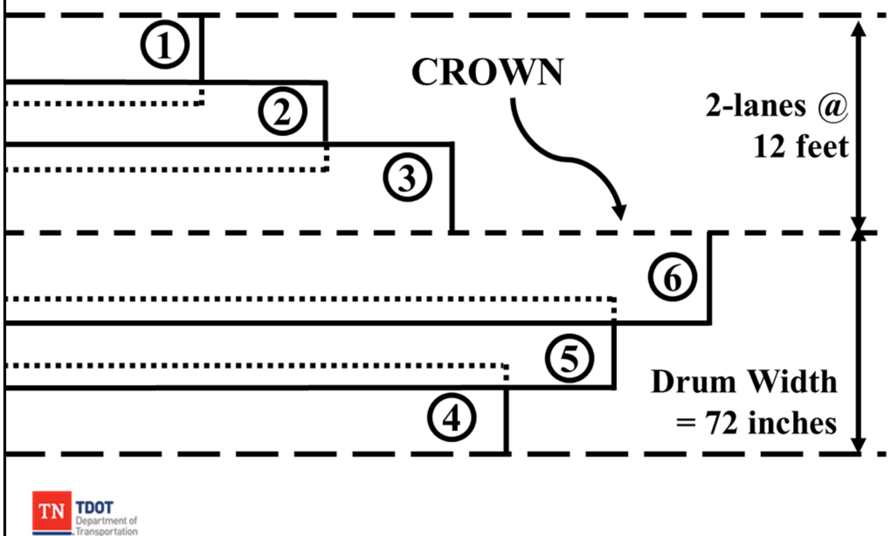
65

- *The roller operator is in control of more variables when using a vibratory roller and thus should be well educated in the proper selection and interaction of the variables.*

- *In addition to roller speed, location on the layer being compacted, and number of passes made, both the nominal amplitude and the frequency of the vibratory impact can be varied.*

66

One Roller Coverage



67

- If the width of the roller drum is 78 in, only two passes of the roller are needed to cover the 12 ft wide lane, including a 6 inch overhang at each edge of pavement.
- A roller that is 72 inches wide cannot cover the complete 12 ft wide lane in only two passes.
- Three passes of the 72 inch wide roller would be necessary to properly compact the lane.
- If the roller had drums that were 60 inch wide, three passes of the roller would be required, similar to the roller with the 72 inch wide drums.
- A 55 inch drum needs four passes for one coverage.
- For thick lifts, first pass should be about 1 ft in from edge to prevent shoving.

68

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Breakdown Rolling

69

- *Most contractors use steel drums. Rollers should stop and start slowly on uncompacted mix and angle the drum when stopping to reverse.*
- *The majority of the compaction is obtained during breakdown rolling, so it is important to keep this roller moving as much as possible.*
- *When the roller does stop, it is best practice to park on a cold mat. Otherwise, you may leave marks.*

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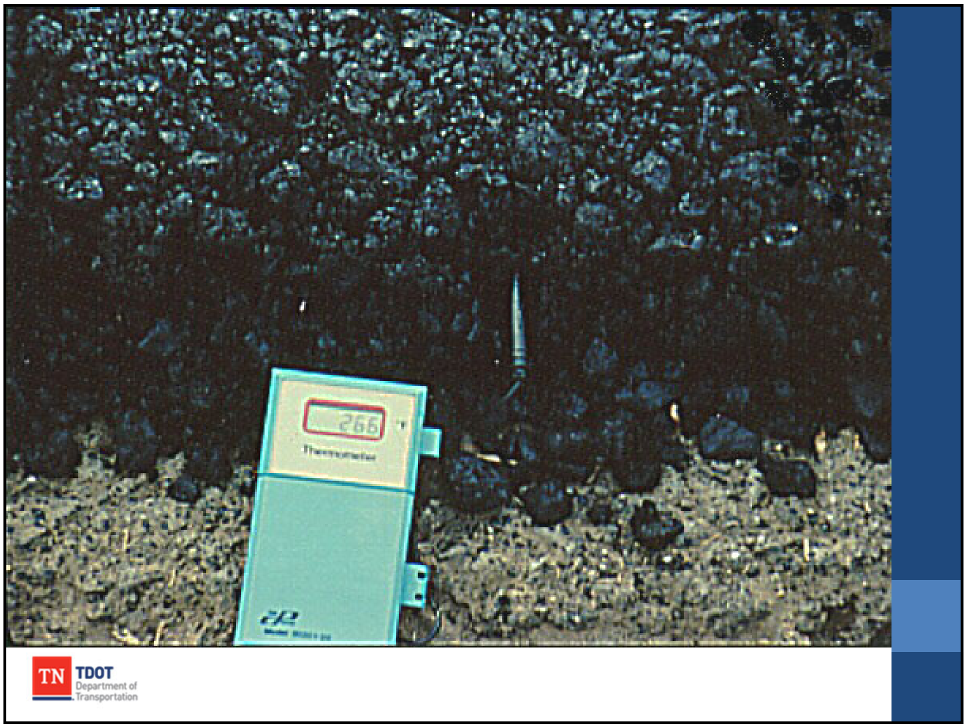

71

- *If you are monitoring compaction, one of the most important tools you should have at your side is a thermometer.*
- *Knowing your pavement temperature at placement and the time it takes to cool to the point where no more passes increase density is crucial especially at certain times of the year.*
- *The following section discusses a method used to determine your rolling zone through knowing temperatures.*

72

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Intermediate Rolling

73

- *If adequate density cannot be achieved with the breakdown roller, an intermediate roller may be needed.*
- *Intermediate rollers can typically be operated at higher speeds than a roller in a breakdown mode.*
- *Intermediate rollers should follow a roller pattern and not concentrate on running down the middle of the mat.*
- *TDOT Spec 407.15 !!!!!*

74

Finish Rolling

75

- Finish rolling is the last step of the operation and is normally used to “iron” out any roller marks left by a breakdown or intermediate roller.
- This roller is typically a static steel wheel roller, or a vibratory roller operating in a static mode.
- Finish rolling is not the place to count on obtaining additional density.
- It is a cosmetic process.

76

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Re-Watering During Paving

77

- *Rollers must re-water periodically during paving.*
- *It is best to re-water during a temporary lull in paving, and refill a half empty tank, than to wait until production is peaking and run out of water.*
- *If this cannot be avoided, and the mix is cooling too rapidly to wait, the intermediate or finish roller should be moved to the breakdown position until the original breakdown roller is available.*

78

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Opening to Traffic

79

- *If the mix has not cooled below a mix-specific temperature before opening to traffic, additional densification can occur in the mix, primarily in the wheel paths.*
- *It is possible that heavy traffic could over-densify the mix and cause rutting.*
- *Therefore, agreement should be reached in the pre-construction meeting as to the minimum temp. before the pavement is opened to traffic.*
- *Intersections, night paving and ramps are key areas.*
- *In some areas, a water truck has been used to cool the pavement temperature.*

80

Joint Compaction

81

- *There are a variety of ways to compact a longitudinal joint.*
- *One way is to hang the edge of the drum 6 inches over the unsupported edge to provide some confinement.*
- On thicker lifts, another technique is to keep the first pass of the roller 12 inches inside the unconfined edge, and make the second pass over the remaining strip.
- With the roller coming back here on the fourth pass, lateral displacement is also reduced since the mix is cooler.

82

1st Roller Pass on Unsupported Edge

- **50:50 opinion: Overhang vs. Stay Back 4-6”**

Contractor is responsible for determining the roller pattern.

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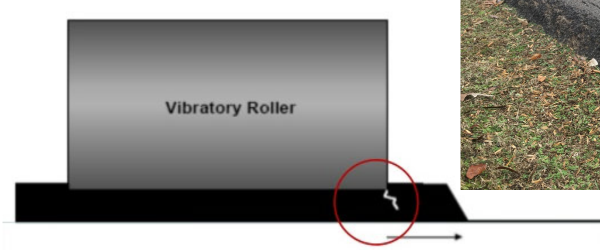
83

- **If stay back 4-6” is selected, watch for lateral movement and stress crack near roller edge**



Edge of drum inside unsupported edge can cause cracking near the edge and lateral mix movement at the unsupported edge.

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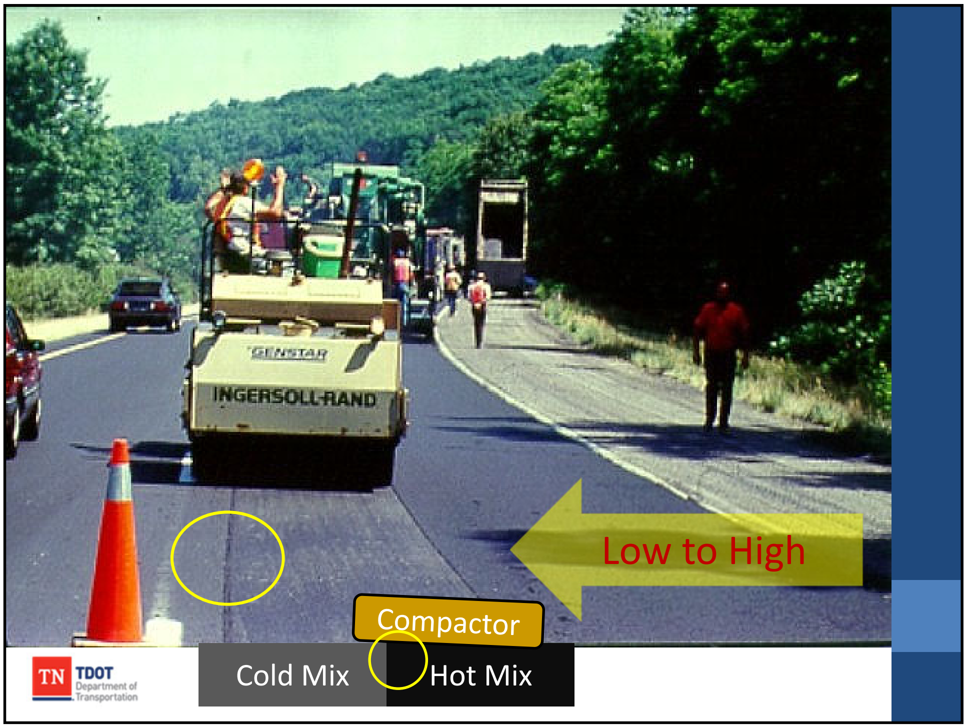

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- *It takes less effort to construct the joint properly.*
- *Pave the first lane straight, set the screed end gate properly on the second lane, and produce a clean joint.*
- *If the level of the second lane is at or below the first lane, proper compaction along the joint cannot be achieved.*
- *When the roller is properly placed with some of the roller on the cold mat, the roller will bridge the joint and not fully compact the hot side.*
- *This roller is improperly positioned in that it should be rolling from the low side to the high side.*

86

Role of the TDOT Inspector

- Circular Letter 407.14-01: “Hot Mix Asphalt Roadway Inspector Checklist”
  - Rollers (407.07)
  - Test Strip (407.15)

87

10.

Density

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Density and QA/QC

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1

Objectives

- What is QC/QA?
- TDOT Density Specification
- Random Sampling
- TDOT Acceptance Testing
- Test Strip Construction

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2

What is Quality ??

- Quality means different things to different people
- Is quality measurable?
- Is quality meeting minimum specifications?
- Management philosophy – includes agency and industry personnel

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3

What is QC/QA?

- Method Specifications
  - The DOT provides the mix design, sets up the plant, determine roller pattern and makes adjustments
- End Result Specifications
  - The DOT Specifies what the end product shall be and the Contractor is responsible for providing it

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Quality Control/ Quality Assurance

- QC/QA is a System
- QUALITY ASSURANCE SYSTEM is to provide CONTROL and maintain ASSURANCE. This partnering approach will help to maintain program credibility

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Quality Control/Quality Assurance

- Separates responsibility for process control and product acceptance
- Ensures that inspection plays an essential role

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Quality Control

- QC is the CONTROL portion of the inspection system. QC ensures the production of uniform materials that meet required specifications through periodic inspection and testing.
- QC is the producer's/contractor's responsibility!

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Quality Assurance

- QA is the ASSURANCE portion of the inspection system. QA assures the owner that the producer's test results are accurate. Random sampling and testing are at greater intervals than the producer's process.
- QA is the buyer's responsibility!

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Nuclear Density Testing

- You must have attended a Radiation Safety course prior to using a Nuclear Gauge!
- TDOT's SOP references ASTM D2950 as the standard test method.
- SAFETY FIRST!!!!

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Nuclear Density/Moisture Testing

- Perform tests in accordance with the TDOT Nuclear Gauge S.O.P.
- The gauge must be rotated about the axis of the probe to obtain additional readings.
- Do not stand right next to the gauge while running a test.
- Never run a test within 30 ft. of another gauge.

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Nuclear Density Testing

- Report test results on TDOT Form no. DT-0315

- This (and other forms) is available at:
http://www.tdot.state.tn.us/materials/fieldops/forms/default.htm

How do we know if the results are acceptable?

If they're not, what should we do?

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

SAMPLE

DAILY ASPHALT DENSITY REPORT

Item No. ______ Grading 411-E
Report No. 123 Date 27-Aug-03
Contract No. 12345
Project Reference No. SP County Lincoln Region 3
Project No. 12345-6789-10 Contractor Lincoln Asphalt
Tonnes Reg. Width 720.6 Producer ______ Location ______
Mix Temp. Road 300-320 Patching or Turnouts 0 Rejected 0 Total Tonnes Mix 720.60

Gauge No.	Standard Count	Theoretical or Laboratory Density	Core Correction	Percent Required Density
21292	2787	153.8	0.8	88.0

Lot No. 1 From Sta. 157+50 To Sta. 93+50 Lin. M (ft.) 6400' Width 10' Lift 2 Lane A

Test No.	Sta. No.	Location	Den. Count	Den kg/m3 (lb/ft3)	Corrected Density	% Density
1	150+26	15' L	759	140.0	140.8	91.5
2	133+17	18' L	731	142.6	143.4	93.2
3	125+88	21' L	752	140.8	141.6	92.1
4	118+23	15' L	758	140.2	141.0	91.7
5	104+02	18' L	745	141.3	142.1	92.4

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Density

Density is a measurement of MASS divided by VOLUME…

$$Mass/Volume$$

or

How much something weighs

vs.

How much space it takes up.

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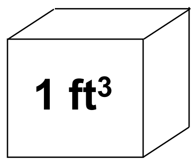
Density

1 cubic foot of water weighs 62.4 lbs. In other words…



The *density* of water is <u>62.4lbs/ft^3</u>.

(or 1gram/cm^3)

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Density vs Specific Gravity

- ***Specific gravity* is the density of a substance divided by the density of water.**
- **Since water has a density of 1 gram/cm^3, and since all of the units cancel …**
- **…the specific gravity of water is 1.**

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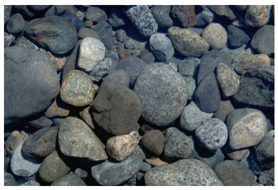
Density vs Specific Gravity



If an aggregate has a specific gravity of 2.540…

…then we know that it's density is *2.540 times* that of water.

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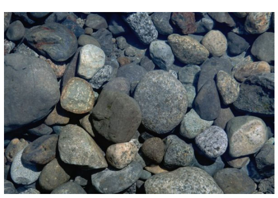
Density vs Specific Gravity



If an aggregate has a specific gravity of 2.540…

…then what is its density in lb/ft^3?

…g/cm^3?

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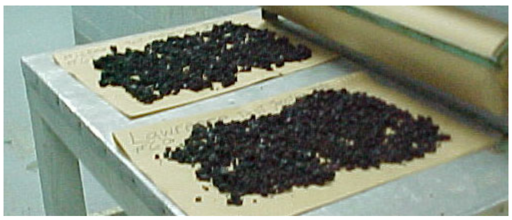
HMA Specific Gravities

- Maximum (theoretical) Gravity
  - Symbolized by G_{mm}
  - Also called “Rice” Gravity
  - Found on the **Job Mix Formula (JMF)**
  - Determined using cooled, loose mix



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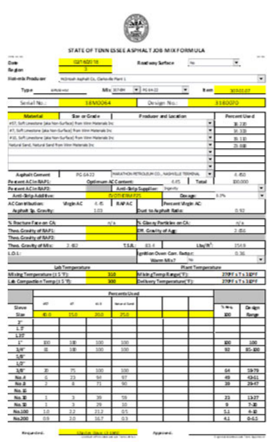
JMF



Type BPMB-HM Mix 307-BM PG 64-22 Item 307-01.07

Serial No.:	18M0064	Design No.:	3180070

Material	Size or Grade	Producer and Location	Percent Used
#57, Soft Limestone (aka Non-Surface) from Winn Materials Inc			38.220
#7, Soft Limestone (aka Non-Surface) from Winn Materials Inc			14.333
#10, Soft Limestone (aka Non-Surface) from Winn Materials Inc			19.110
Natural Sand, Natural Sand from Winn Materials Inc			23.888
Asphalt Cement	PG 64-22	MARATHON PETROLEUM CO., NASHVILLE TERMINAL	4.450

Percent AC in RAP1:		Optimum AC Content:	4.45	Total	100.000
Percent AC in RAP2:		Anti-Strip Supplier:	Ingevity		
Anti-Strip Additive:	EVOTHERM P25	Dosage:	0.3%		
AC Contribution:	Virgin AC	4.45	RAP AC		Percent Virgin AC:
Asphalt Sp. Gravity:	1.03	Dust to Asphalt Ratio:	0.92		

% Fracture Face on CA:	n/a	% Glassy Particles on CA:	n/a
Theo.Gravity of RAP1:		Eff. Gravity of Agg:	2.656
Theo.Gravity of RAP2:			
Theo. Gravity of Mix: 2.482	T.S.R.: 83.4	Lbs/Ft^3:	154.9
L.O.I.:		Ignition Oven Corr. Factor:	0.36
		Warm Mix?	No

Lab Temperature		Plant Temperature	
Mixing Temperature (± 5 °F):	310	Mixing Temp Range(°F):	270ºF ≤ T ≤ 310ºF
Lab Compaction Temp (± 5 °F):	300	Delivery Temperature(°F):	270ºF ≤ T ≤ 310ºF

	Percents Used								
Sieve	#57	#7	#10	Natural Sand				% Req.	Design
Size	40.0	15.0	20.0	25.0				100	Range
2"									
1.5"									
1.25"									
1"	100	100	100	100				100	100
3/4"	81	100	100	100				92	85-100
5/8"									
1/2"									
3/8"	20	75	100	100				64	59-79
No.4	6	23	94	97				49	42-61
No.8	2	8	71	90				39	29-47
No.16									
No.30	1	3	39	59				23	13-27
No.50	1	3	29	10				9	7-20
No.100	1.0	2.2	21.2	0.5				5.1	4-10
No.200	0.9	2.0	16.7	0.3				4.1	0-6.5

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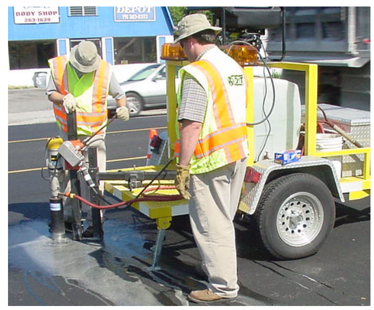
HMA Specific Gravities

- Bulk Gravity
  - Symbolized by G_{mb}
  - Can be determined by testing cores cut from roadway



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HMA Specific Gravities

- Bulk Gravity
  - Symbolized by G_{mb}
  - …or with a corrected nuclear density gauge

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Field Density

- By comparing the Maximum gravity to a specimen's Bulk gravity, we can determine it's level of compaction (field) density.
- The greater the field density, the fewer the air voids.

- % Density = (Bulk density / Max density) * (100)

OR

- % Density = (Gmb / Gmm) * (100)

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Field Density Example

A density test indicates a bulk density of 148 lb/ft^3. The maximum theoretical density from the job mix formula is 160 lb/ft^3.

- % Density = (Bulk density / Max density) * (100)

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Field Density Example

What would we need to do if we got the bulk as a density (lb/ft^3) and the maximum as a specific gravity (i.e. 2.600)?

- Assuming Gmb is 145 lbs/ft^3

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Acceptance Testing

QA testing done to decide whether to allow material to be used at all; or if used, to determine if full payment is due. For HMA there are six (sometimes seven)

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Acceptance Testing

Property	Criteria	Who Tests	Decision
Gradation	Meets JMF?	Plant Tech	Pay Factor
Asphalt Content	Meets JMF?	Plant Tech	Pay Factor
Temperature	Meets 407.11	Plant Tech and Roadway Insp.	Place/Reject
Aggregate Coating	100% Coated	Plant Tech and Roadway Insp.	Place/Reject
Aggregate Segregation	Not Segregated	Plant Tech and Roadway Insp.	Place/Reject
Density	Meets 407.15	Nuclear Gauge Operator	Pay Factor
Smoothness*	Meets SP411B/C	Materials & Tests	Pay Factor

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* Only if SP411B or SP411C is included

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Acceptance of the Mixture 407.20

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/low temperature.

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Acceptance of the Mixture

407.20.B.2.a Consider the Engineer's decision to be final as to the acceptance, rejection or acceptance at an adjusted payment of the lots.

407.20.B.2.b Remove and replace, at no cost to the Department, nonconforming lots of material, products, or compete 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.

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Acceptance for Mix Density on the Roadway 407.20

The Department will apply a deduction in payment, not as a penalty but as liquidated damages, for failure to meet the density requirements as 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.

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Density Requirements Section 407.15

Mix Type	ADT	% of Theoretical (Average)	No Single Test less than
A, B, BM, BM2, C, D, E, Thin Lifts>1”	1000 or Less	90	87
	1000-3000	91	89
	>3000	92	90
CW	<1000	88	85
D, E Shoulder	Any	88	85
AS, ACRL, CS, TL, TLD, TLE, OGFC	Any	None*	None*

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Acceptance for Mix Density on the Roadway 407.20

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. <u>The percent of total payment to be deducted shall be 5 times the percent in-place density for each lot that fails to meet **407.15**</u>

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What does 'No single test less than' mean?

407.15.B

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…

Repair or replace defective mixture to the satisfaction of the Engineer at no cost to the Department.

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Acceptance for Mix Density on the Roadway 407.20

407.20 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 407.15-2.

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What if there is less than 1000 Tons left?

407.20 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.

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Acceptance for Mix Density on the Roadway 407.20

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.

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Small Quantity Exception

407.20.B

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… other tests deemed necessary for acceptance purposes.

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QA Cores for Acceptance

407.20

"For projects with total tonnage per mix type less than 2,000 tons (not including small quantity jobs as defined in 407.20.B.1) the department may alternatively calculate in place density by cores (AASHTO T-166), in this case no cores will be taken for gauge correlation on the test strip."

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11.

Special Topics

Special Topics

1

Special Topics

- Intelligent Compaction
- OGFC

2

Intelligent Compaction

- Make sure contractors have the equipment on SP407IC Jobs
  - Required GPS, Heat Sensor, Display and Data Recorder
  - Must have for Breakdown and Intermediate Rollers

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Intelligent Compaction

Courtesy: Sakai America

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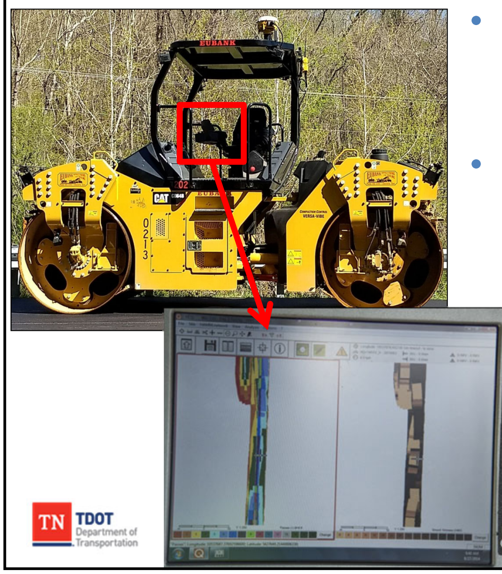
Intelligent Compaction



- Verify that they have established connection with a GPS network
- If equipment stops working for any reason:
  - Allow contractor to finish the paving for the day.
  - Require contractor to fix system prior to resuming work after.

5

2021 Density Summary

- Over 1000 Lots of Density Measurements with Intelligent Compaction
- Only ≈1% of Lots had a Deduction

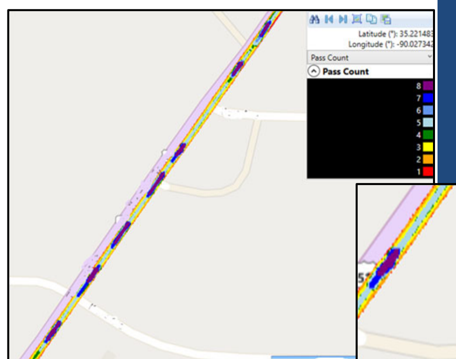
Year	Avg Density	Standard Deviation
2018 (No IC)	93.0 %	1.94
2018 (With IC)	93.8%	1.53
2021 (With IC)	93.6%	0.84

6

IC Examples

High Deviation Lot

Low Deviation Lot



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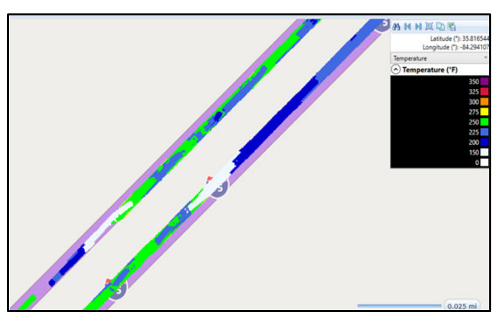
7

2021 IC Examples

- Ensure both sensors on each roller are accurate
- View per roller for better data

Temperature Measurement



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OGFC Best Practices Guide

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9

Overview

- Project Preparation and Specs
- Mix Production/Delivery
- Paving and Rolling
- Extra Consideration

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Seasonal/Temp Limitations

- Paving Season
  - April 1 to November 1
- Surface **AND** Air Temperature minimum 55°F and rising
  - Mix cools quickly after placement due to openness, surface area, and thickness.
  - Paving below 55°F has proven to lead to raveling of the mix.

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Balancing Production

- OGFC cools down quickly so that mix production and delivery must be balanced with lay down and compaction to ensure a smooth operation and a high quality mat.
- Haul trucks: Adequate numbers
- Before you begin paving, calculate an ideal paver speed and continuously check and maintain it.
- Remember, balance of all the production rates is the key to quality OGFC pavement.

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Mixture Delivery

- Delivery times for OGFC should be as short as possible. And preferably less than 1 hour to prevent drain down and maintain temperature.
- To keep mix temperature high, allow tarp to drape close to mix to minimize air between the mix and the tarp.
- Mix must be a min of 280F on arrival.

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Placement

- OGFC tends to be stickier than other mixes. Care should be taken to ensure that the mat is not torn by the paver.
- The screed heater should be turned on to help prevent pulling of the mix.

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Handworking

- OGFC is difficult to effectively handwork. Minimize/refrain from luting if possible.
- Luting/raking will result in a poor finished surface and eventual raveling.
- If rough spots are appearing on mat check to make sure screed heater is working properly rather than handworking.

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Handworking

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Compaction (407.15)

- Minimum of 2 rollers, each 10 ton (min.) static
- No test strip required
- No pneumatic rollers & No vibratory mode
- Breakdown roller to begin rolling approximately 50' from paver, or as soon as practical without picking up material.
- Apply an approved release agent to water in steel drum roller is recommended.

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Compaction (407.15)

- Minimum rolling is two passes with a steel double drum roller before the temperature of the mix falls below 185°F.
- Do not over roll the mat, no more than 4 passes is recommended.
- The goal is to achieve interlock of the aggregates while leaving open voids
- If rollers must idle, remove from the hot mat if at all possible.

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EXTRA CONSIDERATION

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Ponding and Drainage

- C/CW or other impermeable mix is placed below OGFC so that the water is allowed to drain.
  - Important to get proper cross slope (2% min.) for drainage
- Careful attention to OGFC and 411D tie-in
  - Tie-ins need to be avoided in areas where water will have drainage issues (OGFC placed upslope of 411D)

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Shoulder Drainage

- Very important to ensure OGFC layer is day-lighted so that water may drain from the roadway.
- Ponded water may become a safety hazard and will ultimately damage the pavement
- Recommended to either:
  - Clip shoulders prior to paving
  - Only partially pave the shoulder with OGFC

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Shoulder Drainage

Clipping the shoulder with a motor grader

Shoulder only partially overlaid with OGFC

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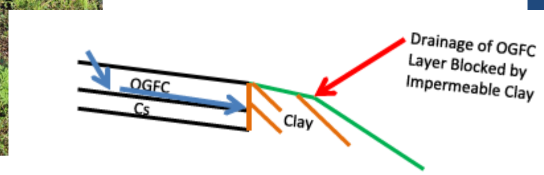
Shoulder Drainage

- On full width paved shoulders: If shoulders aren't clipped, water will stay in the layer leading premature failures.



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Poor Drainage Problems

Poor drainage may cause:

Saturated subbase that pumps, causing expensive base failures

Saturated base/binder layers that strip

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Paving at Ramps

- When paving around ramps, the top of the CS mix needs to be placed evenly with the ramp at joint of other tie in so that the water can drain out of the OGFC.
- OGFC has been used to fully overlay concrete pavement, placing OGFC across the full width of the ramp is an option.

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Ponding at Ramp

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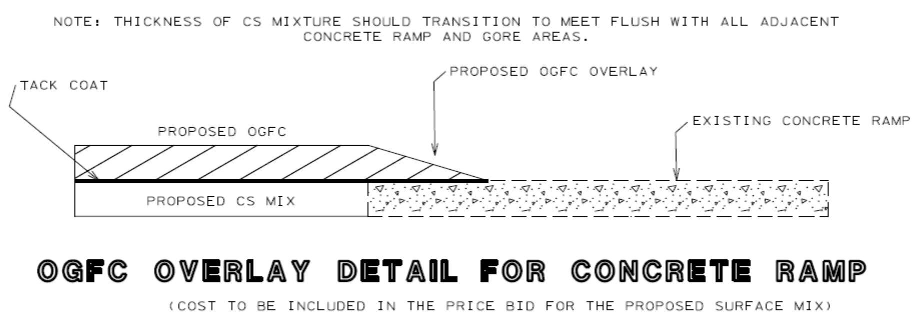
Solution: Ponding at Ramps



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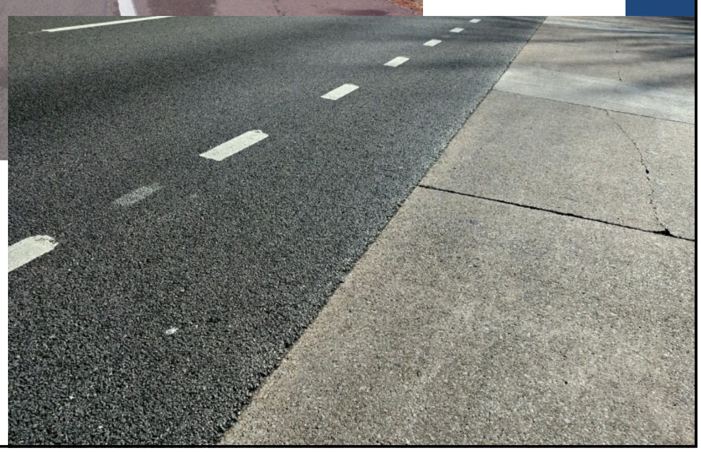

Ramp partially overlaid

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Bridge Tie-ins

- Expansion joints may require additional work, will be dependent on a case by case basis.
- Bridge ends are hard to tie into which sometimes requires hand work.
  - Since OGFC is hard to lute, there are still some issues with getting a smooth transition.
- Some Regions prefer to place D mix at bridge approaches on otherwise OGFC jobs to avoid these issues.

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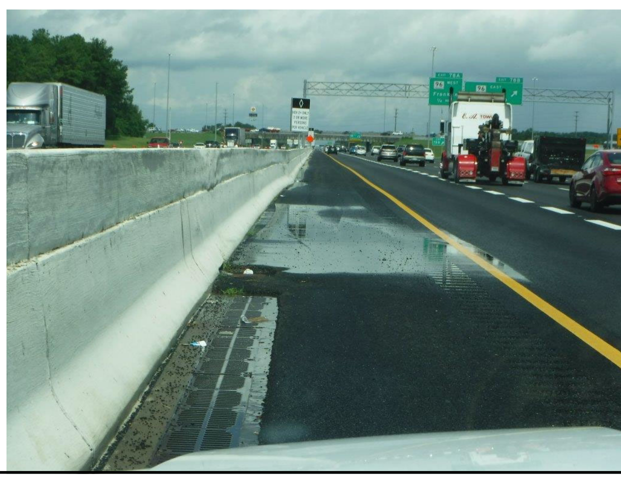
Paving at Drains

- When paving around drains, the bottom of the OGFC layer needs to be left higher than the drains, so that water does not pond.



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Paving at Drains

- Alternatively, OGFC may be day-lighted on the shoulder which allows water to reach the inlet.

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Opening to Traffic

- After Compaction, wait until the pavement temperature gets down to about 110°F-120°F prior to opening to traffic to keep from picking up any of the surface material. When paving during time restrictions, this needs to be accounted for.

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12.

Course Review

Tack Coat Application Rate (Sec. 403)

- Tack truck initially reads 520 gallons.
- Tack truck reads 300 gallons after the application.
- The tack was applied on 12' lanes on 2,000' of roadway.
- The pavement was milled for the project.

- What is the application rate?
- Does it pass TDOT specifications?

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1

- Initial Reading on Tack Truck: 520 gallons
- Final Reading on Tack Truck: 300 gallons
- Tack applied to 2,000' of a 12' wide lane
- Roadway Surface is milled

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2

Spread Rate Calculation

- 500 tons of hot mix is delivered to the project for this section of roadway.
- The paver traveled 6,336’ during placement.
- Assume that the lanes are 11’ wide the entire project length.

- What is the spread rate?

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3

- 500 tons of hot mix is delivered to the project for this section.
- The paver traveled 6,336’ during placement.
- Assume that the lanes are 11’ wide the entire project length.

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4

Density Requirements (Sec. 407)

- The Gmm on the job mix formula for 411-D mix is 2.411.
- The roadway technician places a gauge at the sample location and reads a density of 140.1 lbs/cubic feet.
- Average daily traffic (ADT) is greater than 3,000.

- <u>What is the percent density of the sampled location?</u>
- <u>Does it meet TDOT specifications?</u>

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5

- The Gmm on the job mix formula for 411-D mix is 2.411.
- The roadway technician places a gauge at the sample location and reads a density of 140.1 lbs/cubic feet.
- Average daily traffic (ADT) is greater than 3,000.

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Average Density for the Lot

- Five equal sublots have density readings as follows:
  - 90.7%, 92.6%, 93.6%, 91.9%, 91.7%
- Assuming that the ADT exceeds 3,000, do each of the five sublots meet the density requirement? What is the average density for the entire lot and does it meet spec?

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Milling Speed (Sec. 415)

- The roadway technician walked beside the milling machine for 3 minutes once the machine got up to speed.
- The distance traveled during this time was 175 feet.
- What is the speed of the milling machine in feet/minute?

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13.

Appendix

TDOT Standard Operating Procedures, Specifications, Supplemental Specifications, Special Provisions, & Circular Letters

Standard Operating Procedures

TDOT Specifications

Supplemental Specifications

Special Provisions

Circular Letters

Best Practice Guides

TDOT Forms

October 31, 2022
June 1, 2023
November 9, 2023

Tennessee Department of Transportation
Division of Materials and Tests

Quality Assurance Program for the Sampling and Testing 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: Federal Law (23 CFR 637) requires each state develop a quality assurance program which assures all materials, on projects where Federal Funds 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 approved materials.

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

A. Testing before product placement (e.g. hot mix asphalt, Portland cement concrete, base materials, pre-packaged concrete mixture).

B. Manufacturers' certifications followed by random verification testing (e.g. grey iron castings, cement, liquid asphalt).

C. Producer List pre-approval and testing of a product or its components (e.g. aggregate quality, reinforced concrete pipe, corrugated metal pipe).

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

Sampling and Testing Materials and Products

1. Test Types

There are three basic types of sampling and tests routinely conducted: acceptance, verification, and assurance. All testing shall be performed by a certified technician.

1.1 Acceptance Sampling and Testing

These tests are conducted to approve or accept a product, or combination of materials (systems), by comparing the test results to specification requirements. Acceptance tests are based on a lot or frequency, during the production and/or placement of that product, to ensure specification compliance. There are products that are sampled, tested, and accepted at the manufacturer's facility and then delivered to TDOT projects for use.

1.2 Verification Sampling and Testing

These tests are conducted to verify/validate that products accepted by manufacturers' certifications are in compliance with the applicable Tennessee Department of Transportation Standard Specifications for Road and Bridge Construction TDOT Standard Specifications). In accordance with Federal Law (23 CFR 637), "The verification sampling shall be performed on samples that are taken independently of the quality control samples."

1.3 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. Further guidance is provided within SOP 1-2: Independent Assurance Program.

2. Material Certifications

2.1 All materials accepted on certification must have a Material Certification and/or Sampling Testing Record DT-0044 (T-2) form, completed by the Contractor, showing contract number, project number, county, item number, quantity of material being accepted, etc. Attach the T-2 form to the manufacturer's certification and forward to the Materials and Tests (M&T) Supervisor. The Manufacturer's certification shall state that materials have been tested and inspected and that the manufacturer certifies that TDOT Standard Specifications have been met. The Manufacturer's certification shall contain at a minimum the manufacturer's name, contact information, and specifications that the material meets.

2.2 The manufacturer's certification may not be project specific (i.e. it will not have the contract or project number on the certification). When this occurs, <u>do not</u> write the contract or project number on the certification. Instead, require the contractor to complete, and have notarized, a T-2 form, and attach the 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.

2.3 Any material that is on the Department's QPL may be accepted by a certification, unless otherwise noted, from the manufacturer stating that the material furnished to the project is the same as the material evaluated for the QPL. The Contractor shall forward the certification and a T-2 form to the Project Supervisor for review.

2.4 It is the project personnel's responsibility to provide the final inspection on all material. If for any reason the material is suspect, it should not be used until further evaluation is conducted. Contact the M&T Supervisor for further evaluation(s).

2.5 All manufacturers' certifications must be signed; however, for seed, sod, and nursery materials, the Tennessee Department of Agriculture will provide the certification. Any certification that is not project specific shall be notarized.

2.6 Miscellaneous materials used on special projects (e.g., rest areas) that are overseen by an architect or consulting engineer for the Architecture Department may be accepted by a blanket certification stating that all materials meet specification requirements.

2.7 Material (e.g., tack) transfer shall be completed by the contractor and sent to the Project Supervisor(s) overseeing the projects. The project office(s) will verify that the quantity of material is available for transfer. The contractor shall complete the T-2 form and transfer request with all of the project information needed including applicable bill of lading and the material certification.

2.8 At completion of the project, the Project Supervisor must submit a signed Materials and Tests Certification (DT-1696) form to Regional Operations and the Regional M&T Supervisor(s). The form shall then be forwarded to the Headquarters (HQ) M&T.

2.9 The Contractor shall forward ALL certifications and T-2 forms to the Project Supervisor for review. The Project Supervisor will forward to Regional M&T for review and copies will be forwarded to HQ M&T as necessary.

3. Buy America Certifications

All iron and steel and applicable construction products **shall** meet TDOT Special Provision 106A/106BA, Special Provision Regarding Buy America Requirements, as set forth in the contract.

4. Using the Tables

4.1 There are four parts to this procedure; each part has a specific purpose and must be checked for any material to be put in use. **If field personnel are unsure as to how a material is accepted, they need to contact their M&T representative for clarification to assure that acceptable material is utilized on projects.**

<u>Part 1</u> - <u>Sampling and Testing Guide</u> is a field guide that lists the materials that are accepted based off certification or QPL listing, by acceptance tests, and/or verification tests.

<u>Part 2</u> - <u>Acceptance Sampling and Testing Schedule</u> lists construction materials, test(s) to be performed, who takes the sample, how frequently a sample is taken, and where to take the sample.

<u>Part 3</u> - <u>Verification Sampling and Testing Schedule</u> gives the details for verification test requirements. All verification samples must be submitted for testing within two weeks of the sample date.

<u>Part 4</u> - <u>Using Random Numbers for Sampling and Testing</u> will help personnel choose random and representative test locations when performing tests using random number tables, calculators, spreadsheet program, etc.

4.2 Any reference to sampling by M&T refers to TDOT Regional M&T, and HQ M&T refers to TDOT Headquarters M&T.

4.3 Project Inspector references TDOT personnel performing project inspection or, for projects that include Federal Funds constructed under the oversight of TDOT (Local Programs, Grants, etc.), the Agency's Construction Engineering Inspection (CEI) or certified sampling and testing technician assigned by the Department.

4.4 **All samples** should be taken at random test locations (see Part 4).

5. Useful Links

5.1. M&T Forms

All required DT Forms mentioned in Part 1 can be found here.

5.2. QPL

Materials with a QPL requirement as shown in Part 1 are listed here along with all requirements a product must meet to be on the QPL.

5.3. Producer List

Producers of these materials must be approved **prior to use**. All requirements to be on the Producer List are available at the link provided.

5.4. TDOT Specifications & Special Provisions

5.5. TDOT Standard Operating Procedures

All required Standard Operating Procedures can be found here.

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Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
AGGREGATE PRODUCTS *Required Paperwork:* Project Inspector is responsible for requesting a Fine and Coarse Aggregate Inspection Report (DT-0275) form from M&T for each size or type of aggregate before material is shipped to the job site. When applicable, contact M&T to ensure proctors have been performed.			
General Aggregate (e.g., Underdrains) 903 Gradation testing and quality samples will be taken at a point in production which ensures that representative sampling and testing occurs. Rip-Rap from a Quarry: M&T will issue test reports for quality and quantity only. The Project Inspector is responsible for size at time of placement. Rip-Rap from a Job Site: The Project Inspector will notify M&T so that a quality sample may be obtained and a Coarse Aggregate Quality Report (DT-0320) form issued. The Project Inspector will be responsible for size at time of placement.		X	
Aggregate-Cement Base: 309 *Additional Paperwork:* Project Inspector will complete a Daily Report on Soil and Aggregate Stabilization (DT-0298) form.		X	X
Aggregate - Lime - Fly Ash Stabilized Base: 312 *Additional Paperwork:* Project Inspector will complete a Daily Report on Aggregate-Fly Ash Stabilization (DT-1411) form.		X	X
Borrow Excavation (Solid Rock)/(Graded Solid Rock): 203, SOP 2-2 *Additional Paperwork:* The Project Inspector will notify M&T so that a quality sample may be obtained and a Coarse Aggregate Quality Report (DT-0320) form issued. The contractor shall submit a certified letter stating the material does not contain acid producing material.			X
Granular Backfill: 204.06 *Additional Paperwork:* Project Inspector will complete a Density Worksheet – Nuclear Method (DT-0314) form.		X	
Mineral Aggregate Base: 303 *Additional Paperwork:* Project Inspector will complete a Daily Report on Mineral Aggregate Base (DT-0307) form for Type A and Type B aggregate.		X	X
AGRICULTURAL LIMESTONE: 918.04 *Required Paperwork:* The Contractor shall provide an invoice and documentation that the agricultural limestone meets the Department of Agriculture Tennessee Liming Materials Act.	X		

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
ASPHALT (GENERAL) Before taking samples of asphalt cement (A.C.) and emulsion, a one-gallon minimum shall be discarded to flush the sampling pipe of possible contaminants. All precautions must be taken to avoid sample contamination.			
Asphalt Aggregate: 903 *Required Paperwork:* The TDOT Plant Inspector will complete the Daily Report from the workbook.		X	X
Asphalt Cement: 904.01 *Required Paperwork:* Each shipment from the asphalt terminal shall be accompanied by a completed (DT-0293 PG) form. Terminal Samples: Refer to SOP 3-1. Contract Samples: All samples from asphalt plants shall be taken from the sampling valve on storage tanks and not from transport units. Samples taken, from projects utilizing liquid anti-stripping additives (ASA), should either contain ASA or be accompanied by an ASA sample.	X		X
Asphalt Emulsion: 904.03 *Required Paperwork:* Each shipment from the asphalt terminal shall be accompanied by a completed (DT-0293 Emulsion) form. Terminal Samples: Refer to SOP 3-2. Contract Samples: Refer to Sampling Asphalt Emulsions (pdf) and Sampling Asphalt Emulsions (pptx) for detailed sampling guidance. Field samples of emulsion shall be taken from sample valves, not distributor spray bars. For field samples, sieve test results < 0.3 will be considered passing. Field samples with sieve results > 0.3 will be evaluated on a case by case basis by the M&T Supervisor and the State Bituminous Engineer to determine if the sample passes or fails. For failing sieve test results, the Project Supervisor shall make a note as to whether or not an acceptable uniform spread was achieved.	X		X
Asphalt Mix: 407 *Required Paperwork:* When required, the Project Inspector will complete a Daily Asphalt Density Report (DT-0315) form.		X	X

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
BOLT AND NUT ASSEMBLIES FOR HIGH STRENGTH STEEL STRUCTURES: 908.04 & 602.17.E The manufacturer/distributor shall furnish, for each heat number and/or assembly lot number, a mill test report, and/or a manufacturer/distributor certified test report. TDOT will issue a lab reference number for each manufacturer/distributor submittal. *Additional Paperwork:* Shipments to the project shall be accompanied by a copy of the TDOT lab reference number identifying each heat/lot number. Project Inspector will complete a Rotational Capacity Test (MT-0328) form.	X		X
BRICK (CLAY OR SHALE, CONCRETE, SEWER): 912 *Additional Paperwork:* All brick shall be certified with test reports by the manufacturer stating that specification requirements are met. The Contractor shall submit the certifications and list the type of brick on T-2 form.	X		X
BRIDGE DECK SEALS (MEMBRANES): 906.01	QPL 2		
BRIDGE PAINT	QPL 3		X
CALCIUM CHLORIDE: 921.02 *Required Paperwork:* The Contractor shall provide a completed Report on Sample of Calcium Chloride (DT-0325).	X		
CONCRETE (GENERAL) *Required Paperwork:* The Project Inspector will complete a sample record in SiteManager for each set of cylinders. Cylinders made for Class CP concrete shall be two (2) 6”x12” cylinders. Cylinders for all other concrete shall be two (2) 4”x8” cylinders. Perform all field tests using the same sample. Refer to SOP 4-4 for submittal and approval of concrete mixtures.			
Aggregate: 903.01 & 903.03 *Additional Paperwork:* The Project Inspector will check the Contractor’s Daily Report of Concrete Inspection (DT-0311) form that is completed by the contractor's certified Concrete Field Testing Technician to ensure that gradation, wash, and Fineness Modulus (FM) requirements are met and tests are performed in accordance with the approved process control plan.			X

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
Cast in Place (e.g., drainage structures) *Additional Paperwork:* The contractor shall provide a Contractor's Daily Report of Concrete Inspection (DT-0311) form and a T-2 form that includes: each structure item number, type of structure, Standard Drawing Number, and the code number per structure. Contractor certification(s), stating that the item number was constructed in accordance with the Standard Drawing(s) and specifications, and mill certification(s) shall be attached. Cubic yards of concrete and reinforcing steel shall be identified per structure as incidental items.	X		
Cement, Fly Ash, & Slag Cement: 901.01, 921.15, & 921.16	X		X
Chemical Admixture: 921.06	QPL 4		
Closure Pour	QPL 43	X	
Coatings, Curing Compounds (White or Clear): 604.21 & 913.05	QPL 12		
Flowable Fill: 204.06 *Additional Paperwork:* The producer shall furnish a Contractor's Daily Report of Concrete Inspection (DT-0311) form per day's production.		X	
Grout: 921.09 & SOP 4-4 *Additional Paperwork:* The producer shall furnish a Contractor's Daily Report of Concrete Inspection (DT-0311) form per day's production.			
Non-Structural Grout The producer will furnish a mix design to the Project Supervisor. The mix design will be reviewed and approved according to SOP 4-4.	X		
Structural Grout If the grout has a strength requirement, a mix design shall be submitted to Materials and Tests.		X	
Patching Material	QPL 13		
Non-Structural Patching Material The producer will furnish a mix design to the Project Supervisor. The mix design will be reviewed and approved by M&T. OR a QPL 13 item may be used in place of a mix design approval.	X		
Structural Patching Material If the patching material has a strength requirement, a mix design shall be submitted to M&T OR a QPL 13 item, meeting strength requirements stated in the contract plans, and extended with aggregate in accordance		X	

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Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
with the manufacturer's recommendations, may be used in place of mix design approval.			
Pre-Packaged Grout	QPL 16		
Pre-Packaged Concrete Mixture: 604.03	QPL 15	X	
Precast Products: SOP 5-3 & Reinforced Concrete Facing Panels *Additional Paperwork:* Each shipment shall be accompanied with a producer's certification.	X	X	X
Sound Absorbing Noise Walls: SP 718NB & Noise Walls *Additional Paperwork:* Each shipment shall be accompanied with a producer's certification.	X	X	
Prestressed Products: 615, SOP 5-4 *Additional Paperwork:* Beams and piling will be stamped by Regional M&T and include Report on Precast or Prestressed Concrete (DT-0289)(SiteManager M022) form.	X	X	X
Ready Mix: 501 & 604 *Additional Paperwork:* The producer shall furnish a Contractor's Daily Report of Concrete Inspection (DT-0311) form per day's production.		X	
Concrete Paving: 501 & 604 *Additional Paperwork:* The producer shall furnish a Contractor's Daily Report of Concrete Inspection (DT-0292) form per day's production.		X	
Volumetric Mix: 501 & 604 *Additional Paperwork:* The producer shall furnish a Contractor's Daily Report of Concrete Inspection (DT-0311) form per day's production.		X	
Performance Engineered Mixture (PEM) Ready Mix: 604, SOP 4-4 *Additional Paperwork:* The producer shall furnish a Contractor's Daily Report of Concrete Inspection (DT-0311) form per day's production.		X	X
Shotcrete: 622 *Additional Paperwork:* The producer/contractor shall furnish third party test results indicating compressive strength (28-day) and boiled water absorption results.		X	
CORRUGATED METAL PIPE (CMP): 915.02 *Required Paperwork:*		X	X

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
Certified mill test report and galvanization report shall accompany sample. Approved pipe will be stenciled "TDOT" and reported on Inspection of Corrugated Metal Pipe (DT-0280) form by M&T. The Producer shall notify the M&T prior to shipping.			
EARTH RETAINING STRUCTURES: SP 624	X	X	X
ELECTRICAL ITEMS/ITS COMPONENTS/LIGHTING/TRAFFIC SIGNALS: 730 *Additional Paperwork:* The Contractor shall submit a certificate of compliance and certifications stating that all materials meet TDOT specifications with a T-2 form including all final quantities. In addition, the Contractor shall also provide an approval letter from the owner/maintaining agency stating acceptance of the completed system. For temporary traffic signal systems, the Contractor shall furnish certifications stating that all materials furnished meet Standard Specifications.	X		
EROSION CONTROL ITEMS: 209	QPL 17		
FENCING MATERIALS: 909 *Additional Paperwork:* The Contractor shall furnish certifications citing all applicable ASTM or AASHTO Specifications.	X		X
FIBER EXPANSION JOINT MATERIALS	QPL 5		
FLEXIBLE SURFACE & GROUND MOUNTED DELINEATOR POST	QPL 1		
GEOTEXTILES: 740, 921.12 Each unique geotextile shall be marked with a legible print showing, as a minimum, the manufacturing plant (or manufacturing plant ID code numbers). This marking shall be located on the roll edge of the product at a frequency of once per 5 meters (16.4 feet). The marking shall be unique for each manufacturer and manufacturing plant facility.	QPL 36 OR QPL 17	X	
GRAY IRON CASTINGS: 908.07 *Additional Paperwork:* The manufacturer shall provide notarized certification(s) of material, including quantity, item, weight, and heat date, signed by the manufacturer stating compliance with Standard Specifications and Standard Drawings.	X	X	X

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
Castings to be incorporated into the work shall be accompanied with a certified mill test report that includes: the heat number or ID, description of the casting (including TDOT Standard Drawing Number), the weight of each casting, and the number cast from each ID. All castings shall have a traceable ID number cast into the product.			
GUARDRAIL, POSTS, BLOCKS, BOLTS, WASHERS, ETC Refer to **SOP 6-1** (**Procedures and Qualifications for Guardrail Manufacturer and Supplier**).	X		
GUARDRAIL END TERMINAL: 705	QPL 34 OR QPL 45		
HIGHWAY SIGNING (PERMANENT): 713 The manufacturer's identification markings must be on back of each sign. *Additional Paperwork:* The Contractor shall provide mill test reports on all materials and certifications from the manufacturer showing project information and quantities. All sign supports shall have a certified mill test report and a galvanization report submitted.	X OR QPL 33		
HIGHWAY SIGNING MATERIALS (REFLECTIVE SHEETING): 916	QPL 10		
HYDRATED LIME: 921.04	X		
IMPACT ATTENUATOR Additional Paperwork: The Contractor shall provide shop drawings and certification to the Project Supervisor for review prior to delivery.	QPL 34 OR QPL 45		
JOINT SEALANT (NON-FIBER)	QPL 5		

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
LANDSCAPING MATERIALS			
Commercial Fertilizer: 918.02 *Additional Paperwork:* The Contractor shall provide invoices.	X		
Hay, Straw (baled plant material) *Additional Paperwork:* If shipped from an Imported Fire Ant (IFA) quarantine area in Tennessee, shall be accompanied by a permit from the Tennessee Department of Agriculture or other appropriate regulatory agency; the permit must state the location from which the materials originated and that the material has been inspected and found to be free of IFA. A permit is not required when shipping these materials from a non-quarantine area. The Tennessee Department of Agriculture website has county-by-county information of quarantine areas. (https://www.tn.gov/agriculture/businesses/plants/plant-pests--diseases-and-quarantines/ifa.html)	X		
Seed, Grass: 918.01 *Additional Paperwork:* The Contractor shall provide a Report on Sample of Grass Seed and Grass Seed Certification (DT-0333) form from the producer. Each bag will be labeled in accordance with Section 43-10-106 of the Tennessee Seed Law of 1986.	X		
Sod: 803 *Additional Paperwork:* The Contractor shall provide a copy of the Department of Agriculture authorization prior to removing the sod. Nursery certificates do not indicate that sod is certified.	X		
Trees and Shrubs: 802.02 *Additional Paperwork:* Before performing any work, the Contractor shall provide a nursery dealer's certificate with each shipment of plants. When the project is complete, the Contractor shall submit certifications.	X		

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
PAVEMENT MARKERS (RAISED & SNOWPLOWABLE), THERMOPLASTIC ALTERNATES, PREFORMED TAPE: 716 *Additional Paperwork:* The Contractor shall provide a Daily Pavement Marking (DT-1296) form on the marking materials/tape used. The Project Inspector will verify quantities, sign the daily form, and submit the form to the M&T office weekly. At completion, the marking contractor shall provide a T-2 form listing quantities of marking materials used for each pay item, colors' batch numbers, and QPL numbers used on the project.	QPL 1		
PAVEMENT MARKINGS (PAINT, THERMOPLASTIC, & BEADS): 716 *Additional Paperwork:* The Contractor shall provide a Daily Pavement Marking (DT-1296) form on the marking materials/ beads used. The Project Inspector will verify quantities and thicknesses, sign the daily form, and submit the form to the M&T office weekly. At completion, the marking contractor shall provide a T-2 form listing quantities of marking materials and beads used for each pay item, colors' batch numbers, and lab reference numbers used on the project. Samples shall be submitted to M&T by the manufacturer to obtain lab reference numbers.	X OR QPL 1		X
PVC / HDPE / SRTRP / PP PIPE: 914 *Additional Paperwork:* The Contractor shall provide certifications of compliance from the producer or manufacturer of all plastic pipe and tubing.	X		
SOIL *Required Paperwork:* Project Inspector will submit a Proctor Density Report (DT-0332) form along with the sample. Densities shall be reported on Density Worksheet – Nuclear Method (DT-0314) form.			
Embankment & Subgrade: 205, 207 *Additional Paperwork:* Project Inspector will complete a Daily Report on Embankment (DT-0304) form.		X	
Soil-Lime Subgrade Treatment: 302		X	
Soil-Cement Base: 304 *Additional Paperwork:* Project Inspector will complete a Daily Report on Soil and Aggregate Stabilization (DT-0298) form		X	X
STEEL Assembly to be in accordance with project drawings.			
Dowel & Tie Bars: 907.02	X		

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
Steel Reinforcement (black bar & epoxy coated): 907.01 *Additional Paperwork:* Each shipment shall consist of a certified mill test report including size and heat number of the bars furnished along with a report listing contract number, size, heat number, and quantity of bar. For epoxy coated bar, an additional certificate of compliance for the coating along with a daily coating manufacturing worksheet is required.	X		X
Steel Structures: 908.01 *Additional Paperwork:* All steel structure items (lump sum) shall have Structural Steel Shop Inspection Reports approved by TDOT M&T Division. The item numbers on the report must match the item numbers on the steel at the project site.	X		
Welded Wire Mesh (precast): 907.03 *Additional Paperwork:* The Contractor shall provide a certified mill test report. Additional certification and independent lab results are required for drawn down wire.	X		X
Strands (prestressed): 907.04 *Additional Paperwork:* Each shipment must have stress/strain curves and manufacturer's certification. Each reel or pack must have identification tags showing size, grade, and reel number.	X		X
Structural Steel (pipe endwalls, catch basins, bridge repair items, etc.): 908.01 *Additional Paperwork:* Each shipment shall consist of a certified mill test report and a notarized certification of material signed by the manufacturer stating compliance with Standard Specifications and Standard Drawings including the following: contract number, contractor, shop order number, location of use, drawing number, quantity, item, type of steel, heat number, and manufacturer. If applicable, paint batch certifications and galvanization reports shall be included. The Project Inspector will check the dimensions when steel is delivered to the project site.	X		
Structural Steel Piles: 908.15 *Additional Paperwork:* Steel piles shall be accompanied by certified mill test reports showing correct heat numbers and a T-2 form including correct quantities and heat numbers used. The T-2 form and mill test report will be checked for accuracy. If the mill test report is not job specific, then the Contractor shall include documentation showing the purchase of the piling.	X		
Structural Steel Pile Tips *Additional Paperwork:*	QPL 28		

Material Information	Cert. (X) or QPL T-2 Req.	Accept (Part 2)	Verify (Part 3)
Steel pile tips shall be accompanied by certified mill test reports showing correct heat numbers.			
TEMPORARY TRAFFIC CONTROL ITEMS: 712 *Additional Paperwork:* The Contractor shall submit all certifications/acceptance letters stating that all products used meet the TDOT specifications and comply with NCHRP 350 criteria. If selected from the QPL, the Contractor/Supplier shall certify that products furnished are identical to the product evaluated for the QPL.			
Barricades	X		
Cones	X		
Delineators	QPL 1		
Flexible Drums	QPL 1		
Ground Mounted Sign Supports: 916	X		
Longitudinal Channelizing Barriers and Barricades	QPL 34 OR QPL 45		
Portable Barrier Rail	QPL 34 OR QPL 45		
Portable Sign Stands	QPL 33		
Signs	X		
Temporary Pavement Marking Material	QPL 1		
Trailer Mounted Devices (changeable message signs, flashing arrow boards)	QPL 29 OR QPL 30		
Truck or Trailer-Mounted Attenuators	QPL 45		
Vertical Panels	X		
WATER, SEWER, AND OTHER UTILITY ITEMS All utility items shall be accepted in accordance with the TDOT Construction Circular Letter 105.07-04, Utility Diaries and Inspection Procedures, or as required in other Contract documents. The utility representative shall complete the proper forms and submit to the Project Supervisor.	X		
WATER STOPS: 604.26 & 921.08 *Additional Paperwork:* The Contractor shall provide a certified test report. The Project Inspector will check all shipments for inspection tags.	X		
WOOD TIMBERS AND POSTS (TREATED): 911 *Additional Paperwork:* The Contractor shall provide treatment reports and inspection reports on all wood timber and posts.	X		

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
AGGREGATE						
Aggregate for Underdrains	Aggregate	Gradation	M&T	Per month	Project site or plant stockpile	Project Inspector to notify M&T
Base Courses (Aggregate-Cement OR Aggregate-Lime-Fly Ash)	Aggregate	Gradation	Project Inspector	Every 2,500 tons	Plant stockpile	
		Moisture		Every 2,500 tons or two per day	At time of weighing	First sample should be taken at beginning of day.
	Aggregate-Cement Mixture, & Aggregate-Lime-Fly Ash Mixture	Density, Gauge Moisture		Five tests per 10,000 square-yard lot	Immediately following compaction	
		Thickness		Every 500 linear feet		
Bedding, Backfill	Aggregate for Bridges, Box Culverts, & other major structures	Gradation, Moisture	Project Inspector	At beginning of project and every 2500 tons thereafter (Minimum of 1 per week)	Plant or roadway	
		Density, Gauge Moisture		Three tests per layer	Immediately following compaction	
	Aggregate for Pipe Culverts	Gradation, Moisture		At beginning of project and as material changes	Plant or roadway	
		Density, Gauge Moisture		Per layer every 50 linear feet	Immediately following compaction	
Mineral Aggregate Base	Mineral Aggregate	Gradation, Moisture	Project Inspector	At beginning of project and every 2500 tons thereafter (Minimum of 1 per week)	Plant or roadway	First sample should be taken at beginning of day.
		Density, Gauge Moisture		Five tests per 10,000 square-yard lot	Immediately following compaction	Refer to Section 310 for Conditioning Mineral Aggregate Base
ASPHALT						
Asphalt Plant Mix Pavements	Aggregate	Fractured Face Count	Project Inspector	Per project	Coarse aggregate stockpiles	Plus No. 4 (4.75 mm) sieve material, gravel mixes only.
		Glassy Particles by mass				Plus No. 4 (4.75 mm) sieve material, slag mixes only.
	All Plant Mix Asphalt	Mix Temperature		Every 5th load	From the truck prior to leaving the plant and on the roadway prior to deposit into the paver or the material transfer device	Temperatures on the roadway are to be recorded on the delivery ticket.
	Plant Mix Asphalt (Grading A, B, BM, BM2, C, CW, D, E, E-Shoulder)	Density		Every 1,000 tons	As soon as practical after compaction	Each lot shall be divided into 5 equal sub-lots, and one test shall be performed per sub-lot.
	Plant Mix Asphalt (Grading B, BM, BM2, C, CS, CW, D, E, TL, TLD, TLE, and OGFC)	Loss on Ignition (Surface Mix with Limestone Only)		Per day	Completed mix in truck	LOI testing is to be run on the extracted aggregate reclaimed from the completed plant mix.
		Asphalt Content: AASHTO T-164, Method E-II by extraction, or AASHTO T-308 by ignition oven.		Every 1,000 tons		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 Not required on production days of less than 100 tons Ignition oven may be utilized to determine gradation
		Aggregate Gradation: AASHTO T-30 and AASHTO T-11				

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
ASPHALT						
Asphalt Plant Mix Pavements	Plant Mix Asphalt (Grading A, AS, ACRL, and Asphalt Treated Permeable Base (TPB))	Aggregate Gradation: AASHTO T-30 and AASHTO T-11	Project Inspector	Every 1,000 tons	Combined RAP and aggregate belt samples OR Sample completed mix in truck or on roadway.	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. Not required on production days of less than 100 tons. Ignition oven may be utilized to determine gradation.
		Thickness: Cores (Asphalt TPB Only)		Every 1,000 feet	Prior to being overlaid	Refer to Section 313 of the specification for tolerance guidelines.
	Small Quantities	Visual Inspection		Not to exceed 1,000 tons of each mix type	Placement site	
Asphalt Surface Treatments: Cape Sealing, Fog Sealing, Microsurfacing, Slurry Sealing, Scrub Sealing, etc.	Aggregate	Gradation and Washing	Project Inspector	At beginning of project and every 500 tons thereafter	At source or project site prior to incorporating into work	
		Fractured Face Count		Per project		Plus No. 4 (4.75 mm) sieve material, gravel mixes only
		Glassy Particles by mass				Plus No. 4 (4.75 mm) sieve material, slag mixes only
		Loss on Ignition			From stockpiled materials	For microsurfacing only. If blended aggregate, then after blending
CONCRETE						
Ready Mix, Volumetric Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Polymer Modified	Minor Structures	Cylinders (28-day),	Project Inspector	Every 25 cubic yards or less weekly	Placement site	Refer to Standard Specification 604.3. B.
		Slump, Air Content, & Mix Temperature		Per Day		
	Class A, , S, X	Cylinders (28-day), Slump, Air Content, & Mix Temperature		Every 100 cubic yards placed per day per structure		Sampling frequency for Class X may be otherwise specified
	Class CP			Every 400 cubic yards placed per day		Determine depth measurement per Standard Specification 501.24. Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance.
	Class PEM			Every 100 cubic yards placed per day per structure		Refer to Standard Specification 604.03 A.1. d.
	Class D, DS, L			Test first three loads and every 50 cubic yards thereafter per day per structure One pair of cylinders shall be cast from one of the first three passing loads		Refer to SOP 4-1 for acceptance of concrete for bridge decks
	Class SCC, SH-SCC	Cylinders (28-day), Slumpflow, Air Content, Mix Temperature, Passing Ability by J-Ring, VSI, & T-50				
	Closure Pour Mix	Cylinders (28-day)		Beginning, middle, and end of the pour		
	Structural Grout			Per day		Test/Record acceptance cylinders in accordance with AASHTO T22
	Pre-packaged Concrete Mixture					Use limited to 2 cubic yards per day
	Flowable Fill	Slumpflow, Mix Temperature, & Cylinders (28-day)		Every 100 cubic yards placed per day		Cylinders required for excavatable only
	Polymer Modified (PMC)	Cylinders (28-day), Slump, Air Content		Every 200 square yards placed per structure		

Part Two: Acceptance Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
Prestressed	Prestressed Products	Visual Inspection	M&T	After casting and before shipment		Refer to SOP 5-4
CONCRETE						
Precast	Precast Products, Reinforced Concrete Pipe	Acceptance by Certification in accordance with SOP 5-3				Each item shall be inspected after delivery to the project for cracks, spalls and/or appearance by project personnel prior to incorporating product into the project. After proper installation, the inspector shall determine if the product fitment is in accordance to contract plans.
		Visual Inspection	Project Inspector	Per Product	Project Site	
	Sound Absorbing Noise Walls	Acceptance by certification in accordance with SP 718NB				
	Noise Walls/ Reinforced Concrete Panels	Acceptance by certification that product meets compressive strength, air, slump or slump flow, and dimensional tolerances as outlined below				Producer to supply letter of certification with each lot Test results must meet the requirements of shop drawings, contract plans, and/or mix design requirements
		Cylinders (28-day)	Producer	A pair of 4"x8" cylinders shall be made at a minimum of three (3) random points during production.	Production Facility	
		Air, Slump or Slumpflow	Producer	One (1) test each per day	Production Facility	
		Dimensional Check	Producer	Per Product	Production Facility	
Shotcrete	Shotcrete	Production Test Panel OR Shotcrete facing	Producer/ Contractor	At beginning of project and every 5000 SF thereafter	Project Site	Minimum nine 3-inch diameter cores are required for testing Producer/Contractor shall provide third party test results for compressive strength (28-day) and boiled water absorption testing
EARTH RETAINING STRUCTURES						
Earth Retaining Structures	Select Granular Backfill (Soil)	Proctor Density & Optimum Moisture	Project Inspector	As required by material changes	Prior to Construction	
		Density, Gauge Moisture		Every 500 tons	Project site	
		Electro-Chemical Analysis, Plasticity Index, Internal Angle of Friction	Producer	At beginning of project and every 2 years thereafter	Aggregate plant	Additional test required with appearance change
	Select Granular Backfill (Sized Aggregate)	Gradation	M&T	At beginning of project and per month	Aggregate plant or roadway	
		Unit Weight		At beginning of project and annually thereafter	Aggregate plant	
	All Retaining Wall Products	Accept in accordance with Special Provision 624 Retaining Walls				Materials not listed in this table
EMBANKMENT/SUBGRADE						
Embankment	Soil	Proctor Density & Optimum Moisture	Project Inspector	As required by material changes	Cuts sampled prior to construction. Borrow pits sampled as required prior to placement	Submit 50 - 75 pound sample to M&T

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
		Density, Gauge Moisture		Every 300 linear feet or 1000 cubic yards per lift	During construction, immediately after compaction	Density tests will not be required for embankment containing more than 50% of plus ¾ inch sieve material Within 50 feet of a bridge end (deck or box), one test will be performed for each lift. The test will be performed alternately on the embankment and on the backfill material.
EMBANKMENT/SUBGRADE						
Subgrade Preparation	Soil	Proctor Density & Optimum Moisture	Project Inspector	As required by material changes	May be sampled before grading construction or after grading prior to sub-grade preparation	Submit 50 - 75 pound sample to M&T
		Density, Gauge Moisture		Five tests per 10,000 square-yard lot for top 6 inches	Immediately before placing pavement	
Subgrade Treatment (Lime) OR Soil-Cement Base	Soil-Cement Mixture OR Soil-Lime Mixture	Proctor Density & Optimum Moisture	Project Inspector	Prior to beginning of construction	At beginning of compaction	Additional tests may be required to account for material changes Submit 50 - 75 pound sample to M&T
		Pulverization		Every 10,000 square yards	After mixing, before compaction	Sieve test requirement. See Standard Specs. 304.06.
		Density, Gauge Moisture		Five tests per 10,000 square-yard lot	Immediately following compaction	
		Thickness		Every 500 liner feet		
MISCELLANEOUS						
Miscellaneous	Corrugated Metal Pipe	Laboratory Analysis	Producer	Per heat number	Producer's plant	Samples shall be submitted to HQ M&T Lab prior to use
	Geotextiles (Type IV only)	Laboratory Analysis	Project Inspector	Per project	Project site prior to installation	Submit a sample 100 inches in length by the width of the roll, containing at least one NTPEP manufacturing mark, to HQ M&T Lab
	Gray Iron Castings	Dimensional Check	Project Inspector	Upon product placement	Project site	Check dimensions against standard drawings

Part Three: Verification/Check Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
AGGREGATE						
Base Courses (Aggregate-Cement OR Aggregate-Lime-Fly Ash)	Aggregate	Quality	M&T	Annually	At source	Quality report required for each project.
	Cement	Laboratory Analysis	Project Inspector	Every six months	Mixing site	Mixture dosage rate should be checked.
	Fly Ash, Lime					
Borrow Excavation (Solid Rock and Graded Solid Rock)	Aggregate	Quality	Project Inspector or M&T	Every 100,000 tons or 50,000 cubic yards	At source	Quality report required for each project.
Mineral Aggregate Base	Aggregate	Quality	M&T	Annually	At source	Quality report required for each project.
ASPHALT						
Asphalt Binder (All Grades)	Performance Graded Asphalt Cement	Laboratory Analysis	Contractor monitored by TDOT personnel	Beginning of project and weekly thereafter	Asphalt plant	One-quart sample shall be sent to HQ M&T Lab.
			M&T or drop shipment	Per month	Asphalt terminal	One-quart sample shall be sent to HQ M&T Lab.
Asphalt Plant Mix Pavements	Plant Mix Asphalt (Grading B, BM, BM2, C, CW, D, E, TL, TLD, and TLE)	Air Voids, Volumetric Properties, and TSR: AASHTO T-166, AASHTO T-209,AASHTO T-269, and ASTM D4867	Project Inspector or M&T	During Test Strip Construction or Mix Verification	Completed mix in truck	Exempt small quantities (< 1,000 tons).
	Plant Mix Asphalt (Grading OGFC)	Asphalt Draindown and Cantabro: AASHTO T-305, AASHTO T-401	M&T			
Asphalt Surface Treatments: Cape Sealing, Fog Sealing, Microsurfacing, Slurry Sealing, Scrub Sealing, etc.	Emulsion	Laboratory Analysis	Contractor monitored by TDOT personnel	At beginning of project and every week thereafter	Distributor truck	One-quart sample must be received at HQ M&T Lab less than two weeks after sampling. Minimum of five days between samples is required.
Prime and Tack Coat	Emulsion	Laboratory Analysis	Contractor monitored by TDOT personnel	At beginning of project and every week thereafter	Distributor truck	One-quart sample must be received at HQ M&T Lab less than two weeks after sampling. Minimum of five days between samples is required. If material is greater than one week old, run sieve and residue tests at Contractor's Lab instead of HQ M&T Lab.
			M&T or drop shipment	Per month	Asphalt terminal	One-gallon sample shall be sent to HQ M&T Lab.
CONCRETE						
Ready Mix, Closure Pour, Grout, Flowable Fill, Prestressed, & Precast	Cement, Fly Ash, Slag Cement	Laboratory Analysis	M&T	Every three months	Concrete plant	Cement: Two-pint sample shall be sent to HQ M&T Lab. Fly Ash: 2 oz sample shall be sent to HQ M&T Lab.
	Aggregate: Coarse & Fine	Quality		Annually	Aggregate plant	Also, as appearance changes or locations in quarry are changed. Additional samples to be obtained when production exceeds normal output.

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Part Three: Verification/Check Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
		Gradation and Wash		Per month	Concrete plant	Perform wash test on fine aggregate only when percent passing the No. 200 sieve dry exceeds 2.0%
CONCRETE						
Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Prestressed, & Precast	Precast Products, Reinforced Concrete Pipe	Fitment	Project Inspector	Per Product	Project Site	Verification is based on the final acceptance of the product(s) meeting the requirements of the contract plans.
		Verification in accordance with SOP 5-3				
	Class PEM	SAM number, Surface Resistivity, Resistance of Concrete to Rapid Freezing and Thawing, Resistivity of Concrete	M&T	With every PEM design submission	Project Site	Refer to Standard Specification 604.03 A.1.d. All information for data collection only
	All Classes	Maturity	M&T	During Trial Batch	Producer Facility	Refer to AASHTO T 325 for guidance Must be witnessed be M&T Intended for data collection for designs on select projects
	Prestressed Completed Mix	Cylinders (28-Day) for Beams, Panels, and piling	M&T	Per Bed	Prestress plant	
	Prestressed Products	Visual Inspection	Project Inspector	Per shipment	Project Site	On arrival at site
Polymer Modified (PMC)	Aggregate: Coarse & Fine	Gradation	Project Inspector or M&T	At beginning of project and every 500 tons	Project stockpile	Refer to Standard Specification 619.04.A
		Moisture		Per day		
EARTH RETAINING STRUCTURES						
Earth Retaining Structures	Select Granular Backfill (Sized Aggregate)	Quality	M&T	Annually	Aggregate plant	
	Reinforced Concrete Facing Panels	Non-Destructive Testing and Dimensional Verification	M&T	Quarterly, when producing	Producer yard (In-State) OR Project site (Out-of-State)	When TDOT product is being produced, TDOT shall randomly select a minimum of one (1) precast product at each plant or project site for non-destructive testing and dimensional verification per quarter
		Compressive Strength	M&T	As needed	Producer yard	One pair of cylinders shall be retained for TDOT verification testing. These cylinders shall be retained for a minimum of 30 days unless testing is performed sooner by a TDOT Representative.
	Modular Block	Strength	M&T	Per production run	Producer yard (In-State) OR Project site (Out-of-State)	See SP 624 for additional verification guidance on manufacturing tolerances and visual defects of Modular Block
	All Retaining Wall Products	Verification in accordance with Special Provision 624 Retaining Walls				Materials not listed in this table

Part Three: Verification/Check Samples and Tests

Type of Construction	Material	Test	Sampled By	Frequency	Location or Time of Sampling	Remarks
EMBANKMENT/SUBGRADE						
Soil - Cement Base	Cement	Laboratory Analysis	Project Inspector	Every six months	Mixing site	
MISCELLANEOUS						
Miscellaneous	Bolt/Nut/Washer Assemblies	Laboratory Analysis	Producer	Per heat number	Producer's plant	Prior to use, send a sample of three assemblies to HQ M&T Lab
	Brick	Strength	Project Inspector	At beginning of project	Project site	Prior to use, send a sample of five bricks to HQ M&T Lab
	Corrugated Metal Pipe	Dimensional Check	M&T	Per pipe	Producer's plant OR Project site (Out-of-State)	Verify dimensions of pipe and that heat numbers match lab acceptance
	Fencing Materials	Laboratory Analysis	Project Inspector	At beginning of project	Project site	Send all samples to HQ M&T Lab For fence fabric (farm-stock/chain link), cut 18 inches long by roll width section For tension wire, cut a three-foot sample from the roll For round posts (corner, line), send one post
	Grey Iron Castings	Laboratory Analysis	M&T	Per quarter	Producer's plant	Send two heat numbers (test bars) to HQ M&T Lab
		Dimensional & Weight Check				Check one assembly representing each structure device type
PAVEMENT MARKINGS						
Pavement Markings	Glass Beads	Laboratory Analysis	Producer	Per lot number	Producer's plant	Prior to use, send one quart from each lot representing 44,000 pounds to HQ M&T Lab.
	Paint					Prior to use, send one pint to HQ M&T Lab.
	Thermoplastic					Prior to use, send one quart to HQ M&T Lab.
STEEL						
Steel	Steel Bars	Laboratory Analysis	M&T	Per inspection	Producer's plant or project site	Two bars 34 inches in length shall be sent to HQ M&T Lab.
					Precast plant	
					Prestressed plant	
	Prestressing Strands				Prestressed plant	Two strands 40" ± 2" in length shall be sent to HQ M&T Lab.
	Welded Wire Mesh				Precast plant	A two foot by two foot sample shall be sent to HQ M&T Lab.

Part Four: Using Random Numbers for Sampling and Testing

(With Examples and Random Number Tables)

Significance

The selection of test locations is critical in ensuring control of materials and construction work. If the results from the test locations conform to specified tests, the rest of the work is likely to conform as well; therefore, test site locations shall be random and representative of the material in its entirety.

The procedures outlined below will help you to select random and representative test locations using random number tables, a random number function on a calculator, a spreadsheet program, etc.

Selecting Random Numbers

Randomness in transportation construction inspection indicates unpredictability in the time or location of sampling and testing of a material or procedure in a construction phase.

Random numbers occur in no pattern or sequence. When you review a series of random numbers, you do not know what number may come next; there is no particular order in which random numbers occur.

A sample random-number table is shown below.

	A		B		C		D		E		
	0.814	0.759	0.651	0.947	0.965	0.994	0.581	0.877	0.500	0.208	
	0.105	0.015	0.323	0.630	0.223	0.616	0.070	0.469	0.672	0.931	
1	0.035	0.841	0.590	0.184	0.488	0.794	0.909	0.940	0.062	0.031	1
	0.741	0.336	0.346	0.926	0.237	0.967	0.385	0.657	0.521	0.921	
	0.278	0.697	0.423	0.365	0.010	0.210	0.264	0.745	0.378	0.337	
	0.834	0.355	0.952	0.924	0.591	0.003	0.280	0.363	0.175	0.254	
	0.204	0.159	0.006	0.006	0.764	0.020	0.768	0.209	0.959	0.147	
2	0.426	0.860	0.160	0.009	0.978	0.033	0.394	0.445	0.682	0.600	2
	0.990	0.330	0.581	0.946	0.129	0.047	0.384	0.363	0.038	0.275	
	0.837	0.658	0.140	0.344	0.189	0.047	0.675	0.923	0.101	0.122	
	0.537	0.505	0.909	0.794	0.249	0.339	0.850	0.326	0.510	0.961	
	0.286	0.447	0.286	0.975	0.458	0.484	0.992	0.078	0.947	0.756	
3	0.492	0.633	0.262	0.660	0.451	0.511	0.255	0.439	0.185	0.712	3
	0.428	0.126	0.884	0.203	0.199	0.222	0.638	0.492	0.062	0.967	
	0.443	0.927	0.626	0.542	0.746	0.683	0.822	0.242	0.481	0.077	
	0.343	0.529	0.955	0.122	0.692	0.721	0.393	0.774	0.986	0.485	
	0.070	0.948	0.408	0.338	0.921	0.355	0.252	0.916	0.255	0.456	
4	0.832	0.666	0.385	0.337	0.918	0.098	0.209	0.163	0.921	0.241	4
	0.858	0.470	0.756	0.923	0.799	0.250	0.101	0.615	0.891	0.120	
	0.153	0.773	0.722	0.819	0.626	0.393	0.340	0.202	0.120	0.793	
	0.142	0.636	0.217	0.005	0.597	0.628	0.994	0.150	0.375	0.969	
	0.882	0.905	0.272	0.637	0.201	0.768	0.002	0.568	0.176	0.702	
5	0.369	0.985	0.930	0.070	0.891	0.835	0.340	0.283	0.863	0.566	5
	0.423	0.658	0.311	0.795	0.174	0.419	0.909	0.600	0.885	0.145	
	0.461	0.878	0.363	0.644	0.890	0.278	0.219	0.312	0.585	0.923	
	A		B		C		D		E		

Lot sizes vary depending on the type of construction and the material. For example, a lot for earthwork construction is defined by the width and length of roadway, while concrete tests for bridge decks (slump, temperature, and air content) are determined by the volume of concrete delivered to the site.

Determine the lot size and the number of samples and tests required per lot from the Sampling and Testing (S&T) Guide and Schedule (SOP 1-1).

Knowing the type of construction and the material to be tested, use the S&T Schedule to determine the type of test and frequency of testing.

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Example 1: Moisture and density must be measured on a lift of soil for subgrade preparation of a roadbed. The proposed roadway is 48-feet wide.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), five tests for moisture and density are required for every 10,000 square-yard lot of soil placed.

Subgrade Preparation	Soil	Proctor Density & Optimum Moisture	Project Inspector	As required by material changes	May be sampled before grading construction or after grading prior to sub-grade preparation.	Submit 50-75 pound sample to Regional M&T.
		Density, Moisture		Five tests per 10,000 square-yard lot for top 6 inches	Immediately before placing pavement structure	

Since the project is 48 feet wide, the lot length will be, *at most*,

$$\frac{10000\ \mathrm{yd}^2\ \text{area of aggregate x } 9\,\dfrac{\mathrm{ft}^2}{\mathrm{yd}^2}}{48\ \text{feet wide}} = 1875\ \text{feet per lot}$$

We decide to use 1000 linear feet of roadway as our designated lot since this is shorter than the allowable lot length of 1875 feet.

If using the random number table shown below, we randomly choose a block of numbers, say, block C2.

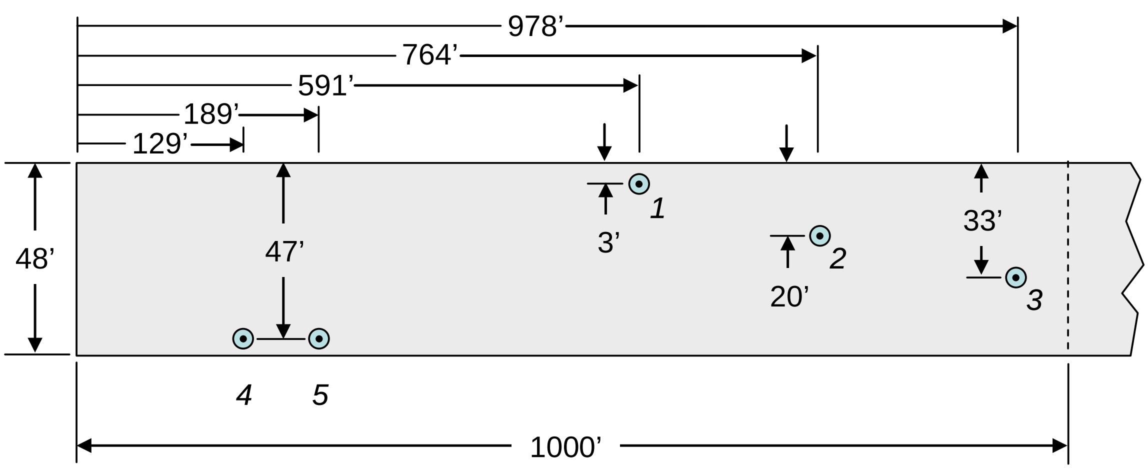
	A		B		C		D		E		
	0.271	0.584	0.674	0.883	0.379	0.976	0.555	0.083	0.967	0.812	
	0.185	0.905	0.686	0.491	0.424	0.566	0.724	0.582	0.393	0.176	
1	0.283	0.202	0.692	0.475	0.436	0.304	0.375	0.660	0.731	0.384	**1**
	0.567	0.800	0.642	0.205	0.827	0.129	0.598	0.216	0.124	0.787	
	0.703	0.621	0.893	0.063	0.755	0.194	0.133	0.110	0.795	0.824	
	0.103	0.338	0.620	0.594	0.591	0.069	0.639	0.203	0.313	0.733	
	0.536	0.826	0.362	0.321	0.764	0.408	0.487	0.515	0.591	0.676	
2	0.017	0.218	0.365	0.209	0.978	0.688	0.546	0.490	0.795	0.241	**2**
	0.840	0.594	0.341	0.006	0.129	0.986	0.350	0.437	0.927	0.782	
	0.161	0.720	0.366	0.219	0.189	0.985	0.899	0.501	0.793	0.889	
	0.251	0.496	0.741	0.314	0.014	0.839	0.124	0.209	0.292	0.099	
	0.380	0.901	0.262	0.180	0.459	0.843	0.640	0.720	0.131	0.132	
3	0.637	0.274	0.959	0.050	0.924	0.773	0.314	0.390	0.819	0.410	**3**
	0.310	0.324	0.111	0.760	0.706	0.165	0.930	0.515	0.639	0.116	
	0.568	0.379	0.600	0.362	0.697	0.006	0.080	0.680	0.028	0.206	
	0.378	0.392	0.910	0.202	0.512	0.156	0.336	0.465	0.813	0.471	
	0.805	0.641	0.118	0.878	0.932	0.196	0.018	0.094	0.419	0.211	
4	0.830	0.106	0.643	0.706	0.720	0.299	0.252	0.598	0.955	0.021	**4**
	0.367	0.538	0.050	0.448	0.896	0.669	0.968	0.984	0.890	0.117	
	0.274	0.509	0.848	0.645	0.890	0.998	0.389	0.611	0.586	0.137	
	0.566	0.802	0.283	0.151	0.399	0.316	0.559	0.684	0.318	0.516	
	0.078	0.505	0.541	0.962	0.868	0.007	0.192	0.610	0.255	0.081	
5	0.458	0.811	0.454	0.476	0.156	0.385	0.198	0.102	0.762	0.372	**5**
	0.486	0.345	0.786	0.759	0.465	0.222	0.487	0.355	0.935	0.223	
	0.783	0.432	0.275	0.218	0.942	0.054	0.641	0.278	0.957	0.778	
	A		**B**		**C**		**D**		**E**		

Using block C2, we have 10 random numbers that range between 0 and 1 carried to the thousandth decimal place. We will use these as multiplication factors to determine our test locations in the following table. The left-hand column of numbers in block C2 will be used to determine the longitudinal coordinates (length of the proposed roadway) by multiplying the lot length by the random number, then rounding to the nearest whole number. The right-hand column of numbers in block C2 will be used to determine the lateral coordinates (perpendicular to the proposed roadway) by multiplying the lot width by the random number, then rounding to the nearest whole number.

SAMPLE NO.	LENGTH	RANDOM NO.	LONGITUDINAL COORDINATE
1	1000	0.591	591
2	1000	0.764	764
3	1000	0.978	978
4	1000	0.129	129
5	1000	0.189	189

SAMPLE NO.	WIDTH	RANDOM NO.	LATERAL COORDINATE
1	48	0.069	3
2	48	0.408	20
3	48	0.688	33
4	48	0.986	47
5	48	0.985	47

Now, we simply match the first longitudinal coordinate with the first lateral coordinate to locate the first test location. Then, we match the remainder of the longitudinal and lateral coordinates to determine the remaining 4 test locations. The figure below shows the locations of the tests on the roadbed.



PLAN VIEW OF TEST AREA
(NOT TO SCALE)

<u>Example 2</u>: Nuclear gauge tests of density on 3.5 inches of Grading 307-A asphalt pavement that is 12 feet wide. The spread rate for 3.5 inches is 402.5 lbs/yd^2.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), five tests for density are required for every 1,000 ton lot of asphalt placed.

Asphalt Plant Mix Pavements	Plant Mix Asphalt Gradings A, B, BM, BM2, C, CW, D, E, and E Shoulder	Density	Project Inspector	Every 1,000 tons	As soon as practical after compaction	Each lot shall be divided into 5 equal sub-lots, and one test shall be performed per sub-lot.

Since the lot size is 1,000 tons, the maximum lot size will be, Converting this into square feet,

$$4{,}969\ \text{yd}^2 \times 9\ \frac{\text{ft}^2}{\text{yd}^2} = 44{,}721\ \text{ft}^2$$

Since the project is 12 feet wide, the maximum lot will be,

$$44{,}721\text{ft}^2 \div 12\ \text{ft wide} = 3{,}726.8\ \text{ft}$$

Dividing this lot into five equal sub-lots,

LOT SIZE (yd^2)		LANE WIDTH (ft) 10	11	12	13
5,000	LOT LENGTH	4500	4091	3750	3462
	SUB-LOT LENGTH	900	818	750	692
10,000	LOT LENGTH	9000	8182	7500	6923
	SUB-LOT LENGTH	1800	1636	1500	1385

Using the table of random numbers shown below, we randomly choose a block of numbers, say, block D5.

	A		B		C		D		E		
	0.781	0.437	0.811	0.662	0.105	0.135	0.509	0.792	0.137	0.779	
	0.311	0.114	0.878	0.378	0.984	0.741	0.177	0.558	0.725	0.807	
1	0.746	0.926	0.294	0.674	0.952	0.597	0.559	0.685	0.891	0.909	1
	0.381	0.729	0.057	0.378	0.166	0.332	0.807	0.034	0.628	0.090	
	0.954	0.130	0.447	0.548	0.199	0.658	0.897	0.349	0.396	0.742	
	0.265	0.732	0.808	0.566	0.484	0.163	0.114	0.631	0.992	0.934	
	0.769	0.313	0.280	0.451	0.035	0.787	0.223	0.994	0.111	0.777	
2	0.729	0.963	0.946	0.178	0.198	0.252	0.085	0.630	0.677	0.055	2
	0.140	0.111	0.712	0.641	0.576	0.558	0.407	0.384	0.653	0.181	
	0.923	0.316	0.508	0.284	0.406	0.228	0.920	0.875	0.403	0.503	
	0.602	0.516	0.251	0.954	0.268	0.197	0.809	0.004	0.769	0.678	
	0.138	0.246	0.819	0.198	0.418	0.126	0.835	0.187	0.680	0.855	
3	0.178	0.399	0.550	0.565	0.071	0.916	0.560	0.219	0.537	0.856	3
	0.613	0.157	0.218	0.001	0.535	0.576	0.146	0.010	0.215	0.190	
	0.097	0.155	0.388	0.403	0.252	0.987	0.775	0.596	0.365	0.231	
	0.373	0.974	0.929	0.104	0.447	0.449	0.447	0.147	0.424	0.195	
	0.880	0.803	0.036	0.846	0.058	0.834	0.010	0.314	0.011	0.621	
4	0.749	0.231	0.217	0.206	0.869	0.810	0.804	0.426	0.157	0.881	4
	0.020	0.048	0.404	0.368	0.917	0.374	0.444	0.214	0.432	0.827	
	0.052	0.601	0.318	0.016	0.766	0.513	0.623	0.065	0.409	0.816	
	0.777	0.941	0.140	0.401	0.171	0.139	0.353	0.481	0.209	0.735	
	0.406	0.017	0.252	0.730	0.476	0.188	0.347	0.656	0.945	0.149	
5	0.044	0.413	0.782	0.032	0.459	0.856	0.838	0.594	0.322	0.654	5
	0.980	0.185	0.574	0.166	0.025	0.962	0.588	0.134	0.198	0.704	
	0.237	0.162	0.155	0.373	0.673	0.104	0.665	0.070	0.849	0.957	
	A		B		C		D		E		

Using block D5, we have 10 random numbers that range between 0 and 1 carried to the thousandth decimal place. We will use the multiplication factors in the left-hand column to determine our longitudinal test locations. Transverse locations are determined randomly with one test 12" off each edge, one test in each wheel path, and one test in the center of the lane.

The distances into each sublot,

$$745\ \text{ft} * 0.353 = 263\ \text{ft}$$
$$745\ \text{ft} * 0.347 = 259\ \text{ft}$$
$$745\ \text{ft} * 0.588 = 438\ \text{ft}$$
$$745\ \text{ft} * 0.838 = 624\ \text{ft}$$
$$745\ \text{ft} * 0.665 = 495\ \text{ft}$$

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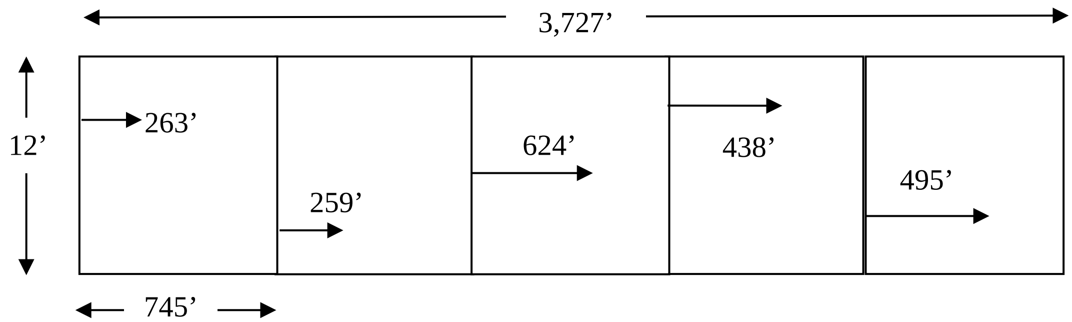
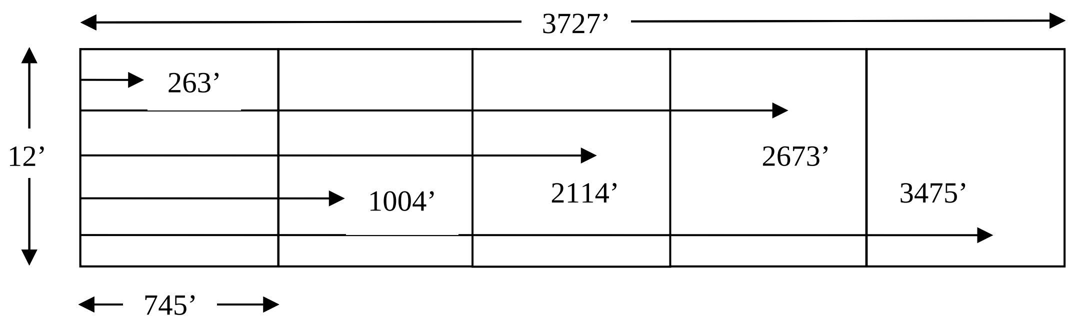


If we wanted to know the total distance into the 3750’ lot for each test:

$$\text{Test 1} = 263\text{ ft}$$
$$\text{Test 2} = 745\text{ ft} + 259\text{ ft} = 1004\text{ ft}$$
$$\text{Test 3} = 745\text{ ft} + 745\text{ ft} + 624\text{ ft} = 2114\text{ ft}$$
$$\text{Test 4} = 745\text{ ft} + 745\text{ ft} + 745\text{ ft} + 438\text{ ft} = 2673\text{ ft}$$
$$\text{Test 5} = 745\text{ ft} + 745\text{ ft} + 745\text{ ft} + 745\text{ ft} + 495\text{ ft} = 3475\text{ ft}$$



<u>Example 3</u>: Slump, temperature, and air content of concrete from mixing trucks delivering concrete to a bridge deck pour that is expected to use 1300 cubic yards of concrete.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), one complete set of tests for air content, slump, and temperature are required for the first three loads of concrete delivered.

One pair of cylinders must be cast from one of the three passing loads. For each additional 50 cubic yards of concrete, a pair of cylinders must be made and tests for air content, slump, and temperature must be performed.

Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Polymer Modified, Prestressed	Class D, DS, L	Cylinders (28-day), Slump, Air Content, & Mix Temperature	Project Inspector	Test first three loads and every 50 cubic yards thereafter per day per structure One pair of cylinders shall be cast from one of the first three passing loads.	Placement site	Refer to SOP 4-1 for acceptance of concrete for bridge decks.

Now we'll use the random number tables in a different way. We must decide which loads of concrete to test. First, we'll assume each truck is hauling 10 cubic yards of concrete. Subsequent to the first 30 cubic yards, we'll test from truck loads by first choosing a random block of numbers from the following table. We'll choose block A3.

	A		B		C		D		E		
	0.818	0.696	0.758	0.117	0.827	0.567	0.974	0.487	0.874	0.665	
	0.565	0.826	0.141	0.229	0.996	0.003	0.783	0.079	0.145	0.827	
1	0.926	0.785	0.743	0.669	0.411	0.702	0.949	0.460	0.434	0.201	1
	0.776	0.529	0.397	0.450	0.851	0.569	0.157	0.571	0.097	0.556	
	0.333	0.996	0.810	0.562	0.053	0.975	0.122	0.055	0.702	0.609	
	0.626	0.783	0.145	0.210	0.591	0.003	0.493	0.136	0.036	0.223	
	0.291	0.607	0.048	0.788	0.764	0.020	0.991	0.719	0.948	0.727	
2	0.950	0.570	0.324	0.232	0.978	0.033	0.803	0.534	0.367	0.897	2
	0.521	0.642	0.912	0.464	0.129	0.047	0.359	0.497	0.382	0.993	
	0.235	0.611	0.262	0.783	0.189	0.047	0.241	0.252	0.706	0.886	
	0.537	0.505	0.557	0.919	0.939	0.579	0.351	0.525	0.304	0.092	
	0.286	0.447	0.366	0.025	0.454	0.643	0.647	0.958	0.887	0.702	
3	0.492	0.633	0.937	0.229	0.556	0.078	0.468	0.850	0.233	0.009	3
	0.428	0.126	0.767	0.250	0.740	0.976	0.835	0.280	0.808	0.401	
	0.443	0.465	0.666	0.947	0.372	0.412	0.408	0.589	0.170	0.211	
	0.970	0.183	0.800	0.534	0.702	0.508	0.295	0.397	0.391	0.421	
	0.198	0.464	0.847	0.596	0.228	0.450	0.671	0.787	0.169	0.648	
4	0.727	0.087	0.544	0.354	0.630	0.454	0.687	0.320	0.852	0.593	4
	0.272	0.647	0.553	0.886	0.761	0.396	0.059	0.207	0.014	0.331	
	0.284	0.210	0.344	0.355	0.060	0.158	0.536	0.940	0.365	0.546	
	0.027	0.134	0.910	0.121	0.186	0.452	0.081	0.231	0.400	0.598	
	0.818	0.052	0.867	0.848	0.497	0.386	0.485	0.976	0.283	0.388	
5	0.010	0.387	0.919	0.694	0.693	0.272	0.859	0.959	0.613	0.065	5
	0.112	0.245	0.158	0.294	0.690	0.704	0.273	0.389	0.075	0.676	
	0.949	0.172	0.810	0.381	0.307	0.129	0.552	0.162	0.016	0.047	
	A		B		C		D		E		

The table below shows one way to determine, using the random numbers above, the truck numbers from which samples will be taken.

SAMPLE NO.	DELIVERED CONCRETE (yd^3)	TOTAL AMOUNT OF CONCRETE (yd^3)	TOTAL LOADS OF CONCRETE (A)	RANDOM NO. (B)	LOAD NUMBER $[(A_n-A_{n-1})xB]+A_{n-1}$
1	10	10	1	NA	1
2	10	20	2	NA	2
3	10	30	3	NA	3
4	50	80	8	0.492	5
5	50	130	13	0.428	10
6	50	180	18	0.443	15
7	50	230	23	0.505	21
8	50	280	28	0.447	25
9	50	330	33	0.633	31
10	50	380	38	0.126	34

<u>Example 4</u>: Slump, temperature, and air content of concrete from mixing trucks delivering concrete to a structural footing that is expected to use 550 cubic yards of concrete.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), one complete set of tests for air content, slump, and temperature are required for the first load of concrete delivered each day for quality control/informational purposes. For each additional 100 cubic yards of concrete, a pair of cylinders must be made and tests for air content, slump, and temperature must be performed.

Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Polymer Modified, Prestressed	Class A, A Paving, S, X	Cylinders (28-day), Slump, Air Content, & Mix Temperature Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance.	Project Inspector	Every 100 cubic yards placed per day per structure unless otherwise specified (i.e. Class X)	Placement site	

Now we'll use the random number tables in a different way. We must decide which loads of concrete to test. First, we'll assume each truck is hauling 10 cubic yards of concrete. Subsequent to the first 10 cubic yards, we'll test from truck loads by first choosing a random block of numbers from the following table. We'll choose block C1.

	A		B		C		D		E		
	0.815	0.125	0.006	0.653	0.614	0.455	0.968	0.103	0.150	0.154	
	0.872	0.226	0.619	0.637	0.585	0.566	0.331	0.028	0.369	0.751	
1	0.685	0.964	0.937	0.948	0.969	0.454	0.194	0.425	0.852	0.500	1
	0.427	0.348	0.222	0.129	0.690	0.911	0.996	0.115	0.681	0.569	
	0.181	0.115	0.519	0.715	0.508	0.308	0.525	0.584	0.694	0.427	
	0.917	0.628	0.054	0.928	0.817	0.812	0.264	0.776	0.756	0.610	
	0.759	0.891	0.311	0.612	0.247	0.044	0.668	0.389	0.953	0.931	
2	0.510	0.632	0.371	0.037	0.667	0.681	0.730	0.638	0.965	0.925	2
	0.836	0.525	0.342	0.752	0.638	0.403	0.687	0.245	0.403	0.785	
	0.669	0.875	0.824	0.842	0.565	0.756	0.401	0.371	0.576	0.689	
	0.931	0.450	0.955	0.323	0.696	0.790	0.021	0.127	0.753	0.550	
	0.771	0.631	0.896	0.968	0.870	0.312	0.764	0.665	0.113	0.610	
3	0.855	0.525	0.056	0.255	0.921	0.282	0.301	0.401	0.775	0.246	3
	0.897	0.753	0.246	0.763	0.259	0.293	0.613	0.154	0.743	0.574	
	0.393	0.878	0.401	0.459	0.134	0.655	0.433	0.323	0.393	0.038	
	0.965	0.130	0.181	0.909	0.940	0.399	0.200	0.724	0.673	0.397	
	0.745	0.233	0.460	0.361	0.935	0.018	0.405	0.945	0.183	0.576	
4	0.204	0.623	0.771	0.120	0.859	0.314	0.880	0.447	0.680	0.938	4
	0.804	0.213	0.903	0.488	0.425	0.685	0.584	0.676	0.717	0.220	
	0.526	0.018	0.323	0.978	0.407	0.197	0.827	0.102	0.641	0.302	
	0.620	0.343	0.587	0.878	0.922	0.977	0.162	0.523	0.011	0.409	
	0.558	0.383	0.880	0.541	0.422	0.466	0.186	0.004	0.457	0.446	
5	0.128	0.893	0.685	0.864	0.349	0.413	0.273	0.971	0.970	0.311	5
	0.455	0.032	0.141	0.835	0.705	0.898	0.958	0.945	0.095	0.779	
	0.790	0.312	0.258	0.518	0.141	0.448	0.185	0.599	0.546	0.751	
	A		B		C		D		E		

The table below shows one way to determine, using the random numbers above, the truck numbers from which samples will be taken for acceptance.

SAMPLE NO.	TOTAL AMOUNT OF CONCRETE (yd^3)	TOTAL LOADS OF CONCRETE (A)	RANDOM NO. (B)	LOAD NUMBER $[(A_n-A_{n-1}) \times B]+A_{n-1}$
1	0-100	10	0.273	3
2	101-200	20	0.614	16
3	201-300	30	0.585	26
4	301-400	40	0.969	40
5	401-500	50	0.690	47
6	501-550	55	0.383	52

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Example 5: Assume the contractor is paving 411-D mix at 132.50 lbs/square yard at 12 feet wide. How long is the average lot and sublot?

In order to find those lengths, view the following table:

Spread	Lot/	Mat Width (Feet)									
(lb/SY)	Sublot	4	6	8	9	10	11	12	14	15	16
132.50	Lot	34000	22600	17000	15100	13600	12300	11300	9700	9100	8500
	Sublot	6800	4520	3400	3020	2720	2460	2260	1940	1820	1700
154.50	Lot	29100	19400	14600	12900	11700	10600	9700	8300	7800	7300
	Sublot	5820	3880	2920	2580	2340	2120	1940	1660	1560	1460
226.00	Lot	19900	13300	10000	8800	8000	7200	6600	5700	5300	5000
	Sublot	3980	2660	2000	1760	1600	1440	1320	1140	1060	1000
254.25	Lot	17700	11800	8800	7900	7100	6400	5900	5100	4700	4400
	Sublot	3540	2360	1760	1580	1420	1280	1180	1020	940	880
282.50	Lot	15900	10600	8000	7100	6400	5800	5300	4600	4200	4000
	Sublot	3180	2120	1600	1420	1280	1160	1060	920	840	800
310.75	Lot	14500	9700	7200	6400	5800	5300	4800	4100	3900	3600
	Sublot	2900	1940	1440	1280	1160	1060	960	820	780	720
345.00	Lot	13000	8700	6500	5800	5200	4700	4300	3700	3500	3300
	Sublot	2600	1740	1300	1160	1040	940	860	740	700	660
460.00	Lot	9800	6500	4900	4300	3900	3600	3300	2800	2600	2400
	Sublot	1960	1300	980	860	780	720	660	560	520	480

Find the row with the spread rate on the plans and follow it over to the column with the appropriate mat width. Where the row and column meet the lot/sublot lengths will be listed. For our example, find the row for 132.50 lbs/square yard and the column for 12 feet wide lanes. The values are **11,300 feet/2,260 feet** for the lot/sublot respectively.

Example 6: Assume the final lot is 500 tons. No matter how small, all lots will still require five equal sublots and five density tests. Instead of testing 500 tons five times consider combining the final two lots and halving the tonnage between the two lots. This will result in two lots of 750 tons.

You may still use the above table to find your lot and sublots. First locate the lot and sublot length for a 1000 ton lot based on the spread rate and lane width. For this example, use a spread rate of 132.5 lbs/square yard at 12 feet wide.

This would yield a Standard Lot of 11,300 feet and 2,260 feet respectively, but this needs to be modified based on the shorter lot.

Now that all of the givens are known, use the following equation to solve for the final lot/sublot lengths:

$$\left(\frac{Lot\ Tonnage}{1{,}000\ tons}\right) \times (Standard\ Lot\ Length, in\ feet) = \text{Lot Length, in feet}$$

$$\left(\frac{750\ tons}{1{,}000\ tons}\right) \times (11{,}300\ feet) = 8{,}475\text{ feet } \sim \textbf{8,500 feet}$$

Once the lot length is determined for 750 tons, divide the new lot length by 5 for equal sublot lengths:

$$\left(\frac{8500\ feet}{5\ sublots}\right) = \textbf{1,700 feet/sublot}$$

These values are the new lot/sublot lengths. These values may be rounded to the nearest 100' for simplicity.

	A		B		C		D		E		
	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	
1	0.504	0.635	0.730	0.899	0.719	0.357	0.284	0.140	0.644	0.082	1
	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	
	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	
2	0.205	0.290	0.040	0.804	0.638	0.987	0.353	0.539	0.208	0.676	2
	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	
	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	
3	0.955	0.924	0.285	0.028	0.299	0.064	0.953	0.791	0.437	0.745	3
	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	
	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	
4	0.689	0.685	0.742	0.863	0.906	0.966	0.617	0.375	0.908	0.685	4
	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	
	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	
5	0.107	0.682	0.077	0.763	0.593	0.877	0.094	0.929	0.268	0.973	5
	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		

	A		B		C		D		E		
	0.001	0.411	0.562	0.371	0.511	0.010	0.189	0.340	0.529	0.991	
	0.095	0.690	0.070	0.561	0.412	0.123	0.060	0.580	0.614	0.151	
1	0.742	0.355	0.526	0.217	0.848	0.774	0.923	0.542	0.653	0.385	1
	0.914	0.676	0.912	0.868	0.085	0.281	0.924	0.704	0.371	0.600	
	0.257	0.536	0.951	0.713	0.939	0.987	0.637	0.536	0.129	0.917	
	0.586	0.163	0.710	0.254	0.744	0.846	0.979	0.344	0.333	0.481	
	0.271	0.577	0.487	0.484	0.408	0.704	0.901	0.347	0.850	0.286	
2	0.480	0.538	0.017	0.074	0.427	0.225	0.452	0.049	0.233	0.846	2
	0.967	0.187	0.657	0.775	0.251	0.877	0.169	0.977	0.879	0.635	
	0.471	0.416	0.107	0.334	0.565	0.735	0.549	0.763	0.850	0.113	
	0.398	0.095	0.496	0.726	0.650	0.498	0.266	0.727	0.355	0.209	
	0.265	0.801	0.509	0.718	0.181	0.286	0.928	0.200	0.588	0.881	
3	0.937	0.348	0.446	0.688	0.955	0.834	0.796	0.045	0.292	0.019	3
	0.999	0.804	0.217	0.945	0.601	0.122	0.897	0.535	0.170	0.606	
	0.871	0.270	0.269	0.056	0.555	0.907	0.732	0.709	0.224	0.424	
	0.550	0.650	0.779	0.280	0.914	0.303	0.377	0.896	0.428	0.791	
	0.262	0.325	0.785	0.248	0.748	0.291	0.552	0.560	0.806	0.450	
4	0.194	0.754	0.700	0.244	0.521	0.673	0.196	0.495	0.227	0.995	4
	0.484	0.315	0.295	0.267	0.637	0.202	0.082	0.750	0.626	0.107	
	0.925	0.002	0.940	0.406	0.756	0.942	0.745	0.665	0.398	0.519	
	0.769	0.126	0.227	0.521	0.395	0.853	0.606	0.467	0.716	0.376	
	0.786	0.339	0.246	0.850	0.310	0.413	0.966	0.387	0.222	0.035	
5	0.121	0.278	0.807	0.006	0.872	0.081	0.317	0.163	0.942	0.763	5
	0.794	0.721	0.766	0.883	0.285	0.936	0.363	0.154	0.021	0.304	
	0.138	0.381	0.875	0.566	0.802	0.077	0.888	0.634	0.880	0.916	
	A		B		C		D		E		

	A		B		C		D		E		
	0.439	0.107	0.450	0.340	0.181	0.794	0.186	0.814	0.350	0.112	
	0.460	0.661	0.706	0.123	0.648	0.988	0.750	0.968	0.955	0.196	
1	0.631	0.799	0.355	0.746	0.842	0.268	0.445	0.942	0.430	0.324	1
	0.398	0.177	0.993	0.666	0.377	0.609	0.533	0.840	0.271	0.270	
	0.258	0.732	0.905	0.314	0.200	0.640	0.736	0.970	0.804	0.352	
	0.099	0.586	0.938	0.597	0.883	0.855	0.489	0.003	0.290	0.397	
	0.024	0.789	0.120	0.111	0.274	0.627	0.731	0.654	0.482	0.637	
2	0.536	0.280	0.146	0.968	0.044	0.326	0.097	0.326	0.228	0.370	2
	0.087	0.955	0.770	0.328	0.492	0.940	0.554	0.913	0.888	0.758	
	0.192	0.771	0.968	0.688	0.247	0.770	0.194	0.621	0.847	0.848	
	0.183	0.040	0.020	0.172	0.625	0.262	0.170	0.501	0.930	0.626	
	0.605	0.948	0.688	0.893	0.686	0.840	0.799	0.047	0.936	0.752	
3	0.924	0.795	0.113	0.148	0.316	0.956	0.536	0.701	0.440	0.702	3
	0.569	0.213	0.626	0.960	0.240	0.823	0.196	0.335	0.663	0.630	
	0.799	0.128	0.560	0.843	0.951	0.600	0.609	0.256	0.292	0.681	
	0.597	0.815	0.412	0.439	0.189	0.094	0.782	0.515	0.809	0.303	
	0.014	0.033	0.240	0.170	0.824	0.248	0.118	0.570	0.344	0.203	
4	0.916	0.958	0.802	0.089	0.958	0.677	0.515	0.843	0.127	0.868	4
	0.989	0.291	0.184	0.927	0.089	0.780	0.214	0.277	0.105	0.138	
	0.545	0.849	0.884	0.192	0.617	0.416	0.763	0.558	0.027	0.098	
	0.227	0.322	0.069	0.477	0.984	0.112	0.207	0.110	0.196	0.615	
	0.342	0.472	0.531	0.716	0.337	0.880	0.593	0.881	0.195	0.188	
5	0.059	0.058	0.688	0.504	0.418	0.197	0.894	0.298	0.843	0.959	5
	0.056	0.926	0.214	0.016	0.050	0.692	0.256	0.966	1.000	0.084	
	0.033	0.489	0.768	0.354	0.855	0.839	0.670	0.853	0.934	0.012	
	A		B		C		D		E		

	A		B		C		D		E		
	0.213	0.416	0.998	0.713	0.003	0.826	0.353	0.763	0.835	0.398	
	0.761	0.812	0.959	0.598	0.771	0.105	0.414	0.251	0.305	0.385	
1	0.071	0.848	0.185	0.978	0.881	0.329	0.822	0.690	0.779	0.126	1
	0.745	0.888	0.662	0.041	0.589	0.145	0.125	0.617	0.474	0.200	
	0.619	0.972	0.230	0.780	0.224	0.463	0.846	0.098	0.541	0.002	
	0.770	0.801	0.055	0.852	0.289	0.381	0.023	0.911	0.736	0.387	
	0.794	0.193	0.499	0.827	0.235	0.046	0.168	0.789	0.543	0.594	
2	0.768	0.053	0.915	0.063	0.541	0.687	0.848	0.742	0.891	0.091	2
	0.752	0.363	0.172	0.583	0.183	0.234	0.105	0.650	0.456	0.330	
	0.746	0.920	0.088	0.285	0.125	0.514	0.795	0.366	0.144	0.758	
	0.676	0.579	0.181	0.237	0.249	0.376	0.805	0.306	0.050	0.951	
	0.524	0.502	0.975	0.401	0.741	0.518	0.312	0.284	0.444	0.002	
3	0.408	0.575	0.505	0.360	0.774	0.546	0.635	0.758	0.440	0.299	3
	0.875	0.176	0.145	0.011	0.174	0.516	0.317	0.560	0.775	0.488	
	0.045	0.320	0.449	0.079	0.726	0.455	0.934	0.341	0.912	0.963	
	0.589	0.945	0.644	0.339	0.984	0.115	0.517	0.414	0.834	0.261	
	0.338	0.428	0.777	0.803	0.755	0.264	0.481	0.030	0.186	0.953	
4	0.034	0.715	0.499	0.896	0.934	0.827	0.601	0.527	0.282	0.758	4
	0.642	0.976	0.896	0.449	0.361	0.777	0.297	0.484	0.949	0.629	
	0.864	0.440	0.059	0.265	0.072	0.879	0.779	0.421	0.657	0.146	
	0.979	0.318	0.153	0.682	0.066	0.806	0.003	0.163	0.249	0.012	
	0.253	0.995	0.678	0.459	0.166	0.223	0.132	0.558	0.377	0.663	
5	0.922	0.764	0.313	0.247	0.330	0.167	0.098	0.416	0.378	0.585	5
	0.711	0.516	0.731	0.061	0.387	0.520	0.865	0.596	0.456	0.745	
	0.341	0.350	0.431	0.984	0.583	0.321	0.142	0.508	0.040	0.741	
	A		B		C		D		E		

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	A		B		C		D		E		
	0.764	0.375	0.774	0.880	0.109	0.349	0.121	0.861	0.612	0.200	
	0.614	0.527	0.172	0.266	0.018	0.374	0.036	0.623	0.341	0.427	
1	0.017	0.694	0.456	0.638	0.812	0.271	0.423	0.329	0.644	0.041	1
	0.823	0.132	0.112	0.039	0.319	0.312	0.565	0.634	0.124	0.199	
	0.001	0.938	0.180	0.639	0.207	0.918	0.905	0.490	0.938	0.019	
	0.281	0.761	0.733	0.457	0.424	0.063	0.159	0.247	0.546	0.975	
	0.503	0.360	0.556	0.533	0.829	0.490	0.527	0.286	0.557	0.078	
2	0.689	0.948	0.589	0.816	0.370	0.794	0.913	0.324	0.529	0.041	2
	0.260	0.313	0.841	0.771	0.752	0.282	0.669	0.749	0.420	0.451	
	0.204	0.118	0.165	0.209	0.865	0.429	0.366	0.493	0.509	0.945	
	0.546	0.394	0.643	0.855	0.104	0.120	0.201	0.987	0.640	0.240	
	0.230	0.569	0.865	0.696	0.044	0.494	0.030	0.699	0.204	0.105	
3	0.808	0.107	0.645	0.308	0.094	0.288	0.391	0.885	0.069	0.994	3
	0.423	0.022	0.370	0.008	0.125	0.774	0.091	0.523	0.700	0.599	
	0.819	0.415	0.405	0.856	0.065	0.079	0.408	0.541	0.723	0.309	
	0.212	0.347	0.045	0.359	0.420	0.422	0.720	0.767	0.983	0.589	
	0.444	0.389	0.427	0.634	0.055	0.337	0.519	0.444	0.644	0.703	
4	0.224	0.571	0.271	0.859	0.636	0.175	0.255	0.080	0.027	0.877	4
	0.840	0.401	0.917	0.099	0.600	0.715	0.332	0.335	0.405	0.983	
	0.233	0.580	0.966	0.419	0.092	0.243	0.175	0.179	0.743	0.611	
	0.668	0.678	0.304	0.650	0.646	0.623	0.290	0.246	0.680	0.359	
	0.430	0.392	0.388	0.807	0.455	0.004	0.586	0.442	0.179	0.162	
5	0.309	0.373	0.239	0.392	0.490	0.549	0.773	0.695	0.917	0.797	5
	0.681	0.901	0.637	0.195	0.392	0.093	0.091	0.642	0.389	0.492	
	0.134	0.119	0.276	0.503	0.096	0.319	0.135	0.225	0.953	0.169	
	A		B		C		D		E		

	A		B		C		D		E		
	0.772	0.571	0.975	0.511	0.489	0.398	0.089	0.964	0.379	0.313	
	0.838	0.849	0.592	0.814	0.914	0.928	0.438	0.875	0.712	0.507	
1	0.447	0.478	0.176	0.084	0.317	0.169	0.755	0.741	0.821	0.134	1
	0.960	0.192	0.970	0.442	0.856	0.621	0.500	0.912	0.814	0.895	
	0.941	0.780	0.393	0.912	0.252	0.713	0.386	0.158	0.941	0.599	
	0.819	0.432	0.555	0.447	0.866	0.737	0.363	0.382	0.615	0.705	
	0.937	0.970	0.331	0.751	0.633	0.711	0.234	0.174	0.518	0.644	
2	0.408	0.983	0.714	0.499	0.782	0.417	0.849	0.013	0.325	0.064	2
	0.848	0.718	0.096	0.035	0.021	0.484	0.146	0.233	0.744	0.090	
	0.814	0.540	0.268	0.199	0.913	0.387	0.614	0.335	0.493	0.194	
	0.373	0.229	0.458	0.544	0.138	0.753	0.825	0.441	0.521	0.304	
	0.748	0.235	0.421	0.304	0.568	0.329	0.098	0.348	0.371	0.646	
3	0.365	0.098	0.826	0.053	0.931	0.166	0.835	0.384	0.716	0.951	3
	0.711	0.021	0.531	0.549	0.727	0.539	0.111	0.627	0.036	0.867	
	0.111	0.106	0.980	0.418	0.757	0.475	0.157	0.525	0.793	0.326	
	0.171	0.226	0.276	0.734	0.265	0.190	0.452	0.998	0.520	0.857	
	0.749	0.458	0.832	0.004	0.218	0.492	0.375	0.428	0.966	0.285	
4	0.074	0.807	0.868	0.560	0.526	0.077	0.236	0.430	0.861	0.112	4
	0.463	0.256	0.120	0.567	0.237	0.012	0.136	0.075	0.617	0.974	
	0.903	0.948	0.531	0.315	0.050	0.839	0.977	0.882	0.196	0.982	
	0.611	0.524	0.293	0.749	0.367	0.958	0.348	0.109	0.780	0.254	
	0.438	0.791	0.982	0.027	0.170	0.127	0.820	0.943	0.075	0.887	
5	0.973	0.410	0.313	0.035	0.949	0.848	0.720	0.672	0.530	0.799	5
	0.382	0.458	0.800	0.781	0.242	0.564	0.019	0.139	0.338	0.176	
	0.751	0.263	0.344	0.467	0.941	0.795	0.019	0.880	0.515	0.415	
	A		B		C		D		E		

	A		B		C		D		E		
	0.975	0.023	0.046	0.500	0.806	0.260	0.202	0.319	0.813	0.862	
	0.600	0.130	0.373	0.995	0.048	0.501	0.552	0.519	0.846	0.403	
1	0.536	0.018	0.935	0.372	0.090	0.931	0.311	0.579	0.466	0.979	1
	0.567	0.042	0.182	0.483	0.143	0.473	0.838	0.578	0.894	0.070	
	0.956	0.913	0.130	0.915	0.895	0.415	0.558	0.554	0.975	0.636	
	0.348	0.419	0.682	0.262	0.536	0.984	0.886	0.878	0.009	0.877	
	0.141	0.217	0.422	0.261	0.384	0.716	0.326	0.212	0.353	0.610	
2	0.625	0.370	0.164	0.966	0.722	0.236	0.548	0.137	0.851	0.053	2
	0.357	0.688	0.676	0.757	0.630	0.527	0.817	0.041	0.235	0.790	
	0.114	0.741	0.129	0.805	0.802	0.800	0.615	0.417	0.741	0.455	
	0.515	0.566	0.935	0.755	0.055	0.412	0.083	0.253	0.174	0.826	
	0.557	0.484	0.163	0.242	0.221	0.150	0.397	0.763	0.868	0.113	
3	0.787	0.758	0.735	0.302	0.391	0.540	0.043	0.991	0.537	0.459	3
	0.111	0.507	0.695	0.634	0.251	0.587	0.386	0.533	0.585	0.449	
	0.824	0.682	0.521	0.056	0.088	0.302	0.128	0.562	0.334	0.244	
	0.597	0.828	0.318	0.337	0.736	0.029	0.891	0.709	0.700	0.134	
	0.768	0.644	0.400	0.481	0.528	0.573	0.928	0.824	0.537	0.445	
4	0.778	0.664	0.687	0.607	0.493	0.515	0.269	0.363	0.662	0.947	4
	0.833	0.812	0.289	0.346	0.923	0.478	0.941	0.580	0.976	0.509	
	0.635	0.995	0.723	0.558	0.349	0.432	0.155	0.276	0.129	0.326	
	0.880	0.025	0.952	0.801	0.596	0.565	0.407	0.303	0.620	0.153	
	0.624	0.276	0.934	0.715	0.372	0.111	0.823	0.740	0.650	0.676	
5	0.084	0.459	0.616	0.230	0.955	0.787	0.486	0.817	0.420	0.599	5
	0.028	0.943	0.707	0.336	0.442	0.751	0.009	0.025	0.406	0.638	
	0.257	0.953	0.580	0.071	0.474	0.137	0.481	0.277	0.533	0.292	
	A		B		C		D		E		

	A		B		C		D		E		
	0.817	0.093	0.254	0.779	0.563	0.409	0.263	0.244	0.026	0.340	
	0.267	0.817	0.444	0.908	0.830	0.238	0.270	0.990	0.287	0.607	
1	0.287	0.574	0.016	0.879	0.159	0.232	0.440	0.553	0.799	0.461	1
	0.416	0.330	0.913	0.890	0.426	0.746	0.078	0.374	0.190	0.396	
	0.116	0.197	0.178	0.223	0.794	0.327	0.401	0.499	0.666	0.475	
	0.554	0.784	0.841	0.113	0.606	0.687	0.319	0.268	0.793	0.461	
	0.777	0.671	0.420	0.990	0.215	0.825	0.222	0.591	0.264	0.230	
2	0.215	0.696	0.455	0.127	0.976	0.774	0.761	0.437	0.664	0.164	2
	0.174	0.315	0.788	0.300	0.037	0.258	0.464	0.286	0.575	0.581	
	0.262	0.845	0.246	0.789	0.815	0.539	0.766	0.646	0.034	0.860	
	0.372	0.973	0.530	0.319	0.021	0.337	0.755	0.423	0.182	0.877	
	0.696	0.264	0.848	0.895	0.963	0.121	0.620	0.738	0.446	0.657	
3	0.551	0.612	0.469	0.596	0.767	0.900	0.050	0.859	0.210	0.652	3
	0.940	0.828	0.328	0.224	0.861	0.612	0.640	0.783	0.952	0.292	
	0.493	0.163	0.854	0.979	0.858	0.562	0.690	0.143	0.796	0.904	
	0.963	0.877	0.075	0.714	0.414	0.351	0.829	0.246	0.447	0.060	
	0.441	0.183	0.880	0.986	0.755	0.034	0.642	0.540	0.393	0.665	
4	0.558	0.228	0.709	0.238	0.572	0.599	0.504	0.971	0.698	0.744	4
	0.811	0.758	0.092	0.848	0.312	0.436	0.017	0.438	0.916	0.304	
	0.017	0.260	0.953	0.564	0.947	0.011	0.425	0.468	0.083	0.789	
	0.178	0.881	0.468	0.731	0.604	0.324	0.398	0.753	0.278	0.130	
	0.979	0.811	0.476	0.125	0.423	0.314	0.456	0.090	0.189	0.066	
5	0.057	0.136	0.483	0.100	0.712	0.204	0.372	0.385	0.918	0.405	5
	0.717	0.633	0.348	0.744	0.255	0.781	0.443	0.625	0.300	0.705	
	0.305	0.247	0.661	0.493	0.889	0.764	0.577	0.169	0.261	0.398	
	A		B		C		D		E		

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Tennessee Department of Transportation
Division of Materials and Tests

Asphalt Pavement Test Strips
(SOP 3-5)

Purpose- The purpose of this document is to establish the practice of constructing test strips for asphalt pavements

Background- Test strip construction is a vital part of the construction of a quality asphalt pavement. During the test strip: the roller pattern for achieving the greatest density of the mix, the application rate of tack coat to achieve complete coverage, validation of the mix at the plant, and correction factors for the nuclear gauges used in QA and QC are all determined.

Policy- Per TDOT Specifications test strips are required: to determine the tack coat application rate before paving each new layer of asphalt (403.05.B); to produce enough mix to perform start up quality control and verification (407.03.D.2.h); and to set a roller pattern and determine a nuclear gauge correction factor (407.15.C).

Construct a test strip at the beginning of work on the pavement course. A test strip is required for each mix A new test strip will be required in the following instances:

- There is a change in job mix formula,
- A change in the source of materials occurs,
- A change in the material from the same source is observed,
- There is reason to believe that the test strip density is not representative of the mixture being placed. For example, test results are consistently above 100% density or test results have been consistent for a steady number of days and had suddenly changed significantly,
- A change in paving or compaction equipment occurs,
- A change in lift thickness, and
- A visual change in subsurface structure or subgrade condition.

Procedure- A. Tack Coat Test Strip

1. On each project and immediately prior to placing a new layer of asphalt, require the contractor to create a Tack Coat Test Strip by spraying a minimum of 100 feet of the roadway to be paved over with tack. Apply tack at a rate within the rate given for the surface condition listed in 403.05.
   a. Note the reading in gallons of the tank prior to and after application of the emulsion the Tack Coat Test Strip.
   b. To ensure enough residual asphalt is left on the surface, calculate the application rate (Gal/SY) of the Tack Coat by:

$$Tack\ Application\ Rate = \frac{(Starting\ Gallons - End\ Gallons) \times 9}{Length(ft) \times Width\ (ft)}$$

Where Length and Width are measurements of the Tack Coat Test Strip

   c. If the application rate is outside the specified limits require an adjustment to fall within the range.

2. Visually inspect the Tack Coat Test Strip. The full width should be coated evenly and completely with tack coat.
    a. If the Tack Coat Test Strip is not evenly coated with tack or excess tack is running off the site, require adjustments to be made to the application rate, size or cleanliness of the spray nozzles, height of the spray bar. The goal is to achieve a minimum double overlap of tack spray.
    b. Require the contractor to create a new 100' long Tack Coat Test Strip to evaluate changes. Repeat as necessary until full coverage is achieved.
    c. Unacceptable Tack Coat Test Strips are to be corrected prior to being covered with the next layer.
3. If emulsion is being used for Tack Coat, observe the time required for the emulsion to break, (i.e. for the water to fully evaporate as evidenced by a color change from brown to black). Require the contractor to apply tack in advance of his paving operation to at a minimum distance to achieve this breaking time for the remainder of the layer. If atmospheric conditions significantly change, the breaking time may be adjusted at the Engineer's judgment.
    a. Note: in no cases should unbroken tack be paved over.

Improper Tack Coat, Zebra Strip/Corn Rows. Unacceptable.

Good Uniform Coverage, Acceptable.

B. Establish Roller Pattern

The role of the TDOT inspector in determining the roller pattern is as an observer. The contractor is ultimately responsible for constructing an asphalt pavement to the specified density. Determining the roller pattern to achieve this density is the contractor's role.

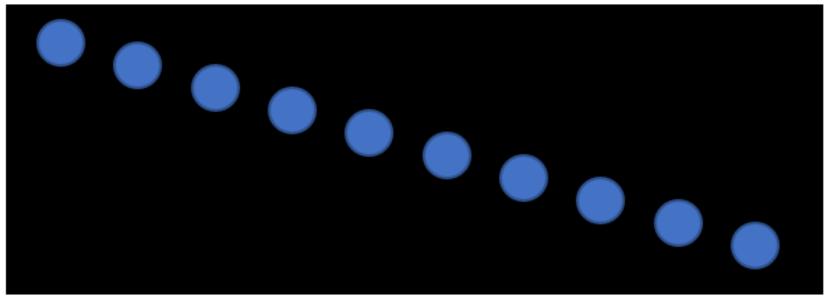
The TDOT inspector and nuclear gauge operator shall:

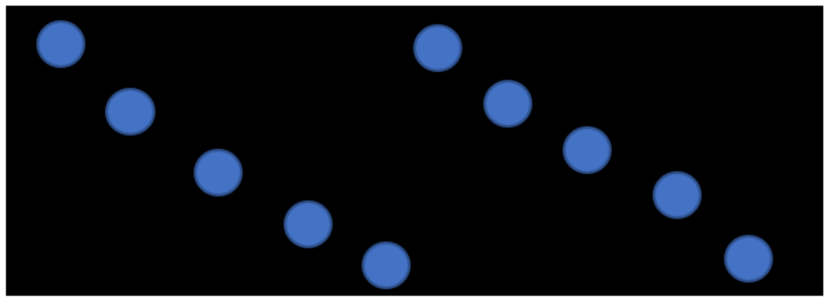
1. Document the equipment, number of passes, vibratory, frequency and amplitude information of each pass on DT0316.
2. Determine density for each pass and record it on DT0316. Make this information available to the contractor upon request. However, do not dictate the roller pattern to the contractor.

A suggested roller pattern establishment procedure is provided in the appendix for the contractor.

C. Calibrate Nuclear Gauge

1. Select at least ten locations on the test strip to run a nuclear gauge test and cut cores. The locations shall be chosen such that they represent locations along the full width and length of the project. Examples of potential patterns:





Note: some districts prefer to cut 12 cores. This is allowable. However, the low and high cores by density shall be discarded prior to step 6.

2. Conduct and record (at least) ten sets of uncorrected density (four 90 degrees test method, see SOP 7-1) tests on the compacted test strip area and record test information.
3. After running each test. Mark the location and test number on pavement with spray paint. DO NOT SPRAY PAINT THE LOCATION PRIOR TO THE NUCLEAR GAUGE TEST. This will get paint on the gauge that will need to be cleaned off.
4. Contact the contractor to cut cores and deliver them to the asphalt lab.
5. The TDOT Plant Technician shall test the cores for laboratory density in accordance with AASHTO T166.
    a. Note the contractor's technician shall not conduct this testing.
6. The nuclear gauge correction factor shall be the difference between the average of ten nuclear gauge readings and the average of ten core density values.
    a. Note this correction factor only applies to the project and the mix design.

APPENDIX

A Suggested Procedure for Establishing the Roller Pattern

This procedure is meant as a guide to the contractor as a method for establishing a roller pattern to achieve maximum density. It is not the TDOT inspector's role or duty to determine the roller pattern. The responsibility for achieving the required density rests with the contractor.

1. Establishing roller pattern and nuclear gauge calibration is required for A, BM, BM2, C, CW, D and E mixtures. Each test strip section shall be one paver width (or lane width) and a minimum of 400 square yard.

2. Compact the test strip using equipment as specified in 407.07 and 407.15. Immediately after placing the bituminous mixture, begin compacting the test strip. Perform compaction in a continuous and uniform manner over the entire test strip.

3. Nuclear readings for the Roller Pattern should be taken using the 15-second test, using the Backscatter Method after each pass at the same location.

4. Continue rolling until the apparent maximum density for the asphalt mixture is obtained. To achieve the apparent maximum density, the mat shall be rolled until the density reading decreases or flattens to no appreciable change, (i.e., less than 1 lb/ft^3). Once the density appears to decrease or flatten, make an additional pass.
    a. If the density decreases or flattens on this pass, then the maximum density will be the density achieved one roller pass before the second decrease.
    b. If the density increases, repeat these steps until maximum density has been achieved.
5. Repeat steps 1-4 with the intermediate roller to establish its roller pattern. If the mat has cooled, move forward on the project and roll the new section with the break down roller to the pattern established in steps 1-4 prior to establishing the roller pattern for the intermediate roller.

6. A roller pattern for density can be established for the final roller, if needed, following steps 1-5 above.

Tennessee Department of Transportation
Division of Materials and Tests

Nuclear Density Testing (SOP 7-1)

Purpose: The purpose of this document is to provide guidance for conducting nuclear density tests on hot mix asphalt, backfill, soil, aggregate base, embankments, and other materials requiring density tests in accordance with SOP 1-1.

Discussion: Many compacted materials on TDOT projects are accepted by means of testing with nuclear density gauges. This document intends to provide guidance and define best practices for operation of these gauges to unify testing operations statewide. Testing details of common concern include proper setup of gauge information, depth of test probes, time length of tests, and recording of data.

Basic Procedure: All test procedures shall be in accordance with AASHTO T310, "*In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)*" and ASTM D2950, "*Standard Test Method for Density of Bituminous Concrete In-Place by Nuclear Methods*" except as revised herein.

Specific instructions on conducting standard counts, entering maximum specific gravity values, offsets, correction factors, and proctor information can be found in the users' manuals corresponding to the make and model of the gauge in use.

Instructions on conducting standard counts can be found in Part Three of this SOP. You can also find specific information in the users' manual for the gauge being used.

PART ONE – ACCEPTANCE TESTING

For All Asphalt Mixtures That Require Density Testing

Step 1: Conduct Standard Count in accordance with Part Three.

Step 2: Enter maximum specific gravity (Gmm) value from asphalt mix design.

Step 3: Enter gauge correction factor from test strip. See Part Two for determining correction factors. (Note: testing may be done prior to obtaining the correction factor, however all tests done during this time must be corrected as soon as possible and prior to finalizing the records for acceptance or assurance tests.)

Step 4: Set gauge setting to Backscatter.

Step 5: Place gauge in location to be tested.

Footnote 1: For guidance on testing frequencies, random numbers, and selecting test locations, see SOP 1-1.

Step 6: Activate a test. When collecting a density test, the following approach **shall** be used:

- *"Four Nineties" Test:* Four tests shall be conducted at a single location, rotating around the test location 90 degrees at a time, as shown in Figure 1. The four test results will then be averaged to obtain a single test value for that location. Test counts for this approach shall be 15 seconds or longer.

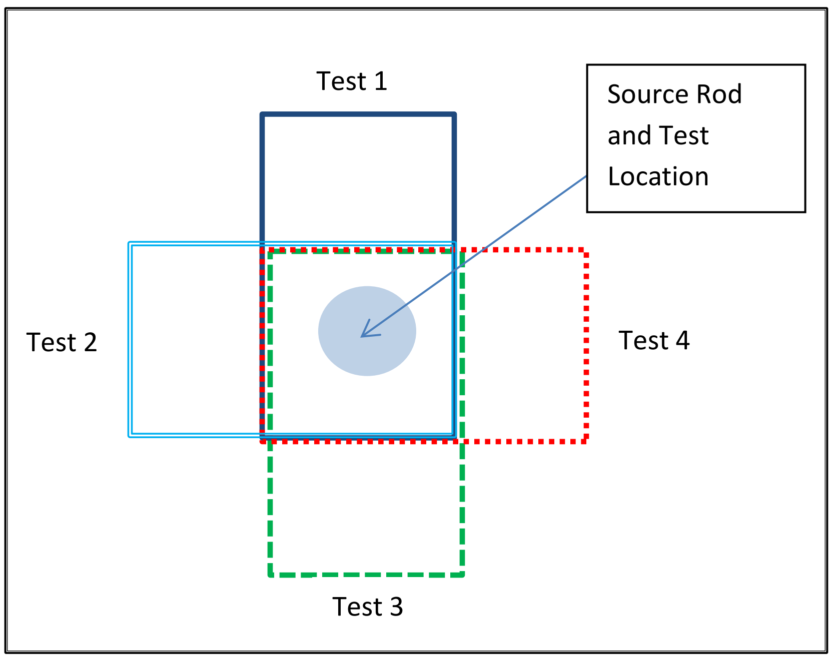


Figure 1. Testing at four 90˚ locations

Step 7: Record the test value into the appropriate paperwork.

- DT-0315, Daily Asphalt Density Report
- SiteManager D2950 – Density of Bituminous Concrete in Place

Soil and Aggregate Materials

Materials: Backfill (Earth retaining structures), Select granular backfill (Earth retaining structures), Embankments, Subgrade preparation, Lime-treated subgrade, Soil-Cement Base, Mineral Aggregate Base and Surface, Aggregate for Underdrains, Aggregate-Cement base course, Aggregate Lime fly ash base course, & Conditioned mineral aggregate base.

Step 1: Conduct Standard Count in accordance with Part Three.

Step 2: Enter maximum dry density and optimum moisture content from Proctor Density report.

Step 3: Select Test location. Create a test hole using the scraper plate, drill rod, and extraction tool provided with the gauge. Take caution to not expand the test hole when extracting the drill rod.

Footnote 2: For guidance on selecting test locations, see SOP 1-1.

Step 4: Set gauge setting to Direct Transmission at a depth reasonably close to one half the depth of the compacted lift.

Step 5: Place gauge in location to be tested and insert test probe into test hole at a depth reasonably close to one half the depth of the compacted lift. Pull gauge back to ensure probe makes contact with material being tested.

Step 6: Activate a test. When collecting a density test, the following approach shall be used:

Single Count Test: A single test shall be conducted at any test location, given that the test count is equal to 60 seconds.

Step 7: Record the test value into the appropriate paperwork.

- DT-0298, Daily Report on Soil and Aggregate Stabilization
- DT-0304, Daily Report on Embankment
- DT-0307, Daily Report on Mineral Aggregate Base
- DT-0314, Density Worksheet – Nuclear Method (Aggregate, Soil)
- SiteManager T310 – Nuclear Density/ Moisture of Soil and Aggregate

PART TWO – DETERMINATION OF ASPHALT CALIBRATION FACTORS

- Conduct test strips in accordance with most current version of TDOT Standard specifications, subsection 407.15. Nuclear Gauge readings are not valid on Asphalt until the gauge is correlated to the mix and project location. A new test strip shall be required for each project and each mix design used on the project (for mix types that require density testing as noted above). Uncorrelated gauges shall not be used for acceptance or assurance testing.
- Test strips are required for all asphalt mixtures that require density testing.
- The minimum size of a single test strip is 400 yd^2, but a larger area is recommended. The following roadway lengths provide an area of 400 yd^2 :
  - 9' wide= 400' long
  - 10' wide= 360' long
  - 11' wide= 330' long
  - 12' wide= 300' long
- Compaction of the test strip shall commence immediately after placement of the bituminous mixture.
- TDOT form DT-0316, Density and Roller Pattern Test Strip

Step 1: Compact test strip area

Step 2: Layout ten test strip test locations such that the full length and width of the test strip is covered. Mark test location and test number on pavement with spray paint. DO NOT spray base of gauge with marking paint.

Step 3: Conduct and record ten sets of uncorrected density (4 90s test method) tests on the compacted test strip area and record test information

Step 4: Cores shall be cut at same locations as nuclear density tests and tested by TDOT Plant Technician for laboratory density in accordance with AASHTO T166. (NOTE: The contractor's technician shall not conduct this testing)

Footnote 3: Only Method A of T166 shall apply when testing test strip cores for density. Cores shall be COMPLETELY DRY before testing. Accelerated drying in accordance with ASTM D 7227 (core drying device) is permitted.

Step 5: The nuclear gauge correction factor shall be the difference between the average of ten nuclear gauge readings and the average of ten core density values.

Additional notes on test strips and correction factors:

- Nuclear gauges are specific to an individual gauge, mix, and project. DO NOT develop a correction factor with a different gauge unit than the one to be used during mainline acceptance testing.
- Developing correction factors based on cores that were not allowed to dry completely will influence results in a manner that can mislead test results into appearing as if they are higher than they actually are. In other words, wet cores appear heavier or denser than they actually are.
- In accordance with TDOT Specifications, a new test strip is required when:
    - There is a change in job mix formulas
    - A change in the source of materials occurs
    - A change in the material from the same source is observed
    - There is reason to believe that the test strip density is not representative of the mixture being placed. For example, test results are consistently above 100% density or test results have been consistent for a steady number of days and had suddenly changed significantly.
    - A change in paving or compaction equipment occurs.

PART THREE – TAKING THE STANDARD COUNT

- Keep a log of your standard counts.
- Standard counts provide a quick reference check to ensure that the gauge is operating correctly.
- A standard count must be taken daily on the reference standard block.
- Max Density and Moisture Variation: **1%** for density and **2%** for moisture.

Preparatory steps before taking the standard count:

1. Turn the gauge on and let it **warm up for a minimum of 10 minutes** (Troxler & InstroTek only).
2. The base of the gauge and the top of the standard block must be clean and debris free.
3. Place the reference block on the material you will be performing the density test.
4. Troxler & IntsroTek gauges, ensure the source rod is placed at the opposite end of the butt plate.
5. Humboldt gauges, ensure the source rod is placed toward the standard block handle.
6. Make sure to slide the gauge towards and up against the butt plate (Troxler & InstroTek) or handle (Humboldt) on the standard count block.

7. Make sure the source rod is in the safe locked position before taking the standard test.
8. Make sure there are no other gauges within 30 feet.
9. Make sure to take the test in an area away from any large vertical objects including walls, vehicles and people.
10. **DO NOT** warm up the gauge or take a standard count on the tailgate of the truck.

If any one of these apply: (Does not apply to Humboldt gauges. Refer to chapter 3.2 in users manual)

- **A standard count log has NOT been kept**
- **The standard count fails**
- **The gauge hasn't been used in the last 30 days**

Do the following: (Does not apply to Humboldt gauges. Refer to chapter 3.2 in users manual)

Step 1: Take five new counts

Step 2: Average the first four

Step 3: Compare with the 5th reading using the equation below:

$$\%\ \text{DIFFERENCE} = \frac{\text{AVERAGE} - \text{5TH READING}}{\text{AVERAGE}} \times 100$$

Step 4: Check if the reading is within the required limits.

Max Density and Moisture Variation: 1% for density and 2% for moisture. If the standard count still fails, call your Regional RSO.

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**
Bituminous Additives **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 **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	10	10	-
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 3% 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.

Mix an approved antistrip agent with the asphalt cement at the dosage 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 as specified in **402** or **403**, respectively.

Do not place AS/ACRL which cannot be covered by the next course of pavement within the same construction season.

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**. Recycled Asphalt Pavement (RAP) meeting the requirements of **307.03.B** may be incorporated into asphalt treated permeable base up to 10% by weight of the aggregate. 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**.

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, except for 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 ½ inch from the lower edge of the straightedge. If the tested surface varies by more than ½ 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 adjust 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 ¼ 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.

The cost of antistrip additive used in Bituminous Plant Mix (Hot Mix) will be included in the price of Treated Permeable Base.

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 403 – TACK COAT

DESCRIPTION

403.01 Description

This work consists of furnishing and applying emulsified asphalt to a previously prepared base or surface course to provide bond for a superimposed course.

MATERIALS

403.02 Bituminous Materials

Provide materials as specified in:

Emulsified Asphalt, SS-1, SS-1h, CSS-1, CSS-1h, TST-1P,
CQS-1h, CQS-1hp, RS-1, CRS-1…………………………**904.03**
Approved Trackless Tack………………………………………... QPL

Apply tack coat at the temperature ranges specified in Table 403.02-1.

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	70 to 160 °F
Approved Trackless Tack from the QPL	Per Manufacturer's Recommendation

Dilution of asphalt emulsion used for tack coat on hot mix asphalt paving projects after leaving the terminal is not allowed. Apply the emulsion as delivered from the terminal.

EQUIPMENT

403.03 Equipment

Provide a power broom, equipment for heating bituminous material, a pressure distributor meeting the requirements of **402.03**, and such other equipment and small tools as may be required to perform the work in a satisfactory manner.

403.04 Preparing the Surface

Prepare the designated surface as specified in **404.05**. Ensure that the surface is dry when applying tack coat.

403.05 Applying Emulsified Asphalt

A. Emulsified Asphalt

Immediately after cleaning the surface, apply emulsified asphalt with the pressure distributor at a rate, established by the Engineer, within the range of 0.05 to 0.10 gallons per square yard of applied emulsion. If the bituminous material is to be placed upon a milled surface, apply at a rate, established by the Engineer, within the range of 0.08 to 0.12 gallons per square yard of applied emulsion. When applying tack coat on freshly-placed asphalt, lower application rates may be permitted, provided a full coverage application is still achieved.

For slurry seal and microsurface, apply a tack coat of SS-1h, CQS-1h, or CQS-1hp emulsion. The tack coat shall consist of one part emulsion and three parts water. The application rate shall be 0.10 to 0.15 gallons per square yard of the diluted emulsion. The Engineer will determine the actual application rate.

Protect the surfaces of trees and structures adjacent to the area being treated to prevent their being splattered or marred.

Allow the emulsified asphalt to break prior to paving the next course. Apply tack coat only so far in advance of the paving operations as is necessary to obtain this proper condition of tackiness. Protect the tack coat from damage until the next course is placed.

B. Test Strip

When setting up an initial roller pattern and density test strip for the first layer of asphalt mixture, prepare a tack coat test strip to demonstrate that the proposed equipment and methods will achieve proper application of tack coat.

For the test strip, apply the tack material at a rate of between 0.05 and 0.10 gallons of applied emulsion per square yard. 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.

In all cases, ensure that the application will result in a minimum double overlap of the actual tack spray as it lands on the surface. Adjustment of the spray-bar and the nozzles may be necessary to achieve this minimum double overlap. Corn-rows or any other pattern that would result in less than double overlap coverage of the tack coat is not acceptable for the tack application. The goal is to have a very thin but uniform coating of asphalt left on the surface when the emulsion has broken.

Once the test strip has been demonstrated and approved by the Engineer, use the same procedure and application rates for the entire project or until another design is proposed and accepted.

C. Fog Sealing

When the Contract requires bituminous material for fog sealing of shoulders, provide emulsified asphalt meeting **403.02** or an item from QPL 40A. Apply diluted emulsified asphalt at a rate of 0.10 to 0.15 gallons per square yard based on a dilution rate of one part emulsified asphalt to one part water. This application may require two equal increments if run-off occurs.

COMPENSATION

403.06 Method of Measurement

The Department will measure Emulsified Asphalt for Tack Coat and Fog Sealing by the ton, as delivered from the terminal, in accordance with **109**. The Department will make no direct payment for water used to dilute Emulsified Asphalt for Fog Sealing.

403.07 Basis of Payment

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	*Pay Unit*
Emulsified Asphalt for Tack Coat	Ton
Emulsified Asphalt for Fog Seal	Ton

The Department will measure and pay for the work required to prepare the designated surface, as provided for under **403.04**, in accordance with the applicable Section or Subsection under which the work is performed.

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 Admixtures and Additives	**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. Manufacture's documentation that asphalt binders will continue to meet requirements listed in **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.

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 plus or minus 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 (LOI) 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 plus or minus 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 plus or minus 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. **Minimum Mixture Quality Control Testing.** During production of the mixture, provide material that conforms to the approved JMF. Perform testing on mixtures to confirm conformance to the acceptance criteria and the JMF as follows. Mixes with a project total of less than 1,000 tons are exempt from all verification testing requirements unless deemed necessary by the Engineer.

1) Start Up Testing. Produce 500 tons of mixture at the beginning of production of each mixture to confirm that the mixture meets the follow requirements:

a) All mix requirements are within the tolerance defined in Table 407.03-2.

b) Gradation and Asphalt Content are within the tolerance for a 1.00 pay factor based on a single test per Table 407.20-2.

c) The average density on the test strip meets the requirements for 100% payment per Table 407.15-1.

Sample mixture for startup testing from one of the first ten trucks loaded of any mixture to complete this testing. Provide a technician certified by the Department in Asphalt Mix Design to perform all start up testing. All testing shall be done under the Department's supervision. Present all test results to the Department for approval of the mix verification.

If any of the above criteria fail verification, cease production. Make adjustments to the process and produce no more than 100 tons to retest the mixture. Once the mixture passes verification full production may proceed. If the retest fails, submit a modified JMF to the Engineer.

All nonconforming mix produced during the test strip construction is subject to acceptance and pay adjustment or removal per **407.20**.

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**

2) Production Testing. Sample and perform testing for conformance of the mix to the JMF within the tolerances defined in Table 407.20-2 on a 1000 ton maximum lot basis throughout production**.** Consider the process to be out of control and cease plant operations if test results from a single lot fall below the 0.90 pay factor limit or consecutive tests fall below the 0.95 pay factor as specified in Table 407.20-2. Make adjustments to the process and produce no more than 100 tons for testing purposes. If the retest fails, submit a modified JMF to the Engineer. The Department will not allow the project to resume unless some corrective action has been taken and documented. Once test results show results compliant with the 1.00 pay factor range full production may resume.

3) Volumetric Testing. On any project using modified asphalt cement, test all the mix design requirements per Table 407.03-2 for each half day of production. Record all results on control charts made available to the department. If results fall outside the tolerance established in Table 407.03-2 then the following applies:

a) Resample and retest.

b) If the retest meets the criteria continue on without interruption.

c) If the retest fails to meet criteria, cease production. Make adjustments to the process and produce no more than 100 tons for testing purposes. If this retest fails, submit a modified JMF to the Engineer. The Department will not allow resumption of the project unless some corrective action has been taken and documented. Once compliance is achieved, resume full production.

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 recycled 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 recycled 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 recycled 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. For all mixtures requiring design, except OGFC, follow ASTM D4867. For OGFC follow ASTM D4867 except as noted:

   a. Modify step 8.6.1 so that the three conditioned samples are subjected to a partial vacuum of 26 inches Hg for 10 minutes to whatever degree of saturation achieved.

   b. Subject the 3 conditioned samples to one freeze thaw cycle per note 6 listed in ASTM D4867 8.7. except as noted.

c. After 15h in freezer, remove samples and immediately immerse the still wrapped specimen in 77 °F water for 2 hours.

d. After 2 hours remove specimen from water bath and remove wrapping from specimen then immerse sample in 140 °F water bath for 24 hours.

All specimens tested for stripping and moisture susceptibility 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%
411 OGFC	50 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 ½-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:

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

   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 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 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 ¾ 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 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 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 plus or minus 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 both sides 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 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.

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 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, 411-TLE, 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. If the temperature meets the above requirements, outside of normal paving season, a request for a seasonal limitation waiver may be submitted for Departmental consideration. Requests shall be submitted in writing at least one week before the anticipated need.

4. If determined necessary by the Department, the Contractor may request a variance from the above required temperatures and seasonal limitations to pave at lower temperatures by submitting a Cold Weather Paving and Compaction Plan. All projects requiring a Cold Weather Paving and Compaction Plan shall utilize Intelligent Compaction to demonstrate proper coverage and compaction temperature at no additional cost to the Department; with the exception of small quantity projects, such as, but not limited to, bridge approaches, intersections, and temporary traffic shifts. Upon completion, the documentation showing appropriate coverage and compaction temperature shall be provided to the Department. Submit requests in writing at least one week before the anticipated need, and include a Cold Weather Paving and Compaction Plan 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.

   In no cases will a Cold Weather Paving and Compaction Plan or seasonal limitation waiver be approved for 411-OGFC, 411-TL, 411-TLD, or 411-TLE.

   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

Minimum temperature for OGFC mixes shall be 280º.

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 plus or minus 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 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 lift thickness, 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 centerline 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) 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. Any amount of mixture not fully adhered to the roadway shall be repaired prior to completion of the project. If the failure is not repaired the same day as originally placed, the method of repair must be approved by the Engineer prior to beginning of the repair. The repairs will be no additional cost to the Department.

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 ¼ 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 roller requirements in Table 407.15, but increase the number of rollers if the required results are not being obtained.

Table 407.15 – Roller Requirements by Mix Type

Mix Type	Roller Requirements
307-A, 307-B, 307-BM-2, 307-C, 307-CW (except surface)	3 Rollers (Intermediate roller shall be Pneumatic)
307-AS, 307-ACRL, 411-D, 411-E, 307-CW (surface), 313-Asphalt Treated Permeable Base	3 Rollers (unspecified)
411-TL, 411-TLD, 411-TLE, 307-CS (when paved as a continuous layer)	2 Rollers (unspecified)
411-OGFC	2 Rollers (both rollers shall be static steel double drum, 10 Ton minimum
Any mix used for scratch paving	2 Rollers (breakdown shall be pneumatic)

1. If the compaction effort is detrimental to the quality of the mat, immediately stop and re-evaluate rolling patterns and equipment. To modify the roller train from that which is specified for the mix, submit to the engineer a written request of the rollers to be substituted and a narrative explanation of how the specified equipment has been detrimental to the quality of the pavement.

2. The Department will only consider requests for substitution of equipment when it is shown that best practices are being followed and that the problem is not due to improper operation or poor maintenance of the equipment. If this request is approved by the Engineer, a new test strip and roller pattern shall be established.

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 1,000 tons of bituminous pavement.

4. Compaction of 411-OGFC mixtures shall consist of a minimum of two passes before the material temperature has fallen below 185 °F. 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 Table 407.15-1.

Table 407.15-1: Density Requirements for Bituminous Pavement

Mix Type	% of Maximum Theoretical Density (Lot Average)	No Single Test Less Than, % (Sub Lot)
Travel Lanes ADT <1,000 A, B, BM, BM-2, C, CW, D, E	90.0	87.0
Travel Lanes 1,000 <ADT <3,000 A, B, BM, BM-2, C, CW, D, E	91.0	89.0
Travel Lanes ADT >3,000 A, B, BM, BM-2, C, CW, D, E	92.0	90.0
Travel Lanes and Shoulders Any ADT CS, TL, TLD, TLE, OGFC	NA	NA
Shoulders B, BM, BM-2, D, E	88.0	85.0

Correct sublots that test 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, BM-2, C, CW, D, and E mixes to establish rolling patterns, to accommodate the Department to calibrate nuclear gauges, to verify that the base course or surface course mixture meets the density requirements of the specifications, and for mix design and production verification as required. A test strip is not required for mixes AS, A-CRL, CS, TL, TLD, and TLE, but adjustments to the roller pattern may be made at the direction of the Engineer.

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 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 project, mix design and the nuclear gauges used during the test strip construction. If a different mix design or nuclear gauge needs to be used, it will be necessary to cut new cores from the ongoing pavement construction to establish a new nuclear gauge correction factor. Nuclear gauge correction factors determined for a mix design on another project shall not be used.

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 ½ 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

The Department will pay for liquid anti-strip additive and hydrated lime anti-strip additive based on certified documentation of material costs not to exceed $15 per gallon and $90 per ton, respectively.

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 other asphalt modifiers, 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 continuous shift's production that does not start over at Midnight. The number of sublots in a lot will vary 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 1,000 tons, the Department will accept the mix on the basis of visual inspection and Contractor Quality Control certification. If the daily production of any mix is less than 100 tons, no tests will be required for that quantity of mix. 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 to not 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.

   Monthly, per mixture, the Engineer shall determine the correction factor for the ignition oven used for acceptance of the mixture per AASHTO T 308 and adjust the Asphalt Cement content for acceptance of the mixture 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
All mixes except 411-OGFC 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
411-OGFC only Asphalt Cement Content (Extraction or ignition oven	1.00	0.00-0.30	0.00-0.25
	0.90	0.31-0.35	0.26-0.30
	0.80	0.36-0.40	0.31-0.35
	0.60[(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
Gradation No. 8, 16, 30, & 50 sieves [(3)]	1.00	0.00-3.80	0.00-3.30
	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 No. 100 & 200 sieves [(3)]	1.00	0.00-1.80	0.00-1.60
	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. For projects with total project tonnage per mix type less than 2,000 tons (not including small quantity jobs as defined in **407.20.B.1**) the Department may alternatively calculate in place density by cores (AASHTO T-166), in this case no cores will be taken for gauge correlation on the test strip. The Department inspector conducting the density tests shall be a certified Nuclear Gauge Field Technician.

   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 Table 407.15-1. 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:

$$PA = \frac{MBI \times (DA - BA) \times T}{100}$$

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 plus or minus 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 plus or minus 2%.

Replace or overlay all mix produced with aggregate tested and found to have a LOI that differs plus or minus 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 plus or minus 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 TLE	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 and TLE.** 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 411.03-3.

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 411TLE	High Volume (ADT > 1,000)	2,000	8 – 16	4.0 ± 0.2	3 – 5.5	14
411E 411TLE	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	½
411D (PG70-22, PG76-22, PG82-22)	0	10	15	½
411E & 411TLE (Roadway)	0	15	20	½
411E & 411TLE (Shoulder)	15	30	35	½
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 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., ¾ to ½ inch, ½ 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 plus or minus 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 3% 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 for stripping by the Ten Minute Boil test for dosage rate and ASTM D4867 (Root-Tunnecliff procedure) for moisture susceptibility.

Mix an approved anti-strip agent with the asphalt cement at the dosage 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 ¼ 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-TLE Roadway	5.9
411-TLE Shoulder	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 415 – COLD PLANING OF BITUMINOUS PLANT MIX PAVEMENTS

DESCRIPTION

415.01 Description

This work consists of cold planing an existing bituminous plant mix pavement.

EQUIPMENT

415.02 Equipment

Provide a power broom, a water truck, and a planing machine, as well as equipment to remove the material planed from the pavement.

The planing machine shall be a power operated, self-propelled milling machine or grinder capable of removing bituminous concrete to the required width, depth, profile, cross-slope, and surface texture. The machine shall be capable of accurately establishing profile by referencing from either the existing pavement or from an independent grade control and shall have positive means for controlling cross-slope. The machine shall have a floating moldboard with sufficient down pressure to plane the milled surface. The machine shall have an effective means of removing cuttings from the pavement and for preventing dust from escaping into the air.

When milling the Interstate or controlled access freeways, the planing machine shall be capable of restoring pavement profile with a non-contact leveling system. The non-contact leveling system shall have a minimum of three sensors dispersed the length of the machine.

The maximum spacing between teeth on the cutter drum shall not exceed 5/8 inches. Provide supplemental equipment as necessary to remove material in areas that cannot be reached by the planing machine.

CONSTRUCTION REQUIREMENTS

415.03 General Requirements

Coordinate operations so that vertical longitudinal faces do not exceed 1-1/4 inches in height in areas to be used by public traffic. Taper transverse faces in a manner approved by the Engineer to avoid creating a traffic hazard. Perform cold planing in the direction of traffic.

When milling roadways for hot mix overlays, operate the planing machine at a consistent forward speed to provide an acceptable surface texture. The maximum allowable forward speed shall be 60 feet per minute when the teeth spacing is between ½ and 5/8 inches, and 80 feet per minute when the teeth spacing is less than ½ inch.

After planing, ensure that the finished surface provides a smooth riding surface free of scallops, scabs, gouges, ridges, oil film, and other imperfections of workmanship, has a uniform texture, and is true to the required grade and cross-section. The elevation of the longitudinal edges of adjacent cuts shall not differ more than 1/8 inch.

Do not begin milling unless the subsequent layer of pavement can be placed within the limitation specified in **407.09**.

Thoroughly sweep the planed pavement immediately behind the machine, and haul away all materials swept up. When the Engineer deems necessary, provide and use a water truck to control dust.

Where sound pavement has been gouged, torn, or otherwise damaged during the milling operations, or damage is done to any other property of any kind including utility frames, grates, and covers, make repairs at no cost to the Department. Take appropriate measures so that the cold planing operation does not trap water.

415.04 Surface Requirements

Where the planed pavement is not to be resurfaced, provide a uniform texture throughout the Project and a satisfactory riding surface. The average texture depth shall be no less than 0.20 inches.

The finished surface on the Interstate and controlled access freeways shall be of uniform profile throughout, without any scabbing, scallops, gouges, ridges, or other imperfections resulting from worn cutter teeth, improper operating speeds, poor equipment maintenance, or other instances of poor workmanship. The cross-slope shall be as shown on the Plans in the tangent, transition, and super-elevated curve sections.

The finished surface after the final cut shall not show a deviation greater than 1/8 inch from a 10-foot straightedge, and the cross-slope shall not deviate more than 3/8 inches in 10 feet. Correct all irregularities exceeding these limits.

Texture all approaches and tapers when required by the Engineer. Length, width, and depth of cut on approaches and tapers shall be as determined by the Engineer. Match the approaches and tapers to the finished cut on the main line, and transition to the existing surface to within plus or minus 1/8 inch.

When deemed necessary by the Engineer, transition private entrances to provide a smooth approach to the roadway.

Unless otherwise shown on the Plans, take ownership of the cuttings and remove them from the Project.

COMPENSATION

415.05 Method of Measurement

The Department will measure Cold Planing of Bituminous Pavement by the quantity of material removed in tons or cubic yards, or by the square yard of planed pavement. The method of measurement will depend upon the pay item designated in the proposal.

Where payment is by the square yard, the Department will measure the pavement acceptably planed by the square yard in accordance with **109.**

Unless otherwise specified, the Department will not measure water used to control dust for separate payment but will consider it incidental to the planing operation.

415.06 Basis of Payment

The Department will pay for the accepted quantity of Cold Planed Bituminous Pavement at the contract unit price, which payment shall be full compensation for all labor, materials, equipment, hauling, and incidentals necessary to plane the pavement, control dust, and dispose of the cuttings.

STATE **OF** **TENNESSEE**

(Rev. 12-15-21)
(Rev. 12-19-22)
(Rev. 10-17-23)
(Rev. 12-27-23)

January 1, 2021

Supplemental Specifications – 400SS

of the

Standard Specifications for Road and Bridge Construction

January 1, 2021

Subsection 403.04, (pg. 285), 12-15-21; **Preparing Surface;** Revise Paragraph:

Prepare the designated surface as specified in **405.05**. Ensure that the surface is dry when applying tack coat.

Subsection 403.04, (pg. 285), 12-27-23; **Preparing the Surface;** Revise Paragraph:

Prepare the designated surface as specified in **405.05**. Ensure that the surface is swept clean and dry when applying tack coat.

Subsection 403.05.C, (pg. 286), 12-15-21; **Fog Sealing;** Revise 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. Apply diluted emulsified asphalt at a rate of 0.10 to 0.15 gallons per square yard based on a dilution rate of one-part emulsified asphalt to one part water. This application may require two equal increments if run-off occurs. Apply fog seal when the ambient air temperature or the surface temperature is a minimum of 50°F.

Subsection 405.06.A, (pg. 290), 12-27-23; **Applying Bituminous Material;** Revise 3rd Paragraph:

At least ~~14~~ 7 working days before the scheduled start of construction of any bituminous seal coat, submit a starting aggregate spread rate and emulsion shot rate as determined by AASHTO R 102 or an equivalent design method. ~~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.

Subsection 407.03.E.1, (pg. 310), 10-17-23; **Tensile Strength Ratio;** Revise 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%
411 OGFC	50 psi	70%

Subsection 407.06.B, (pg. 324), 12-19-22; **Material Transfer Devices (MTDs);** Revise 2nd Paragraph:

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 to allow feeding the paving machine from the front, side or rear.

Subsection 407.09, (pg. 326-327), 12-15-21; **Weather Limitations;** Revise No. 2 & 3:

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. Placement may proceed if either the air or surface temperature is met except for 411-TL, 411-TLD, 411-TLE, and 411-OGFC mixtures.

   Measurement of the surface temperature shall be done on pavement that is shaded from direct sunlight unless no shaded location exists. If paving based on the air temperature, stop work once the air temperature falls below the minimum threshold. Do not start paving if the surface temperature does not meet the requirements and the air temperature is forecast to fall below the minimum temperature within 4 hours of starting work.

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. For 411-TL, 411-TLD, 411-TLE, and 411-OGFC mixtures, placement shall proceed only when the pavement surface temperature and the air temperature are a minimum of 55° F and rising. Stop paving if the air temperature falls below 55°F immediately. Placement of these mixtures is restricted to the period between April 1 and October 31.

   For all other mixtures, 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. If the temperature meets the above requirements, outside of normal paving season, a request for a seasonal limitation waiver may be submitted for Departmental consideration. Requests shall be submitted in writing at least one week before the anticipated need.

Subsection 407.09, (pg. 326-327), 12-27-23; **Weather Limitations;** Revise Table 407.09-1, No. 3, and Remove No. 4:

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~~ < 2.0 inches	45	55
~~> 1.5 inches to < 3.0 inches~~	~~40~~	~~50~~
≥ ~~3~~ 2.0 inches	35	35[1]~~45~~
[1]If compacted thickness < 3 inches and Temperature is < 55 degrees, an approved Warm Mix Additive is required in the mix.		

3. For 411-TL, 411-TLD, 411-TLE,and 411-OGFC mixtures, placement shall proceed only when the pavement surface temperature and the air temperature are a minimum of 55°F and rising. Stop paving if the air temperature falls below 55°F immediately. Placement of these mixtures is restricted to the period between April 1 and October 31.

   ~~For all other mixtures, 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. If the temperature meets the above requirements, outside of normal paving season, a request for a seasonal limitation waiver may be submitted for Departmental consideration. Requests shall be submitted in writing at least one week before the anticipated need.~~

4. ~~If determined necessary by the Department, the Contractor may request a variance from the above required temperatures and seasonal limitations to pave at lower temperatures by submitting a Cold Weather Paving and Compaction Plan. All projects requiring a Cold Weather Paving and Compaction Plan shall utilize Intelligent Compaction to demonstrate proper coverage and compaction temperature at no additional cost to the Department; with the exception of small quantity projects, such as, but not limited to, bridge approaches, intersections, and temporary traffic shifts. Upon completion, the documentation showing appropriate coverage and compaction temperature shall be provided to the Department. Submit requests in writing at least one week before the anticipated need, and include a Cold Weather Paving and Compaction Plan 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.~~

   ~~In no cases will a Cold Weather Paving and Compaction Plan or seasonal limitation waiver be approved for 411-OGFC, 411-TL, 411-TLD, or 411-TLE.~~

   ~~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.~~

Subsection 407.15.A, (pg. 334), 12-19-22; **Compaction, General;** Revise Table 407.15:

Table 407.15 – Roller Requirements by Mix Type

Mix Type	Roller Requirements
307-A, 307-B, 307-BM-2, 307-C, 307-CW (except surface)	3 Rollers (Intermediate roller shall be Pneumatic)
307-AS, 307-ACRL, 411-D, 411-E, 307-CW (surface), 313-Asphalt Treated Permeable Base	3 Rollers (unspecified)
411-TL, 411-TLD, 411-TLE (when lift thickness > 1 inch)	3 Rollers (unspecified)
411-TL, 411-TLD, 411-TLE, 307-CS (when paved as a continuous layer)	2 Rollers (unspecified)
411-OGFC	2 Rollers (both rollers shall be static steel double drum, 10 Ton minimum
Any mix used for scratch paving	2 Rollers (breakdown shall be pneumatic)

Subsection 407.15.B, (pg. 336), 12-27-23; **Density Requirements;** Revise Table 407.15-1:

Table 407.15-1: Density Requirements for Bituminous Pavement

Mix Type	% of Maximum Theoretical Density (Lot Average)	No Single Test Less Than, % (Sub Lot)
Travel Lanes ADT <1,000 A, B, BM, BM-2, C, CW, D, E TL, TLD, TLE (lift thickness > 1 inch)	90.0	87.0
Travel Lanes 1,000 <ADT <3,000 A, B, BM, BM-2, C, CW, D, E TL, TLD, TLE (lift thickness > 1 inch)	91.0	89.0
Travel Lanes ADT >3,000 A, B, BM, BM-2, C, CW, D, E TL, TLD, TLE (lift thickness > 1 inch)	92.0	90.0
Travel Lanes and Shoulders Any ADT CS, ~~TL, TLD, TLE~~, OGFC TL, TLD, TLE (lift thickness <= 1 inch)	NA	NA
Shoulders B, BM, BM-2, D, E TL, TLD, TLE (lift thickness > 1 inch)	88.0	85.0

Subsection 407.15.C, (pg. 336-337), 12-15-21; **Test Strips;** Revise 1st Paragraph:

Construct test strips for all mixtures that require density testing to establish rolling patterns, to accommodate the Department to calibrate nuclear gauges, to verify that the base course or surface course mixture meets the density requirements of the specifications, and for mix design and production verification as required. Adjustments to the roller pattern may be made at the direction of the Engineer for mixtures that do not require density testing.

Subsection 407.20.B.2.a, (pg. 342), 12-27-23; **Defective Materials, Acceptance or Rejection;** Revise 3rd Paragraph:

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. The Contractor may submit a written request to have the split sample tested at a Regional Laboratory.

Subsection 407.20.C.3, (pg. 346-347), 12-15-21; **Loss on Ignition (LOI);** Revise 2nd & Remove 4th Paragraph:

If the percent of LOI in the aggregate differs by plus or minus 2% from the LOI indicated in the JMF, the Department will make a payment deduction in the price bid for the mix applied to the entire days production, 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 plus or minus 2%.

Subsection 411.03.B, (pg. 353), 12-15-21; **Proportioning;** Revise Table 411.03-01:

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)	93.5 – 94.0	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 TLE	93.0 – 94.3	5.7 – 7.0 (1)
Grading TLE (shoulders)	93.5 – 94.0	6.0 – 6.5 (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%.

Subsection 411.03.B.4, (pg. 356), 10-17-23; **Grading OGFC;** Revise Table 411.03-5:

Table 411.03-5: Mixture Properties (Grading OGFC)

Mix	Minimum Void Content % (1)	Voids in Coarse Aggregate % (2)	Max. Cantabro Abrasion Loss % (2) (3)	Drain Down Loss % (4)
411OGFC	17	VCA_{DRC} > VCA_{MIX}	20	<0.3%

(1) Determined using the "Volume Method" described in Section 6.2.2. of AASHTO T 269.

(2) As described in National Asphalt Pavement Association (NAPA) Publication IS-115, "Design, Construction and Maintenance of Open-Graded Friction Courses."

(3) Cantabro Abrasion Loss specimens shall be aged as loose mix for 4 hours at lab compaction temperature.

(4) Tested in accordance with AASHTO T 305.

Subsection 411.03.C.1, (pg. 357), 12-27-23; **Recycled Asphalt Pavement;** Revise 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)
411-D (PG64-22, PG67-22)	0	15	20	½
411-D (PG70-22, PG76-22, PG82-22)	0	10	15	½
411-E & 411-TLE (Roadway)	0	15	20	½
411-E & 411-TLE (Shoulder)	15	30	35	½
411-TL (PG64-22, PG67-22)	0	15	15	5/16
411-TL (PG70-22, PG76-22, PG82-22)	0	10	10	5/16
411-TLD (PG64-22, PG67-22)	0	15	15	5/16
411-TLD (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 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., ¾ to ½ inch, ½ inch to #4, etc.). The Contractor may use the larger percentages of fractionated RAP specified only if the stockpile meets the consistency requirements set forth in Departmental procedures for approval of asphalt mix designs. ~~individual fractions of two different maximum particle size are introduced into the plant as separate material sources for increased control.~~

Subsection 411.03.C.1, (pg. 358), 12-15-21; **Recycled Asphalt Pavement;** Revise 2nd Paragraph:

All mixes shall contain at least 80% virgin asphalt, except for 411E Shoulder and 411TLE Shoulder Mixtures, which shall have at least 65% virgin asphalt.

Subsection 414.03.B, (pg. 367), 12-19-22; **Micro-Surfacing;** Revise Table 14.03-3:

Table 414.03-3: Micro-Surfacing

Test	Requirement
Mixing Time Test, seconds at 77 °F (T-102)	120 min
Mix Time, at 50 and 100 °F	(informational)
Set Time Tests: 30 minutes (T-139)	12 kg-cm min
Early Rolling Traffic Time: 60 minutes (T-139)	20 kg-cm min
Wet Stripping Test, % coating (T-114)	90% min
Wet Track Abrasion Test, loss in g/ft^2 (T-100)	75 max 6 days 50 max 1 hour
Measurement of Excess Asphalt (T-109)	50 grams/ft^2 max Sand Adhesion, 1,000 Cycles at 125 lbs
Classification Compatibility (T-144)	11 pt. min
~~Loss on Ignition (LOI) Test, **407.03.E.3**~~	~~(informational)~~

Subsection 414.06.B, (pg. 377), 12-19-22; **Quality Control;** Add Subsection 5:

5. **Aggregate Gradation**. Prior to the start of production and at a minimum of once per day of production, perform a washed gradation (AASHTO T 27 with AASHTO T 11) of the stockpiled aggregate to ensure the gradation meets the mixture control tolerances of Table 903.12-2.

Subsection 415.03, (pg. 382), 12-19-22; **General Requirements;** Revise 1st Paragraph:

Coordinate operations so that vertical longitudinal faces do not exceed height requirements indicated by plans in areas to be used by public traffic. Taper transverse faces in a manner approved by the Engineer to avoid creating a traffic hazard. Perform cold planing in the direction of traffic.

S T A T E **O F** **T E N N E S S E E**

(Rev. 5-15-17)
(Rev. 4-15-19)
(Rev. 11-9-20)

January 1, 2021

SPECIAL PROVISION

REGARDING

BITUMINOUS PLANT MIX PAVEMENTS (HOT MIX)

ROADWAY DENSITY

Description

This work consists of the requirements for acceptance of asphalt roadway density by use of core samples, and for testing and acceptance of asphalt longitudinal joint density.

Meet all requirements of **407** of the Standard Specifications except as modified.

407.03.D.2.h - Contractor Quality Control System. Add the following between the second and third paragraphs:

Conduct quality control testing of surface and binder mixes for roadway density throughout placement to verify that the mixture being placed meets specified density requirements. A Quality Control Plan (QCP) for this density testing is required. Acceptable methods of quality control testing include coring, nuclear gauge testing, and non-nuclear gauge testing. Document all tests and records from the control strip (if any). Make quality control records available upon request to the Department.

407.07 - Rollers. Replace the entire subsection with the following:

Provide a sufficient number and type of self-propelled rollers to achieve proper compaction and obtain the specified densities.

407.15 - Compaction. Replace the entire subsection with the following:

A. General

After the bituminous mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly compacted. Use a method that shall be capable of compacting the mixture to the specified density while it is in a workable condition. Rollers shall not park or be refueled on the bituminous pavements.

B. Density Requirements

Meet the applicable density requirements for travel lanes and joints as specified in Table 407DEN-1 and Table 407DEN-2.

1. Mix Types: All Travel Lanes for A, B, BM, BM-2, C, CW, D, E
2. All levels of ADT
3. %Gmm values specified are for lot averages.

Table 407DEN-1

Travel Lane Density		
% Gmm		% Pay
Min	Max	
99.0	100	90
98.0	<99	94
97.0	<98	98
96.0	<97	100
95.0	<96	101
94.0	<95	102
93.0	<94	101
92.0	<93	100
91.0	<92	98
90.0	<91	94
89.0	<90	90
88.0	<89	86
	<88	*

Table 407DEN-2

Joint Density Incentive/Disincentive		
%Gmm		$/L.F./Lot
Min	Max	
98.0	100	*
97.0	<98	-0.70
96.0	<97	-0.42
95.0	<96	0.00
94.0	<95	0.00
93.0	<94	0.07
92.0	<93	0.14
91.0	<92	0.07
90.0	<91	0.00
89.0	<90	-0.14
88.0	<89	-0.42
87.0	<88	-0.70
86.0	<87	-0.98
	<86	*

*Shall be removed and replaced at no cost to the Department or as directed by the engineer.

% Pay for travel lanes shall be applied to the theoretical quantity of the mix on the travel lanes only, even when the shoulder and travel lane are placed concurrently. No incentive shall be paid for the second travel lane unless the joint for that lot is a minimum of 90.0%.

Any lot of joint density tests averaging below 87% shall be sealed at no cost to the Department. Approved sealers are listed on the Department's Qualified Products List (QPL), Listing #40 for Pavement Sealers. Sealing of deficient longitudinal joint lots will only be required for surface mixes. No incentive/disincentive shall be applied to a longitudinal joint between a travel lane and a shoulder.

Meet the applicable density requirements for shoulders as specified in Table 407DEN-3.

1. Mix Types: All shoulder mixes
2. All levels of ADT
3. %Gmm values specified are for lot averages.

Table 407DEN-3

Shoulder Density		
% Gmm		% Pay
Min	Max	
98.0	100	*
97.0	<98	96
96.0	<97	98
95.0	<96	100
94.0	<95	100
93.0	<94	100
92.0	<93	100
91.0	<92	100
90.0	<91	100
89.0	<90	100
88.0	<89	100
87.0	<88	98
86.0	<87	94
85.0	<86	90
	<85	*

* Shall be removed and replaced at no cost to the Department or as directed by the engineer.

% Pay for shoulders shall be applied to the theoretical quantity of mix on the shoulder even when the travel lane and shoulder are placed concurrently.

407.20.B.5 - Acceptance of the Mixture. Replace the entire subsection with the following:

5. Acceptance for Mix Density on the Roadway

a. **General.** The Department will apply a deduction in payment, not as a penalty but as liquidated damages, for failure to meet the density requirements as specified in **407.15.B**. As soon as practical after the final rolling is completed on each lot, 5 density tests (1 per sublot) shall be performed by the Department at random locations determined by the Engineer, and an average of all such tests shall be computed. Any deduction for failure to meet density requirements or incentive for exceeding density requirements shall be computed to the nearest 0.1% as a percentage of the total payment otherwise due for each lot.

Consecutive lots with density deductions is cause to stop production as directed by the Engineer. Adjust the rolling operation and Quality Control Plan to achieve the required density. Construct a test strip of not more than 250 tons to demonstrate to the Engineer that the changes made produce densities meeting the requirement without deductions. Only resume full production after the Engineer has accepted the test strip.

b. Travel Lane, Turning Lane, Ramp or Shoulder Density. For density acceptance purposes, the pavement shall be divided into lots of 1,000 tons for surface mixes (D, E, C, and CW), 2,000 tons for intermediate mixes (B, BM, and BM2), and 3,000 tons for base mixes (A). Lots shall be divided into 5 even sublots. One core will be tested in each sublot and the average for the entire lot shall be compared with the requirements in Table 407DEN-1 for travel lanes or Table 407DEN-3 for shoulders. When possible, attention should be provided to avoid cutting cores in areas where signal/loop wire may be affected. If test location selections indicate testing locations in these areas, a new random number should be selected. At the beginning of a project or at any time advisable, the Department may consider smaller lots to evaluate compaction methods or for other reasons as approved or directed by the Engineer.

c. Joint Density. For density acceptance purposes, joints shall use the same length lot and longitudinal coring location as the last adjoining lane to be paved. The average of the 5 cores for the entire lot shall be compared with the requirements in Table 407DEN-2. At the beginning of a project or at any time advisable, the Department may consider smaller lots to evaluate compaction methods or for other reasons as approved or directed by the Engineer.

d. Test Method. Five randomly selected cores (4” min./ 6” max. diameter), from each lot, will be tested to determine density compliance and acceptance. The density (bulk specific gravity) determination for a compacted asphalt mixture shall be performed 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 D 7227.

The Bulk Specific Gravity (G_{mb}) of the cores shall be averaged for each lot.

For **lanes and shoulders** the maximum theoretical gravity (G_{mm}) from acceptance testing for that shift’s production will be averaged and the percent density will be determined for compliance by dividing the G_{mb} average for each lot by the G_{mm} daily average.

For **joints** the maximum theoretical gravity (G_{mm}) from acceptance testing for both adjoining lanes shall be averaged, and the percent density will be determined for compliance by dividing the G_{mb} average for each lot by the G_{mm} daily average.

Obtain the cores at the locations randomly selected by the Engineer. The Department will test the cores by a certified plant technician.

If a lot is split between two days, determine the percent density of each individual core using the daily G_{mm} average from the day the sublot (represented by the core being tested) was paved.

After obtaining the cores, all core holes shall be properly filled and compacted in kind with hot mix asphalt at no additional cost to the Department.

Cores shall be clearly labeled in a discrete, sequential manner (i.e. – M1, M2,...,M30; J1, J2,...,J15) throughout the course of the project. After testing, cores shall be retained along with copies of test results and will be periodically obtained by regional materials and tests for spot-check verification testing. The cores may be discarded, if regional materials and tests determines that they are no longer needed for payment or dispute resolution.

e. Incentive/Disincentive Payment. The Department shall apply the incentive disincentive payment in accordance with the tables in **407.15.B**.

Any deduction in monies due the Contractor for failure to meet the density requirements shall be made under the item for Density Deduction.

Any incentive payment due the Contractor shall be under the item for Density Incentive.

STATE OF TENNESSEE

August 14, 2017 January 1, 2021
(Rev. 10-17-19)
(Rev. 11-5-21)

SPECIAL PROVISION

REGARDING

INTELLIGENT COMPACTION (IC) FOR HOT MIX ASPHALT (HMA)

Description

This work consists of the requirements for modification of standard HMA compaction equipment for the purpose of tracking and documenting location, and temperature. Compaction equipment and procedures shall meet all requirements listed in **407.07** and **407.15** except as modified herein.

Equipment

A. Rollers

Install Intelligent Compaction equipment meeting the requirements listed herein on the first (breakdown) and second (intermediate) roller in the roller train. Roller type(s) are to be as required in **Table 407.15 – Roller Requirements by Mix Type**. The IC systems may be either an integrated system or an added-on/retrofit systems.

B. Global Navigational Satellite System (GNSS)

Rollers shall be equipped with a GNSS units to monitor the equipment locations and track the number of roller passes utilizing the same reference system. GNSS system shall have a survey tolerance of not greater than 2.0 in in both the horizontal (x and y) directions.

GNSS receivers shall utilize the Universal Transverse Mercator (UTM) or Tennessee State Plane coordinate system. Once declared, the coordinate system utilized shall be the same for both rollers for the entire project.

GNSS data shall be in the following format:

1. Time: Military, local time zone, hhmmss.ss
2. GNSS: Latitude/Longitude, degrees/minutes; ddmm.mmmmmmmm or decimal degrees; dd.dddddddd
3. Grid: Meters, 0.001 m

C. Temperature Measurement

Rollers shall be equipped with non-contact temperature sensors for both the forward and reverse directions for measuring pavement surface temperatures. Temperature sensor shall be accurate to ±3°F.

D. Integrated On-Board Documentation System

An on-board documentation system that is capable of displaying real-time color-coded maps of IC data as defined under Project IC Data.

The Intelligent Compaction System shall be capable of transferring the Project IC Data by means of cellular data upload to cloud storage during the day's production.

E. Cloud Storage and Cloud Computing

Provide a system of cloud storage and cloud computing. The cloud storage shall be sufficient to contain all Project IC Data associated with the contract and accessible to the Department. The cloud computing system shall support real-time visualization/mapping of the Project IC Data. Paving operations shall not begin until real-time access is granted to the Department.

Project IC Data is to be uploaded throughout the project in real-time if data cellular coverage allows, but not less than once per day otherwise. If cellular data coverage for uploading the data at the project site is unavailable, upload the data prior to the next day's production by other means.

Provide the Department with unlimited review access to the intelligent compaction records through cloud storage and cloud computing starting from the beginning of the project paving until project finalization.

Construction Requirements

A. Project IC Data

Track and record the Project IC Data for the contract. Project IC data shall consist of:

1. Location of the roller in real time,
2. Number of roller passes at a given gridded location,
3. Pavement surface temperatures associated with each roller pass, and
4. The roller speed associated with each roller pass.

All data is to be gridded in one foot by one foot grid.

At the end of the project, provide a copy of the final Project IC Data for each pavement layer in a separate digital file to the Department formatted in the most current version of Veta. Veta is available at www.intelligentcompaction.com.

Export the raw or gridded data:

1. Directly into Veta if a file format compatible with Veta is available, or
2. Through a direct transfer of data from cloud storage to Veta.

Ensure that the date/time stamp is reflective of the local time zone for both mapped and exported data.

B. System Failure

In the event that the intelligent compaction system does not work due to failure of the system, work may continue for the day's production. The Intelligent Compaction system must be operational prior to starting the next day's production.

Notify the Engineer if real time data cannot be uploaded to cloud storage due to lack of cellular data or satellite coverage. Notification must be made each day if real time uploading of data is unavailable. In instances where the file is not uploaded in real time to the cloud storage, it must be uploaded by other means prior to the next day's paving.

File Name

Name Veta project files (*.VETAPROJ) using filenames CNXXXX_ROUTE_HMA_YYY standardized format where XXXX is replaced by the contract number (e.g. Z999), YYY is replaced with the mix type (e.g. D, BM2, TLD, etc) and ROUTE is replaced with the five character State Route or Interstate designation (e.g. SR001 or I0040).

Method of Measurement & Basis of Payment

The Department will not measure and pay for Intelligent Compaction directly, and will consider such work incidental to other items of work relating to the placement of Asphalt.

S T A T E **O F** **T E N N E S S E E**

October 19, 2020 January 1, 2021
(Rev. 12-20-23)

SPECIAL PROVISION

REGARDING

ELECTRONIC TICKET DELIVERY SYSTEM

FOR ASPHALT

Description

This work shall consist of the use of an Electronic Ticket Delivery System (e-ticketing) for certified weights of asphalt mixtures delivered to the project site.

Construction Requirements

Provide electronic Certified Public Weigher e-tickets for each load of asphalt mixtures that are delivered to the project. E-tickets shall be automatically generated using a combined software and hardware fleet management system or an e-ticketing delivery system. Fully integrate the e-ticketing system with the load read out scale system used to weigh the mixture being delivered.

The system shall be capable of maintaining the data offline due to loss of power or connectivity.

Provide real time continuous ticketing system access to the Department for the duration of the project using a web based application. E-ticketing delivery system shall be identified and access granted after an agreement has been reached between the Contractor and Department to allow the e-ticketing delivery system chosen. Provide on-site technical assistance as needed during the project to operate the system. Do not deliver any mixture to the project that will use the e-ticketing system before an agreement has been reached.

The e-ticketing system shall allow individual certified e-tickets and generate daily summary sheets to be exported as PDF files by the Department. The system shall be designed so data inputs from scales cannot be altered by either the Contractor or the Department. The Department shall have the ability to make notes on each e-ticket for documentation of tests, comments, or rejection of load. At the end of each asphalt paving placement shift, generate a shift summary sheet of the e-tickets and make available for the Engineer within 24 hours of the shift ending. The e-tickets shift summary sheet shall list all the required information in tabular form and be signed by a Certified Public Weigher. Any loads in excess of the legal weight limit shall be rejected and no payment will be issued.

The certified e-tickets for asphalt mixtures shall be accessible real time at any point during or after placement of the mixture. The certified e-tickets and shift summary sheets shall include the following:

1. Mixture Type, Item Description
2. TDOT Mix design number
3. Project Number, County, Route
4. Date
5. Ticket number
6. Gross weight of the loaded truck
7. Tare weight of the truck
8. Net weight of the mixture to be paid
9. Running Daily Total for the particular mixture
10. Truck number
11. Truck Legal limit
12. Time Loaded
13. Time offloaded
14. Engineer Comments (if applicable)

Method of Measurement

Utilize an electronic ticket delivery system (e-ticketing) for asphalt as specified. If any e-tickets or the shift summary sheets are not available for the Engineer, payment may be withheld for the items of work on the monthly estimate.

Basis of Payment

The Department will not directly pay for the electronic ticket delivery system (e-ticketing) separately. The contract unit prices for the asphalt mixtures that e-tickets are required to be used shall be full compensation for all activities, including materials, equipment, labor, and any incidentals to complete the work as specified.

CIRCULAR LETTER

SECTION: 109.01 MEASUREMENT OF QUANTITIES
NUMBER: 109.01-02
SUBJECT: TRUCK WEIGHT LIMITS
DATE: OCTOBER 2, 2015

The Department now will require that all weight tickets conform to the new limits outlined on these sheets as required by law.

Interstate weight limits shall apply when hauling on any of the following:

a) Ramps entering or exiting the interstate system.
b) Any portion of an existing interstate open or previously opened to traffic.
c) The surface course of a new interstate facility (never opened to public traffic). However, Non-Interstate Highway limits will apply to hauling on the subgrade or base courses of newly constructed interstate widening projects if accessed by non-interstate routes.
d) New and existing structures on interstates.

In consideration of the status of construction, relative to the present federal interstate system, it is considered that the above determinations provide adequate guidance as to the applicability of interstate truck weights.

SECTION I: Non-Interstate Highway

1) Two axle truck (one front, one rear)
   20,000# each axle
   Maximum gross weight = 40,000# *

2) Three axle straight (one front, tandem rear)
   Front axle = 20,000#
   Tandem axle = 34,000#
   Maximum gross weight = 54,000# *

   Exception: Class 9 tag or zone tag
   Maximum gross weight = 66,000# *

3) Four axle straight (one front, three rear)
   Front axle = 20,000#
   Single axle rear = 20,000#
   Tandem axle = 34,000#
   Maximum gross weight = 74,000# *

4) Three axle truck tractor and trailer (one axle front of tractor, one rear of tractor, one rear of trailer)
   Front axle = 20,000#
   Rear axle Tractor = 20,000#
   Rear axle Trailer = 20,000#
   Maximum gross weight = 60,000# *

5) Four axle truck tractor and trailer (one front of tractor, one rear of tractor, tandem rear of trailer)
   Front axle Tractor = 20,000#
   Rear axle Tractor = 20,000#
   Tandem axle Trailer = 34,000#
   Maximum gross weight = 74,000# *

6) Four axle truck tractor and trailer (one front of tractor, tandem rear of tractor, one rear of trailer)
   Front axle Tractor = 20,000#
   Tandem rear Tractor = 34,000#
   Single axle Trailer = 20,000#
   Maximum gross weight = 74,000# *

7) Five axle tractor and trailer (one front of tractor, tandem rear of tractor, tandem rear of trailer)
   Maximum gross weight = 80,000# *

* A tolerance of up to 500 pounds will be allowed over the maximum gross weight.

SECTION II: Interstate Highway (Contracts Let On or After October 31, 2008)

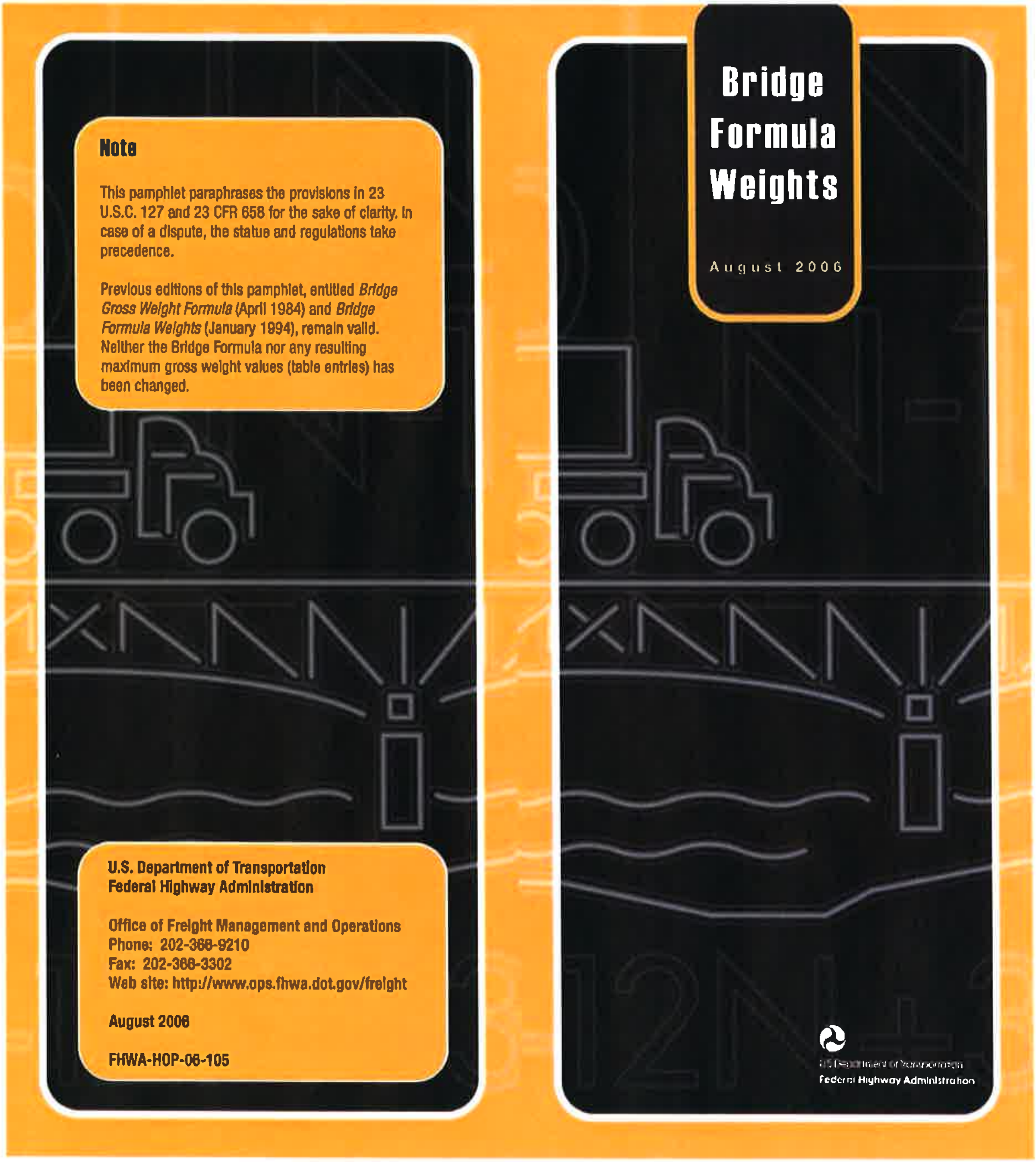
Per Section 107.02 of the Standard Specifications, all trucks delivering material (rock, asphalt, concrete, etc.) to construction projects shall display the allowable gross weight for the Interstate System on the side of the truck. The Bridge Formula shall be used to determine Interstate System gross weights as defined below and in the attached Bridge Formula Weights brochure:

Weight Distribution Formula (Bridge Formula)

$$W = 500\ ((L\ N)/(N-1) + 12N + 36)$$

W = overall gross weight
N = number of axles under consideration
L = distance in feet between extremes of axles under consideration

Copy of Bridge Formula Weights brochure is attached.



Note

This pamphlet paraphrases the provisions in 23 U.S.C. 127 and 23 CFR 658 for the sake of clarity. In case of a dispute, the statue and regulations take precedence.

Previous editions of this pamphlet, entitled *Bridge Gross Weight Formula* (April 1984) and *Bridge Formula Weights* (January 1994), remain valid. Neither the Bridge Formula nor any resulting maximum gross weight values (table entries) has been changed.

U.S. Department of Transportation
Federal Highway Administration

Office of Freight Management and Operations
Phone: 202-366-9210
Fax: 202-366-3302
Web site: http://www.ops.fhwa.dot.gov/freight

August 2006

FHWA-HOP-06-105

Bridge Formula Weights

August 2006

Federal Highway Administration

Bridge Formula Weights

With a few exceptions noted in this pamphlet, the Bridge Formula establishes the maximum weight any set of axles on a motor vehicle may carry on the Interstate highway system. This pamphlet describes the Bridge Formula, why it was established, and how it is used.

What Is It?

Congress enacted the Bridge Formula in 1975 to limit the weight-to-length ratio of a vehicle crossing a bridge. This is accomplished either by spreading weight over additional axles or by increasing the distance between axles.

Compliance with Bridge Formula weight limits is determined by using the following formula:

$$W = 500 \left[\frac{LN}{N-1} + 12N + 36 \right]$$

W = the overall gross weight on any group of two or more consecutive axles to the nearest 500 pounds.

L = the distance in feet between the outer axles of any group of two or more consecutive axles.

N = the number of axles in the group under consideration.

In addition to Bridge Formula weight limits, Federal law states that single axles are limited to 20,000 pounds, and axles closer than 96 inches apart (tandem axles) are limited to 34,000 pounds. Gross vehicle weight is limited to 80,000 pounds (23 U.S.C. 127).

Is the Formula Necessary?

Bridges on the Interstate System highways are designed to support a wide variety of vehicles and their expected loads. As trucks grew heavier in the 1950s and 1960s, something had to

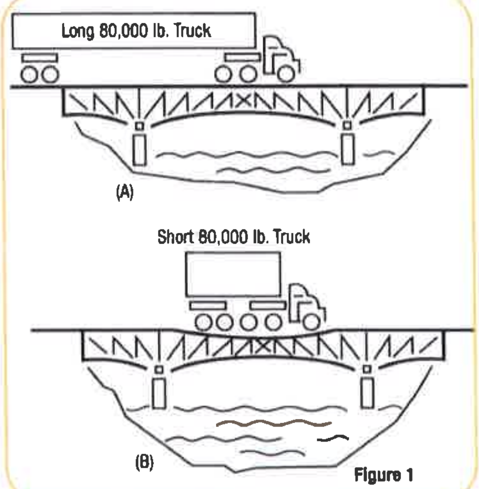


Figure 1

be done to protect bridges. The solution was to link allowable weights to the number and spacing of axles.

Axle spacing is as important as axle weight in designing bridges. In Figure 1A, the stress on bridge members as a longer truck rolls across is much less than that caused by a short vehicle as shown in Figure 1B, even though both trucks have the same total weight and individual axle weights. The weight of the longer vehicle is spread out, while the weight of the shorter vehicle is concentrated on a smaller area.

How Is the Formula Used?

The weight on various axle configurations must be checked to determine compliance with the Bridge Formula. Three definitions are needed to use the Bridge Formula correctly.

Gross Weight—the weight of a vehicle or vehicle combination and any load thereon. The Federal gross weight limit on the Interstate System is 80,000 pounds unless the Bridge Formula dictates a lower weight limit.

Single-Axle Weight—The total weight on one or more axles whose centers are spaced not more 40 inches apart. The Federal single-axle weight limit on the Interstate System is 20,000 pounds.

Tandem-Axle Weight—The total weight on two or more consecutive axles whose centers are spaced more than 40 inches apart but not more than 96 inches apart. The Federal tandem-axle weight limit on the Interstate System is 34,000 pounds.

Interstate System weight limits in some States may be higher than the figures noted above due to "grandfather" rights. When the Interstate System axle and gross weight limits were first adopted in 1956, and amended in 1975, States were allowed to keep or "grandfather" weight limits that were higher.

Bridge Formula calculations yield a series of weights (Bridge Table, pages 5-6). It is important to note that the single-axle weight limit replaces the Bridge Formula weight limit on axles not more than 40 inches apart, and the tandem-axle weight limit replaces the Bridge Formula weight limit for axles over 40 but not more than 96 inches apart. At 97 inches apart, for example, two axles may carry 38,000 pounds (Figure 2A), and three axles may carry 42,000 pounds, as shown in Figure 2B.

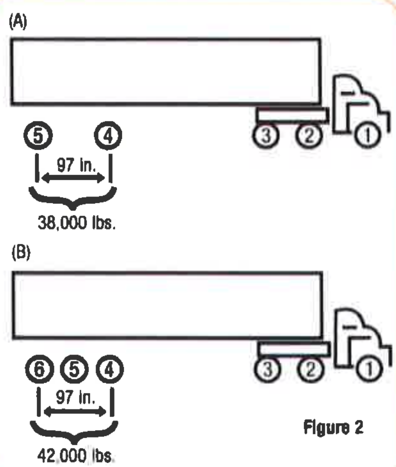


Figure 2

Federal law states that any two or more consecutive axles may not exceed the weight computed by the Bridge Formula even though single axles, tandem axles, and gross weight are within legal limits. As a result, the axle group that includes the entire truck—sometimes called the "outer bridge" group—must comply with the Bridge Formula. However, interior combinations of axles, such as the "tractor bridge" (axles 1, 2, and 3) and "trailer bridge" (axles 2, 3, 4, and 5), must also comply with weights computed by the Bridge Formula (Figure 3).

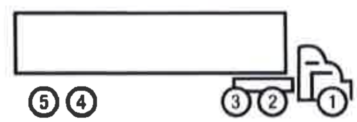


Figure 3

Figure 3 shows the most common vehicle checked for compliance with weight limit requirements. Although the Bridge Formula applies to each combination of two or more axles, experience shows that axle combinations 1 through 3, 1 through 5, and 2 through 5 are critical and must be checked. If these combinations are found to be satisfactory, then all of the others on this type of vehicle normally will be satisfactory.

The vehicle with weights and axle dimensions shown in Figure 4 is used to illustrate a Bridge Formula check.

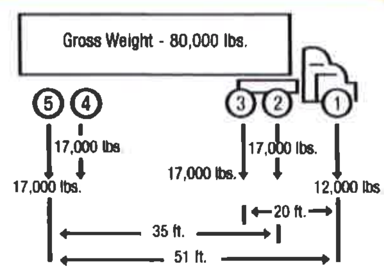


Figure 4

Permissible Gross Loads for Vehicles in Regular Operation[1]

Based on weight formula $W = 500 \left[\frac{LN}{N-1} + 12N + 36 \right]$

Distance in feet (L) between the extremes of any group of 2 or more consecutive axles

Maximum load in pounds carried on any group of 2 or more consecutive axles[1]

	L	N= 2 AXLES	3 AXLES	4 AXLES	5 AXLES	6 AXLES	7 AXLES	8 AXLES	9 AXLES
Tandem Axle Weight (see pages 3 & 4)	4	34,000							
	5	34,000							
	6	34,000							
	7	34,000							
	8	34,000	34,000						
	More than 8/less than 9	38,000	42,000						
	9	39,000	42,500						
	10	40,000	43,500						
	11		44,000						
	12		45,000	50,000					
	13		45,500	50,500					
	14		46,500	51,500					
	15		47,000	52,000					
	16		48,000*	52,500	58,000				
	17		48,500	53,500	58,500				
	18		49,500	54,000	59,000				
	19 Example		50,000	54,500	60,000				
	20 (see page 7)		$\boxed{51,000}$	55,500	60,500	66,000			
	21		51,500	56,000	61,000	66,500			
	22		52,500	56,500	61,500	67,000			
	23		53,000	57,500	62,500	68,000			
	24		54,000	58,000	63,000	68,500	74,000		
	25		54,500	58,500	63,500	69,000	74,500		
	26		55,500	59,500	64,000	69,500	75,000		
	27		56,000	60,000	65,000	70,000	75,500		
	28		57,000	60,500	65,500	71,000	76,500	82,000	
	29		57,500	61,500	66,000	71,500	77,000	82,500	
	30		58,500	62,000	66,500	72,000	77,500	83,000	
	31		59,000	62,500	67,500	72,500	78,000	83,500	
	32		60,000	63,500	68,000	73,000	78,500	84,500	90,000
	33			64,000	68,500	74,000	79,000	85,000	90,500
	34			64,500	69,000	74,500	80,000	85,500	91,000
	35			65,500	70,000	75,000	80,500	86,000	91,500
	36		Exception (see page 9)	66,000	70,500	75,500	81,000	86,500	92,000
	37			66,500	71,000	76,000	81,500	87,000	93,000
	38			67,500	71,500	77,000	82,000	87,500	93,500
	39			68,000	72,000	77,500	82,500	88,500	94,000
	40			68,500	73,000	78,000	83,500	89,000	94,500
	41			69,500	73,500	78,500	84,000	89,500	95,000
	42			70,000	74,000	79,000	84,500	90,000	95,500
	43			70,500	75,000	80,000	85,000	90,500	96,000
	44			71,500	75,500	80,500	85,500	91,000	96,500
	45			72,000	76,000	81,000	86,000	91,500	97,500
	46			72,500	76,500	81,500	87,000	92,500	98,000
	47			73,500	77,500	82,000	87,500	93,000	98,500
	48			74,000	78,000	83,000	88,000	93,500	99,000
	49			74,500	78,500	83,500	88,500	94,000	99,500
	50			75,500	79,000	84,000	89,000	94,500	100,000
	51			76,000	80,000	84,500	89,500	95,000	100,500
	52			76,500	80,500	85,000	90,500	95,500	101,000
	53			77,500	81,000	86,000	91,000	96,500	101,500
	54			78,000	81,500	86,500	91,500	97,000	102,000
	55			78,500	82,500	87,000	92,000	97,500	102,500
	56		Interstate Gross Weight Limit (see page 2)	79,500	83,000	87,500	92,500	98,000	103,000
	57			80,000	83,500	88,000	93,000	98,500	104,000
	58				84,000	89,000	94,000	99,000	104,500
	59				85,000	89,500	94,500	99,500	105,000
	60				85,500	90,000	95,000	100,500	105,500

*The values in this table reflect FHWA's policy of rounding down when calculated weights fall exactly halfway between 500-pound increments. Because the Bridge Formula is designed to protect highway infrastructure, FHWA determined that this conservative policy is consistent with the statutory mandate.

[1]The following loaded vehicles must not operate over H15-44 bridges; 3-S2 (5-axle tractor semitrailer with a wheelbase of less than 38 feet), 2-S1-2 (5-axle semitrailer combination with a wheelbase of less than 45 feet), 3-3 (6-axle truck trailer combination with a wheelbase less than 45 feet), and any truck with 7 or more axles. H15-44 bridges are designed for a specific vehicle load; H15 refers to a 15-ton 2-axle truck; 44 refers to the year AASHTO published the loading information. See *AASHTO Standard Specifications for Highway Bridges.*

Before checking for compliance with the Bridge Formula, a vehicle's single-axle, tandem-axle, and gross weight should be checked. Here the single axle (number 1) does not exceed 20,000 pounds, tandems 2-3 and 4-5 do not exceed 34,000 pounds each, and the gross weight does not exceed 80,000 pounds. Thus, these preliminary requirements are satisfied. The first Bridge Formula combination is checked as follows:

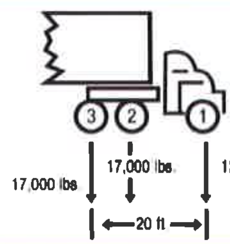


Figure 5

Check axles 1 through 3 (Figure 5)

Actual weight = 12,000 + 17,000 + 17,000 = 46,000 pounds.

N = 3 axles

L = 20 feet

$$W = 500\left[\frac{LN}{N-1} + 12N + 36\right]$$

$$W = 500\left[\frac{(20 \times 3)}{(3-1)} + (12 \times 3) + 36\right] = 51{,}000 \text{ lbs.}$$

Maximum weight (W) = 51,000 pounds, which is more than the actual weight of 46,000 pounds. Thus, the Bridge Formula requirement is satisfied.

Example From the Bridge Table (pages 5 & 6)

The same number (51,000 pounds) could have been obtained from the Bridge Table by reading down the left side to L = 20 and across to the right where N = 3.

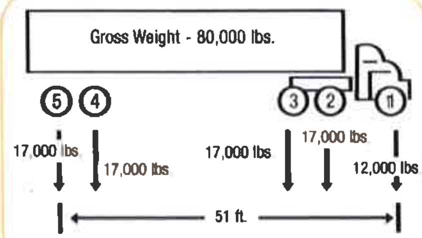


Figure 6

Now check axles 1 through 5 (Figure 6)

Actual weight = 12,000 + 17,000 + 17,000 + 17,000 + 17,000 = 80,000 pounds.

Maximum weight (W) = 80,000 pounds (Bridge Table for "L" of 51 feet and "N" of 5 axles).

Therefore, this axle spacing is satisfactory.

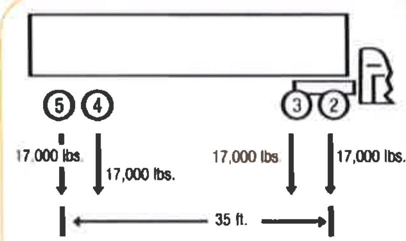


Figure 7

Now check axles 2 through 5 (Figure 7)

Actual weight = 17,000 + 17,000 + 17,000 + 17,000 = 68,000 pounds.

Maximum weight (W) = 65,500 pounds (Bridge Table for "L" of 35 feet and "N" of 4 axles).

This is a violation because the actual weight exceeds the weight allowed by the Bridge Formula. To correct the situation, some load must be removed from the vehicle or the axle spacing (35 feet) must be increased.

Exception to Formula and Bridge Table

In addition to the grandfather rights noted on page 3, Federal law (23 U.S.C. 127) includes one other exception to the Bridge Formula and the Bridge Table—two consecutive sets of tandem axles may carry 34,000 pounds each if the overall distance between the first and last axles of these tandems is 36 feet or more. For example, a five-axle tractor-semitrailer combination may carry 34,000 pounds both on the tractor tandem (axles 2 and 3) and the trailer tandem (axles 4 and 5), provided axles 2 and 5 are spaced at least 36 feet apart. Without this exception, the Bridge Formula would allow an actual weight of only 66,000 to 67,500 pounds on tandems spaced 36 to 38 feet apart.

Bridge Formula Application to Single-Unit Trucks

The procedure described above could be used to check any axle combinations, but several closely spaced axles usually produce the most critical situation.

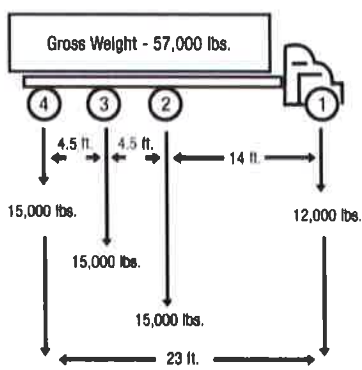


Figure 8

The truck shown in Figure 8 satisfies the single-axle weight limit (12,000 pounds are less than 20,000 pounds), the tandem-axle limit (30,000 pounds are less than 34,000 pounds) and the gross-weight limit (57,000 pounds are less than 80,000 pounds). With these restrictions satisfied, a check is done for Bridge Formula requirements, axles 1 through 4.

Actual Weight= 12,000 + 15,000 + 15,000 + 15,000 = 57,000 pounds.

Maximum weight (W) = 57,500 pounds (Bridge Table for "L" of 23 feet and "N" of 4 axles).

Since axles 1 through 4 are satisfactory, check axles 2 through 4:

Actual weight = 15,000 + 15,000 + 15,000 = 45,000 pounds.

Maximum weight (W) = 42,500 pounds (Bridge Table for "L" of 9 feet and "N" of 3 axles).

This is a violation because the actual weight exceeds the weight allowed by the Bridge Formula. The load must either be reduced, axles added, or spacing increased to comply with the Bridge Formula.

Quality Assurance Statement

The Federal Highway Administration (FHWA) provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FHWA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Asphalt Laydown Checklist

Date: Contract No.:

Project Number: County:

Prime Contractor: Paving Contractor:

Inspection made by:

Project Description:

The inspection checklist shall be completed by the District Supervisor, or their designated representative, during the test strip construction.

Asphalt Laydown

Temp Traffic Control (Section 712)	YES	NO	COMMENTS
If applicable, has a Lighting plan been submitted and approved?			
Is lighting on all paving equipment (Paver, Transfer Device, Rollers, trail vehicle) per the approved plan and in compliance?(712.04 & table 712.04-1)			
Is the lighting adequate?			
Are workers and other personnel wearing personal protective equipment? (107.10)			
Does the Contractor’s traffic control comply with Standard Specifications and applicable Plan Notes? (712)			

Milling/Cold Planing (Sect 415)	YES	NO	COMMENTS
What is the width of the milling machine(s)?			
Do the Plan Notes require a fine tooth milling machine?			
Are the milling teeth in good condition and all in place? Fine Teeth Spacing ≤ ½”, Max Tooth Spacing = 5/8"			Teeth spacing =
Is the milled surface free of scabbing, scallops, gouges, ridges, etc…			

Is the Contractor maintaining the maximum forward speed of 60 ft/min for ½”-5/8” teeth spacing or 80 ft/min for teeth spacing of less than ½”?			Speed=
Is the proper depth and cross-slope being obtained by milling? Is the contractor utilizing automatic slope & Grade Controls?			

Tack Coat (Section 403)	**YES**	**NO**	**COMMENTS**
Does the distributor meet requirements? (402.03)			
What is the date of the most recent calibration?			
Are the proper nozzle sizes being used?			
Are the nozzles set at 30° from the spray bar?			
Are the nozzles clean and unclogged?			
Is the bar height sufficient to allow at least a double lap spray?			
Has the tack coat test strip been completed and is it acceptable? What is the application rate to obtain uniform full coverage without ponding, pooling, or corn-rowing?			Application rate=
Has the existing surface been cleaned, and all foreign materials been removed?			
Is the tack breaking properly (Brown to Black)?			
Are debris/milling fines building up on construction equipment/hauling truck tires after the tack application? If yes, the roadway must be cleaned in a more efficient manner.			

Material Transfer Device (MTD) (Subsection 407.06B)	**YES**	**NO**	**COMMENTS**
Who is the manufacturer and what is the model of the equipment?			
Does the MTD have a minimum of 15 tons storage capacity and capable of remixing the material?			
Does the paver have a surge hopper with a minimum of 15 tons storage capacity and sloping sides?			

Rollers (Subsection 407.07)	**YES**	**NO**	**COMMENTS**
Is intelligent compaction being utilized? If so, which type of system (base station, cellular, etc.)?			
Do the rollers meet size, type, and quantity specification requirements? (407.07 & 407.15)			
If the inside shoulder and inside traffic lane are being paved concurrently, is there a 4th roller (min. 4 ft wide) for the inside shoulder?			
Is a pneumatic roller (rubber tire) used for intermediate rolling? (407.15)			
Are rollers equipped with a device for moisten and cleaning the wheels as required? (407.07)			
Is rolling being completed from the low side up?			
Is rolling being completed as identified in the test strip? Correct number of passes? Within the established temperature range?			Number of passes= Temperature range=
Is a release agent being used on the tires of the pneumatic roller? If yes, what type and is it approved?			

Paver (Subsection 407.06)	**YES**	**NO**	**COMMENTS**
Is a minimum 40-foot ski or non contact grade control system used for grade control? (407.14)			
Is a 12 foot straightedge and level on the paver?			
Is the mix maintained at half the auger height?			
Are auger extensions within 18 inches of the end plate?			
Is the paver screed heated? Is it in vibratory mode?			
Is the screed producing effectively a finished surface of required evenness and texture without tearing, shoving or gouging the mixture?			
Are temperature limitations being adhered to? Is there an approved "cold weather paving plan" if out of season? Will not be approved for OGFC, TLD, or TLE. (407.09)			

Rev. 2.5.21

Is the surface that the mix is to be placed free from excessive moisture?			
Is the pavement and shoulder cross slope being checked. Are they correct (within 0.5% of the plans)?			
Are depth checks being made? Is the thickness correct?			
Are spread rate checks being computed at least twice daily?			
Delivery (Subsection 407.05)	**YES**	**NO**	**COMMENTS**
Are truck beds covered with tarps extending 6 inches over the sides and secured at 5-foot intervals? (407.05)			
Are truck beds tight, clean, and smooth, with a thin coat of approved release agent?			
Are the weigh tickets being submitted electronically? (SP109ETAS)			
Is the TDOT inspector collecting the weight tickets and signing them? What is the mix type? What is the AC type?			Mix Type= Grade AC=
Are the allowable weights displayed? Tare weight? Allowable gross weight? Interstate? Non-interstate?			
Does each truck bed have a 3/8” hole on each side for checking temperature?			
Is the TDOT inspector recording temperatures every 5th load. (SOP 1-1)			
Is the mix temperature in the paver hopper within the allowable specification limits? (407.11)			
Longitudinal Joint	**YES**	**NO**	**COMMENTS**
Is the joint area along the edge clean prior to placement of the adjacent mat? Is tack coat applied?			
Is the material slightly high at the joint to allow for compaction (about 0.25” per 1” laid)?			
Is the longitudinal joint being overlapped 1 to 1.5 inches over the adjacent mat to create a tight joint?			
Is the luter casting mix across the mat?			
On a multiple course pavement, is the longitudinal joint offset by at least one foot of the preceding layer?			

For surface course, is the longitudinal joint at the lane edge or center line of roadway?			
Transverse Joint	**YES**	**NO**	**COMMENTS**
When tying into existing pavement is a full head of material maintained in front of the screed to the end?			
Is the contractor cutting back on previous runs to expose the full depth of the previous course to form transverse joints?			
Is the contractor utilizing nulling blocks for takeoff?			
Is the material slightly high at the joint to allow for compaction (about 0.25" per 1" laid)?			
When continuing paving, is the joint thoroughly cleaned and tack applied to ensure a good bond?			
Is the joint straightedged to ensure smoothness?			
Test Strip (407.15)	**YES**	**NO**	**COMMENTS**
Is the test strip a minimum of 400 SY as required?			
Is the mix being compacted to achieve the required density?			
Do the average and individual densities meet minimum requirements for the type of mix (expressed in percent of maximum theoretical density)? What density is required?			Required density:
Have temperature ranges of each roller been established during development of the roller pattern?			

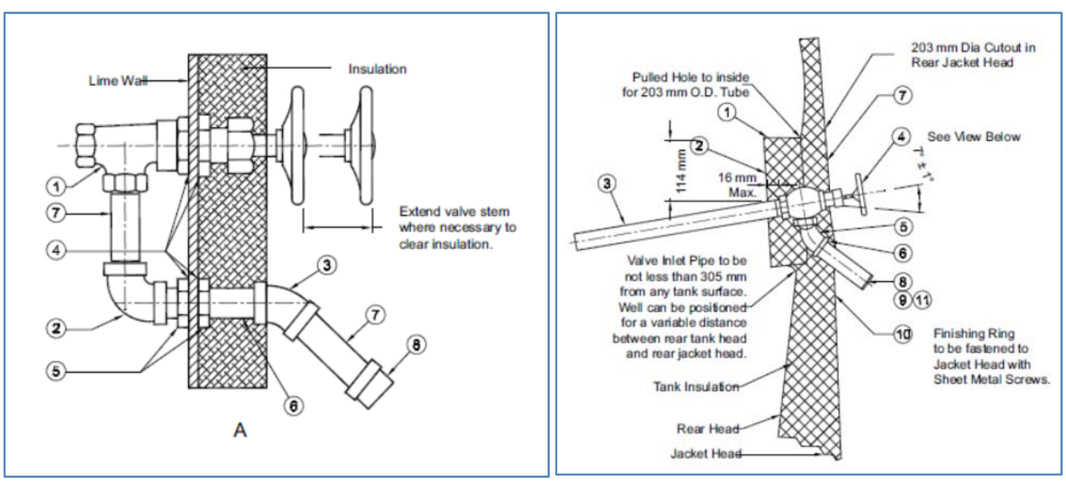
COMMENTS:

Sampling Asphalt Emulsions

TDOT Standard Operating Procedures for the Sampling and Testing, and Acceptance of Materials and Products (SOP 1-1) state that *Emulsions for prime coats, tack coats, and sealers (fog seals*) AND *Emulsions for Surface Treatment, Microsurfacing, Slurry sealing and related similar processes* should be Sampled by the project inspector and once per week thereafter.

Proper sampling of these materials should include the following:

- All samples should be taken by contractor personnel, observed by TDOT employee, either from the contractor's storage tank or directly from the distributor.
- All samples should be taken from the sample valve, and a MINIMUM of 1-gallon of material should be run through the sample valve and wasted prior to collecting the sample.
- Samples should NOT be taken from distributor spray bars. This can cause contaminated samples.
- All emulsion samples should be collected in wide-mouth jars or bottles made of plastic or wide-mouth plastic-lined cans with lined screw caps. (Sample containers can be obtained from Regional or HQ M&T)
- Containers should be completely filled to eliminate possible crusting or condensation in the container.
- Samples shall be not exposed to direct sunlight for long periods of time and not allowed to freeze.
- Per TDOT M&T SOP 1-1, samples should be received at the TDOT central laboratory in Nashville as soon as reasonably possible. Samples taken more than two weeks after sampling are considered expired and will be discarded.
- Samples should be *properly labeled*, accompanied by a completed T-2 form for identification.



Example diagram of emulsion sample valves (AASHTO T-40)

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

Item No. ____________ Grading ____________

Report No. ____________ **ASPHALT DENSITY REPORT** Date ____________

Contract No. ____________

Project Reference No. ____________ County ____________ Region ____________

Project No. ____________ Contractor ____________

Gauge No.	Standard Count	Theoretical or Laboratory Density	Core Correction	Percent Required Density

Lot No. ______ From Sta. ______ To Sta. ______ Lin. M (ft.) ______ Width ______ Lift ______ Lane ______

Date	Test No	Sta No	Location	Den. Test 1	Den. Test 2	Den. Test 3	Den. Test 4	Avg	Corrected Density	Density (%)
			1' From Left							
			Left Wheel							
			Center							
			Right Wheel							
			1' From Right							

Tons in Lot ____________ Mix Running Total ____________

Lot No. ______ From Sta. ______ To Sta. ______ Lin. M (ft.) ______ Width ______ Lift ______ Lane ______

Date	Test No	Sta No	Location	Den. Test 1	Den. Test 2	Den. Test 3	Den. Test 4	Avg	Corrected Density	Density (%)
			1' From Left							
			Left Wheel							
			Center							
			Right Wheel							
			1' From Right							

Tons in Lot Mix Running Total

Lot No. ______ From Sta. ______ To Sta. ______ Lin. M (ft.) ______ Width ______ Lift ______ Lane ______

Date	Test No	Sta No	Location	Den. Test 1	Den. Test 2	Den. Test 3	Den. Test 4	Avg	Corrected Density	Density (%)
			1' From Left							
			Left Wheel							
			Center							
			Right Wheel							
			1' From Right							

Tons in Lot ____________ Mix Running Total ____________

Remarks:

lb/yd^2 (kg/yd^2) ________	
Lot No.	Avg. % Density

Original to:
Headquarters Materials and Tests
Copies to:
Regional Materials and Tests
Project Supervisor
Form DT-0315 (Rev. 07-17)

Signature ____________

Title ____________

CALIBRATING NUCLEAR DENSITY GAUGE WITH ASPHALT CORES

Ref. No. ________________ County __________ Region _________ Date __________

Project No. ________________ Contr. No __________ Type Mix ________________

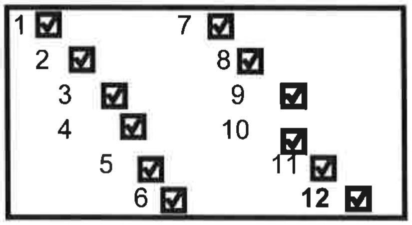
Gauge No. ________________ Standard Count __________

A control strip one paver width wide and having an area of at least 400 SY per roller * shall be constructed with an approved bituminous mixture. It shall be compacted until there is no appreciable increase in density (1.0 lbs/cu.ft.) as measured with the nuclear gauge.

NO. OF CORES

____

Typical test pattern for end section combining all rollers



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										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
	Avg. =	**#DIV/0!**	lbs./ft.^{3}		Avg. =	**#DIV/0!**	**#DIV/0!**	**#DIV/0!**		

NOTE: Nuclear Density Gauge Correction = + or - **#DIV/0!** lbs./ft.^{3}
(core - gauge)

* Core Sp. Gr. = (Wt. Dry) / (Blot Dry) (Wt. Water)

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

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

Sp. Gr. = 2.151

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

T.D.O.T Insp. ....