COURSE AGENDA

ND Technician Certification – Asphalt Pavement Inspector

Segment 1

Registration and Welcome
Outline of Class

Year Review- CERT Information

Project Communication

Roles & Responsibilities
--Agency & Contractor Involvement in QC/QA

Preparation for Paving
--Class Problems – Tack Rate

Segment 2

Hot Plants and Mixture Delivery
--Class Problem -- Number of Trucks

Asphalt Paving/Loading, Transport & Delivery

Asphalt Pavers and Placement
Pavement Compaction

Segment 3

Balancing Paving Operations & Operations Management
Class Problems – Spread Rates, Mix Delivery, Paver Production, Compaction Rates

Segregation, Ride Quality & Mat Problems
Statistics 101
Sampling & Random Numbers

Segment 4

Density Specifications
Relative Density Calculations, Sampling Locations
Supplemental Specifications

Certification Testing

Segment 5

New Technologies and Updates
Thermal Segregation

RIDE Spec and year review

Inspector Diary and documentation
Paving Foreman's Cheat Sheet
Hot Bituminous Paving Checklist

Written exam

References

AC 150/5370 Hot-Mix Asphalt Paving Handbook 2000 w/ CD

Class Handouts

Instructor

Ken Swedeen
Executive Director
DAPA
Pierre, SD

Guest Speaker
Bernie Southam
NDDOT Bismarck District

North Dakota Department of Transportation

TTCP
Pavement Inspection
January 26-28, 2016
Mandan, ND

WELCOME!

- Instructors
- Registration
- Schedule
  - Breaks/Lunch
- Course Materials
- Test

Instructors

- Ken Swedeen
  - Executive Director, Dakota Asphalt Pavement Association, 12 years (2001)
  - City Engineer-Sioux Falls, SD, 1999-2000
  - **Materials**/Resident/District Maintenance Engineer, **Wyoming DOT**, 20 years (Cheyenne, Jackson, Casper)
  - Registered PE in Texas, Wyoming; Graduate SDSU (BSCE) and Univ. of Wyoming (MBA)
- Drop Ins: Bernie Southard, NDDOT-Bismarck District

"Build with Asphalt"

Dakota Asphalt Pavement Association

- Represent over 80 Contractor, Producer, Refiner, Engineering Firms and other Companies involved in the HMA Industry in North and South Dakota
- Dedicated to Quality Asphalt Construction through Education, Research & Training
- Bituminous Certification Courses
- Working with Agencies, LTAP's
- Short Courses – HMAT
- Research – SDSU, UND, NDSU

Quality Assurance

Federal Regulations
and
Quality Assurance

23 CFR 637 Subpart B – Quality Assurance Procedures for Construction Acceptance Program.

"Purpose is to assure the quality of materials and construction in all Federal-aid highway projects on the National Highway System."

Quality Assurance Program

- Required on all Federal-aid highway construction projects on the NHS (23 CFR 637).
- Implementation to begin by 1997.

I- 9

The Seven Elements of a QA Program

Quality Assurance Program

The core elements of a QA program include:

- Contractor QC
- Agency Acceptance
- Agency Independent Assurance
- Specifications
- Dispute resolution
- Laboratory accreditation and qualification
- Personnel qualification and certification

Quality Control

Definition

The system used by a contractor to monitor, assess, and adjust processes to ensure that the final product meets the specified level of quality

Contractor Responsibility for Quality Control

Under a proper QA program, responsibility for QC is assigned to the contractor

Scope of QC Activities

- QC Key Activities:
  - Materials production and transportation
  - Field placement processes
- QC Processes:
  - Sampling and testing
  - Inspection
  - Material storage and stockpiling

Agency Responsibility for Acceptance

- All Acceptance decisions must be made by the agency
- Contractor QC data **may be included** in the final Acceptance determination

Scope of Acceptance Activities

Primary Acceptance activities include:

- Monitoring the contractor's QC activity
- Acceptance sampling and testing
- Agency inspection

Evaluating product quality

Upcoming Events

- April 4-5, 2016

ND Asphalt Conference

  - Ramada Inn (formerly Doubleweod), Bismarck, ND
  - NDLTAP

http://www.ndltap.org/

Remember……

This course is about the importance of YOUR job in the quality of the finished product…THE ROAD

- The quality of that finished product will:
  - Affect smoothness and therefore user costs and pavement service life
  - Affect density and therefore pavement service life
  - Affect future funding decisions and maintenance costs
  - Affect the customer, the highway user and taxpayer
  - Affect the paycheck of the Contractor and others

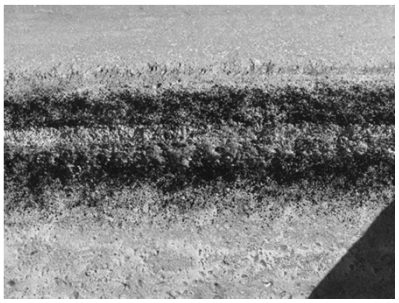
Let's Get Started!

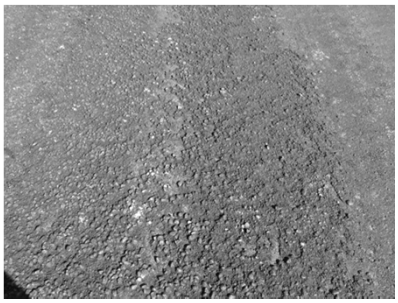
2014-2015 NDDOT/SDDOT Construction Observations

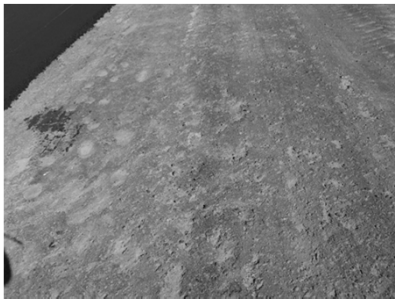
- Paving Waste – End of Day
- Dumping of Paver Wings (Too Often)
- Laydown & Compaction Procedures for LJ's-CL & Shoulder
- Proper Tack Coverage on Joints
- Identifying & Troubleshooting Segregation Problems
- Proper Tack on Mainline – Reducing contamination ahead of paver
- Quality and appearance issues
- Straight & Parallel Lines (Joints?)
- Acceptance of poor quality work
- Construction Joint Quality

Construction Signage

Joints, Tack & Other
Construction Issues







All of these things can be corrected with minimal effort and cost
”ROADWAY INSPECTION”

Project Organization and Communication

NDDOT Asphalt Certification Program

Project Organization and Communication

- Overview
  - Importance of Communication
  - Project Documents
  - Project Records
  - Pre-Construction Conference
  - Pre-Paving Conference
  - Ongoing Communication
  - Safety

Project Organization and Communication

- Importance of Communication
  - the most important part of planning and organization
  - Pre-con initiates verbal communication
  - Quality construction relies on communication
  - Communication provides safer projects

Project Organization and Communication

Communication…..

Means "Sharing Information"

Project Organization and Communication

- Changes in project
  - Asphalt paving projects are not always built as originally planned
  - changes can come from both Contractor or agency
  - when changes occur it is essential the pertinent information be communicated between the parties
  - Daily, informal meetings provide a means for ensuring that everyone is on the same page
  - <u>Put it in writing to document changes</u>

Project Organization and Communication

- Improving Communication
  - Avoid "adversarial attitude"
  - Speak clearly
    - keep it simple and to the point
  - Listen carefully
    - words, facial expressions, body language
  - Summarize conversation
  - Makes notes
    - for future reference

Quality & Communication

- Little things mean a lot
- The messenger is sometimes as important as the message
- Adversarial vs. Allied
- Quality doesn't have to cost money, time or "bad" relations
- In general, everyone wants a "good" project
- Example: Clarence Reinhart, 3 Rivers Co.

Project Organization and Communication

- Project Documents
  - There shouldn't be any confusion about which documents are being used
  - Sometimes, they can be in conflict
  - Hierarchy for solving discrepancies
    - Special Provisions
    - Plans/Plan Notes
    - Supplemental Specifications
    - Standard Specifications

Jackson (Jackson Hole) Steets – WYDOT
Early Season Reconstruction 1990-1991

Project Organization and Communication

- Special Provisions
  - "Additions or revisions to the Standard Specifications or Supplemental Specifications that apply only to a particular project"

Project Organization and Communication

- Plans
  - "The drawings that show the location, character, dimensions and details of the work to be done on a given project."

Project Organization and Communication

- Supplemental Specifications
  - "Approved additions and/or revisions to the Standard Specifications"

Project Organization and Communication

- Standard Specifications
  - "The directions, provisions and requirements for performing the work illustrated and described in the plans."
    - Describes qualities and quantities of materials
    - May reference other specifications

Project Organization and Communication

- Other Referenced Specifications
  - AASHTO
  - ASTM
  - MUTCD
  - OSHA
  - DOT Manuals

Project Organization and Communication

- Project Records
  - Rule of Project Reporting
    - "If in doubt about whether the information is important, write it down in the appropriate place."
  - Diaries
    - Kept by contractor and agency
  - Reports
    - Keep current, accurate, complete
      - plant reports
      - pavement reports

Project Organization and Communication

- Project Records
  - Pay Estimates
    - Documents work performed to date
    - Accepted for pay
  - Traffic Control Plan
    - MUTCD standards
    - Lane closures, lane shifts, speed limits

Project Organization and Communication

- Change Orders
  - modify the contract documents
  - can be large or small
  - overruns and underruns
  - make sure all parties understand the change

Project Organization and Communication

- Asphalt Production Reports
  - Daily HMA Production
  - Daily HMA Construction
  - Project Sampling, Density
  - QC/QA Testing Results
  - Traffic Control Checklist

Project Organization and Communication

- Pre-Construction Conference
  - Agency Input
    - Outline work, unusual aspects
  - Contractor Input
    - Construction schedule
  - Project Personnel
    - key people for all parties, main contact person
  - Testing Requirements, Responsibilities
  - Safety

Project Organization and Communication

- Pre-Paving Conference
  - Key personnel
  - Contractor input
  - Agency input
  - Discussion
  - Meeting minutes
  - Action items

Project Organization and Communication

- Key Project Personnel
  - Everyone should know who will be on project
  - Who has what authority?

Project Organization and Communication

- Pre-Paving Conference
  - Contractor Input
    - Roles and Responsibility of Personnel
    - Plant Operation and Delivery
    - Revision of Paving Plan
    - Paving Methodologies
    - Other

Project Organization and Communication

- Pre-Paving Conference
  - Agency Input
    - Unusual aspects of project
    - Roles and responsibilities of personnel
    - Review QC/QA
    - Other

Project Organization and Communication

- Pre-Paving Conference
  - Discussion
  - Meeting minutes
  - Action items

Project Organization and Communication

- Ongoing Communications
  - Weekly Updates
  - Major Events

Project Organization and Communication

- Safety
  - Most important aspect of project
  - Communicate that this is **everyone's** responsibility
  - safety of agency and contractor personnel
    - (traffic and equipment)
  - safety of traveling public
    - proper traffic control

Project Organization and Communication

<u>The Construction Team</u>

<u>Goal:</u> Agency and Contractor Personnel working together to get the desired result of a successful, quality pavement for the traveling public

Preparation for Paving

North Dakota
Department of Transportation
Asphalt Concrete Certification Program
Roadway Inspection

PREPARATION FOR PAVING

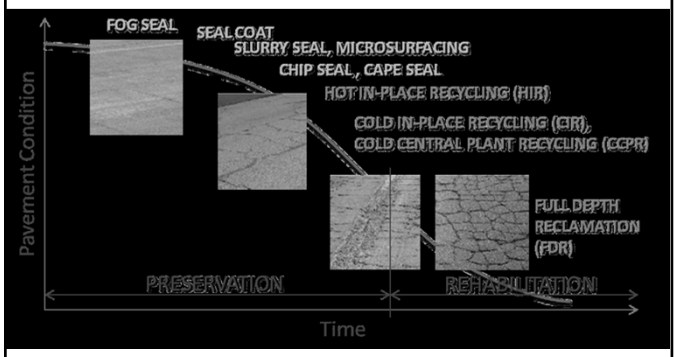
The performance of a hot mix asphalt pavement is directly related to the condition of the surface on which it is constructed.

Surface Preparation

- Rarely gets due consideration
- It is often time consuming and labor intensive
- Asphalt layers cover up the potential problems
- THE PROBLEMS WE DO NOT TAKE CARE OF TODAY WILL NOT GO AWAY
  - Often the problems get worse
  - They are more costly to fix the second time

Surface Preparation

- Various categories of surface preparation
  - Subgrade for full depth asphalt
  - Granular base for deep strength asphalt
  - Existing asphalt pavement overlay
  - Existing pcc pavement overlay
- Type of preparation depends on:
  - Type of Distress
  - Severity & Extent of Distress
  - Cause of Distress



Surface Preparation

- Subgrade preparation
  - The subgrade is the pavement foundation
  - Must support the pavement and anticipated traffic
    - Soil type considered in thickness design
  - Must be properly graded to provide drainage
    - Transverse and longitudinal grade
    - Smoothness and cross slope
  - Must be uniformly compacted to required density

Surface Preparation

- Subgrade preparation (cont.)
  - Density requirements
    - Moisture content considerations
    - Standard, Modified Proctor test
    - Local requirements?
    - Recommendations

?
90%
?
?
100%
±1.5%
95%
?

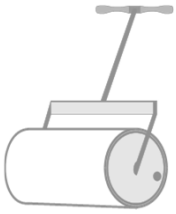
Surface Preparation

- Subgrade must support the construction traffic
  - Loose or weak areas corrected before paving
  - Proof roll with loaded truck
  - Prime coat
    - Typically not used on subgrade
    - Especially not on clay or other fine grained soil
  - Correct distortions during paving if they occur
  - Light water spray prior to paving
    - Minimizes dust

Checking Subgrade Elevations

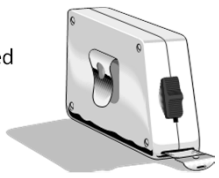
Surface Preparation

- Granular base preparation
  - Placed to uniform thickness on prepared grade
  - Must meet material specifications
    - Gradation
    - Moisture content
    - Density
  - Surface must be smooth



Surface Preparation

- Granular base preparation (cont.)
  - Base must not yield excessively
  - Proof rolling
    - Loaded tandem axle truck
    - Proof roller
  - Excess deflection must be corrected
    - Moisture condition
    - Scarification
    - Recompaction



Surface Preparation

- Prime coat
  - Primary purposes
    - Reduces possibility of slip plane
    - Holds surface together under traffic
    - Protects base from weather
  - Cutback asphalt typically used
    - MC-30 or MC-70
    - 0.2-0.5 gal/yd^2
    - Penetrates into base materials

Surface Preparation

- Prime coat (cont.)
  - Use of emulsions
    - CSS-1,1h or SS-1,1h
    - 0.1 to 0.3 gal/yd^2 per inch of depth
    - Must be mixed into the base material
  - Prime coat should be applied 24 to 48 hours prior to paving
    - Allows for curing

Surface Preparation

- Prime coat (cont.)
  - Applied with distributor
  - Excess asphalt blotted with sand
    - Too much sand prevents bond
  - Typically is not considered to add to structural capacity of the pavement
    - Depth of emulsion treated base?

Surface Preparation

- Asphalt overlay
  - Primary purposes
    - Correct surface irregularities
    - Add structural capacity

Surface Preparation

- Asphalt overlay (cont.)
  - Extent of preparation needed is a function of the condition of the existing surface
    - Failed areas removed and replaced
    - Patch potholes
    - Clean and fill cracks
    - Repair ruts

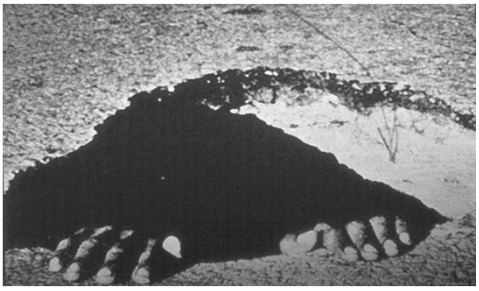
Pavement management system?

Surface Preparation

- Asphalt overlay (cont.)
  - Replacement and patching
    - Attempting to bridge with thin overlay is not wise
    - Failed areas should be removed
    - Cut back to sound pavement
    - Vertical sides - tack edges and bottom of excavation
    - Excavate down to firm base/soil
    - Correct drainage problems
    - Replace removed materials - COMPACTION!
    - Greater than 4” - replace in lifts

No Matter What Depth

All Potholes should be repaired



Pothole Repair Materials

- Survivability – time materials stay in the repair
- Workability – ease of use during installation
- Total cost – initial, installation and re-repairs
- Availability in bulk and bag quantities
- Temperature Range
  - Winter Performance
  - Summer Performance

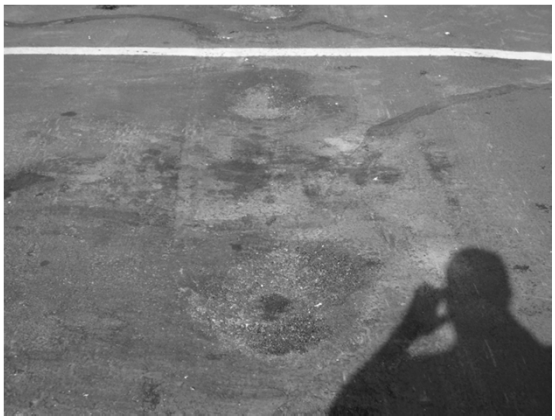
http://www.youtube.com/watch?v=bcYxq0kRXgU#

http://www.youtube.com/watch?v=xS4f0YcetXU

Spray Patcher

Drainage Problem

OASIS



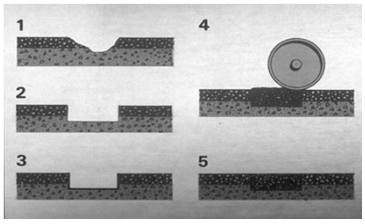
Pothole Crew - Early Days

Applying Cold Patch Material

Compacting Cold Patch Material

Preparing the Pothole

Proper Patch Repair Technique



Removal of Failed Materials

"Squaring Up" in Preparation for Patching

Apply Tack Coat

Akzo Nobel Pothole Patcher

Fill Area with Asphalt Material

Fill Area with Asphalt Material

Spread Mixture Carefully

Compact each lift thoroughly

Straight Edge the Patch

Surface Preparation

- Asphalt overlay (cont.)
  - Crack filling
    - Block or alligator cracks - remove and replace
    - Fill cracks wider than 3/8”
    - Can use router
    - Clean cracks of debris - air blowing
    - Fill cracks with ASTM D3405 material
    - Level of filler slightly below surface

How Should I Prepare The Cracks?

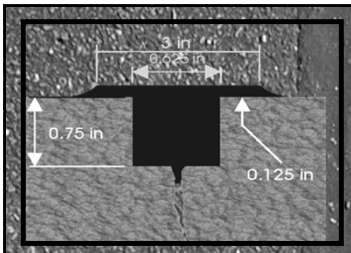
Routing Provides:

- **Clean Pavement For Good Adhesion**
- **Cracks Are Cut Back To Sound Pavement Structure**
- **The Routed Reservoir Provides Protection From Sealant Wear**

What Sealant Should I Use?

The Type Of Sealant To Use Varies Based On:

- **Pavement Type**
- **Climate**
- **Desired Performance**



How Should Sealant Be Applied?

Proper Sealant Application Will Ensure A Successful Project

Surface Preparation

- Asphalt overlay (cont.)
  - Leveling course
    - Restores proper line and cross section
    - Improves ride
    - Fills in low spots in surface
    - Corrects rutting
    - Use rubber tire rollers
    - Difficult to measure density
    - See HMA Handbook, Section 14, pp. 124-125

Correctly Placed Leveling Wedges Ensure Smoother Pavements

Surface Preparation

- Asphalt overlay (cont.)
  - Surface cleaning
    - Power broom
    - Street sweeper
    - Water spray
    - Dried mud etc. removed
    - Spilled asphalt mix removed

Surface Preparation

- Asphalt overlay (cont.)
  - Tack coat
    - Ensures bond between existing surface and overlay
    - Slippage can occur without bond
    - Surface must be clean
    - Applied to faces of curbs, gutters, cold joints, structures
    - Apply to warm surface - 80°F
    - Overlay placed after tack "breaks"

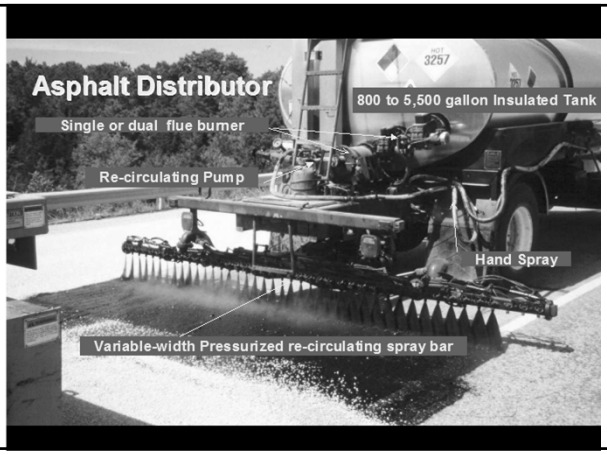
Surface Preparation

- Tack coat (cont.)
  - Typically asphalt emulsion is used
    - CSS-1, 1h or SS-1, 1h
    - Dilute emulsion 1:1 with water
    - Apply 0.05 to 0.15 gal/yd^2 dilute emulsion
    - Residual of 0.02 to 0.05 gal/yd^2
    - Too much -vs- too little
    - Temperature 70°F - 160°F

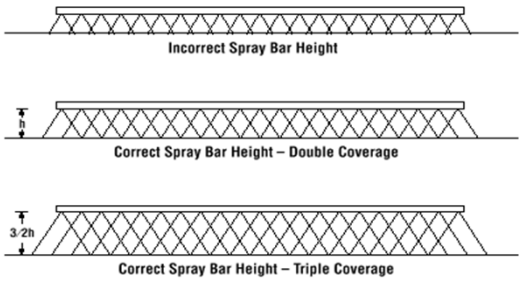
$$(\text{Rate}/2)*0.65$$

Surface Preparation

Uniform Tack Application

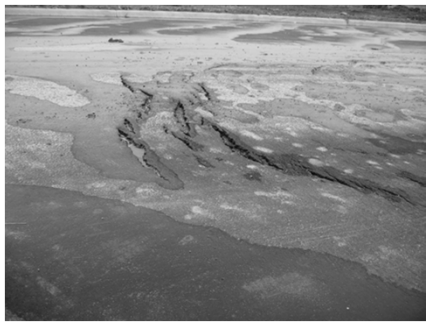


Spray Bar Height and Coverage

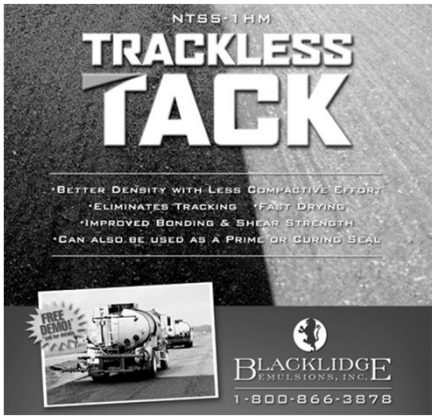


Uniform Tack Application

Enough Tack?? How Much to Repair?

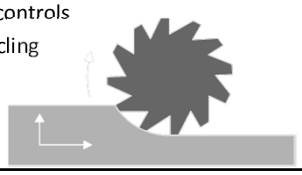


Tack…Don't Overlook It's Importance



Surface Preparation

- Cold milling
  - Also called cold planing
  - Used in place of leveling course
    - Removes high points in surface
  - Mills 6 in. to 13 ft.
  - Automatic grade and slope controls
  - Produces RAP for HMA recycling
  - Increases surface texture

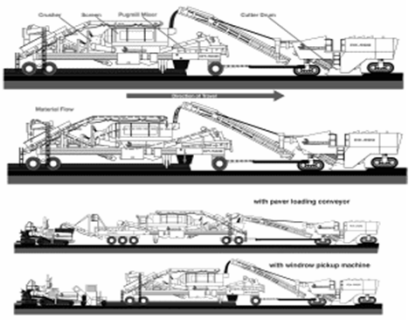


Surface Preparation

- Cold milling (cont.)
  - Reduces structural capacity
  - Repair uncovered problems
  - Surface is typically dusty
    - Clean with broom and/or flush with water
  - More tack may be required
    - 0.15 to 0.25 gal/yd^2 dilute emulsion
    - 0.05 to 0.08 gal/yd^2 residual asphalt

Surface Preparation

- Cold milling (cont.)
  - Full or Partial Depth Reclamation
    - "FDR" or "PDR"
  - Cold In-Place Recycling (CIPR)
  - Hot In-Place Recycling (HIPR)
  - Mine & Blend, Blended Base
- Many Options Available Depending:
  - Existing Pavement Condition (Distresses)
  - Design Criteria
  - Roadway Geometrics



CIPR "Train"

Reclaiming Unit

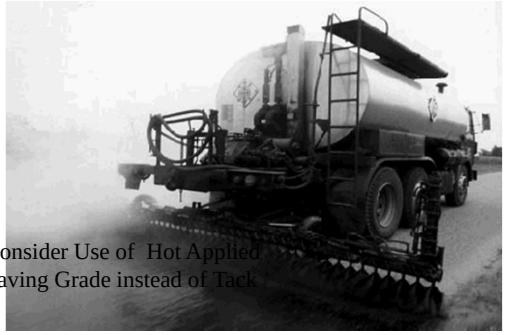
Heavier Trucks
Radial Tires
Higher Tire Pressures

Milling Machine

Surface Preparation

- PCC Pavement Overlay
  - Full depth replacement of distressed slabs
    - Asphalt or pcc patch
    - Correct problems in base/subgrade
  - Spalled joints repaired partial depth
    - use pcc for patching
  - Stabilize rocking slabs
  - Replace joint sealer as required
  - Clean and tack surface
  - Crack & Seat, Rubblizing, Saw & Seal, Crack Relief Layer

Tack Application on PCC



Consider Use of Hot Applied Paving Grade instead of Tack

PCC Surface Preparation

Cracking & Seating

Guillotine Drop Hammer

50 Ton Proof Roller

Surface of Cracked Concrete

Surface of Rubblized Concrete

Resonant Pavement Breaker

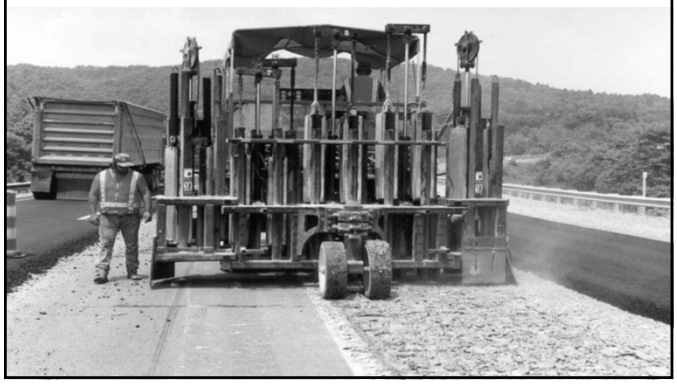
PCC Surface Preparation

RMI Resonant Breaker

10 Ton Vibratory Roller

35 Ton Pneumatic Roller

PCC Surface Preparation
Multiple Head Pavement Breaker



Roller with Z-Grid

Proof Rollers Identify "Soft Spots"

Overlaying Rubblized Pavement

SHOT RATE PROBLEM

Diluted Emulsified Asphalt

If the specified tack application rate of SS-1h is 0.05 gals./ sq. yd. on a project, what is the diluted application rate at each of the following dilution ratios? Assume the original undiluted quantity of emulsion is 1,000 gallons.

1. 1:1 ratio
2. 2:1 ratio
3. 1.5: 1 ratio

Shot Rate Problem 1
Tons of emulsion needed

Calculate the tons of emulsion necessary to chip seal 10 miles of recently paved roadway 24 feet wide. Assume the emulsion weighs 8.35 lbs./gallon and an application rate of 0.35 gals./sq. yd.

Shot Rate Problem 2

We determine that the volumeter is not accurate enough for our project, so we weigh the next load of emulsion. The distributor is loaded and weighs 54,400 lbs. and the tare weight of the truck is 28,800 lbs.. **How many miles will the load of emulsion go if we need 0.35 gal./sq. yd, 12 feet wide, the temperature of the emulsion is 150ºF and the bill of lading shows a weight of 8.45 lbs./gal.?**

HOMEWORK PROBLEM
Tack Application Rate and Quantity

Determine the undiluted tack application rate and the number of tons of tack used on this project. Use the following project information:

1) Type of emulsion - SS-1h
2) SS-1h is diluted 1:1
3) Starting gallons - 2251
4) Ending gallons - 964
5) Length of roadway covered in tack - 2.1 miles @ 26 feet wide
6) Temperature of tack - 140º F
7) Unit weight of SS-1h - 8.35 lbs./gals.

(Round application rate to nearest 0.01 gals./sq. yd. and tons to 0.01 tons)

HMA PLANTS

See *Hot-Mix Asphalt Paving HANDBOOK 2000* , Part II, Chapter 5-Chapter 12, pp. 41-112 for more Information

Hot Plant Operations

What is an Asphalt Plant?

Basic Purpose Of HMA Plants

To produce a **quality** hot asphalt mixture that contains the desired proportions of asphalt and aggregate. Basic Functions: Drying, Heating and Mixing

Two Types of Hot Plants

Batch Plant

Drum Plant

Basic Operations are the Same

- Storage and handling of the materials
- Aggregate proportioning and feeding
- Drying and heating of the aggregate
- Control and collection of dust
- Proportion and mix asphalt with aggregate
- Store and dispense finished HMA

Storage and handling of the materials

The 3 A's

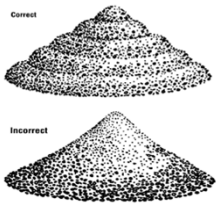
- Aggregate
- Asphalt
- Air

Aggregate Storage and Handling

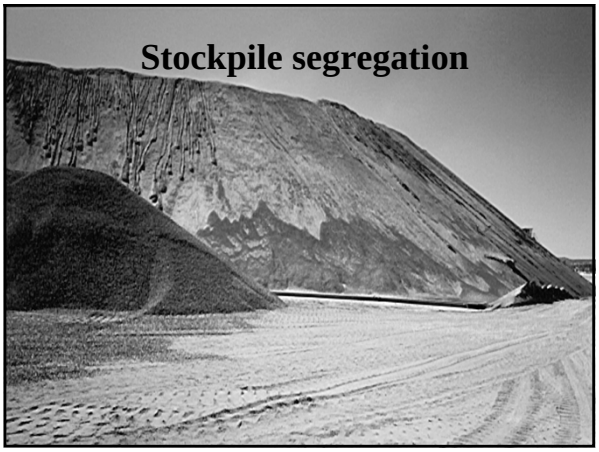
Aggregate storage operations must address:

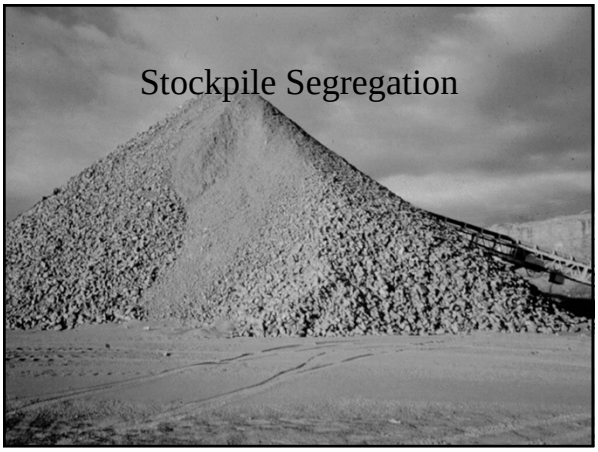
- Segregation
- Degradation
- Contamination

Aggregate Stockpiling



Minimize Segregation

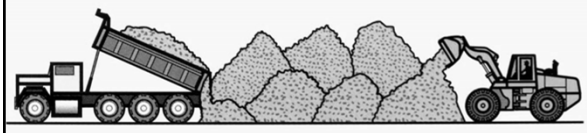




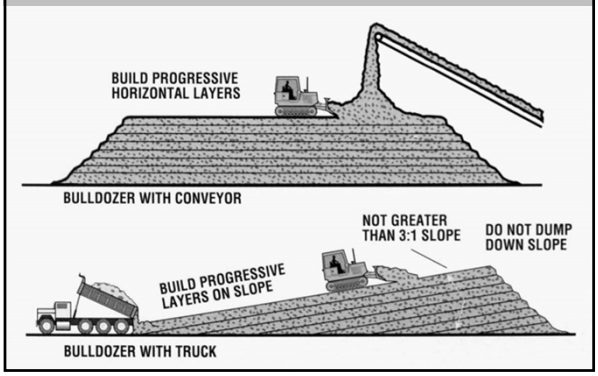
Build stockpiles in layers

Figure 4.04 Building a Horizontal Stockpile

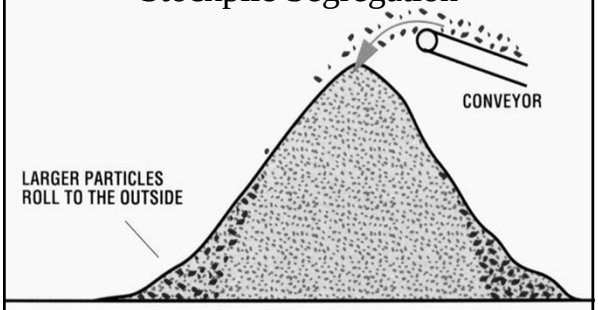
Build Stockpiles in Horizontal Layers



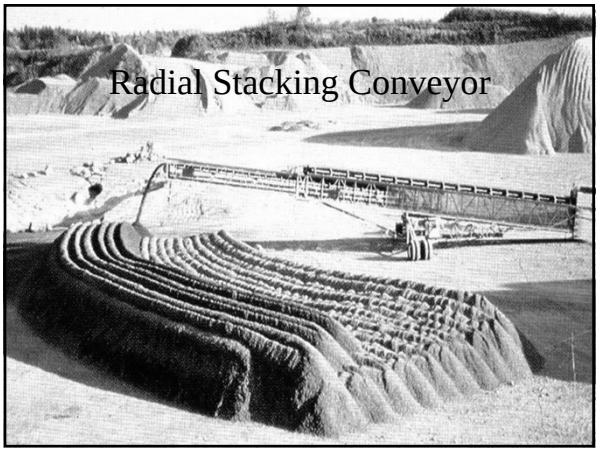
Build Stockpiles in Horizontal Layers



Stockpile Segregation



Radial Stacking Conveyor



Radial Stacker

Contamination

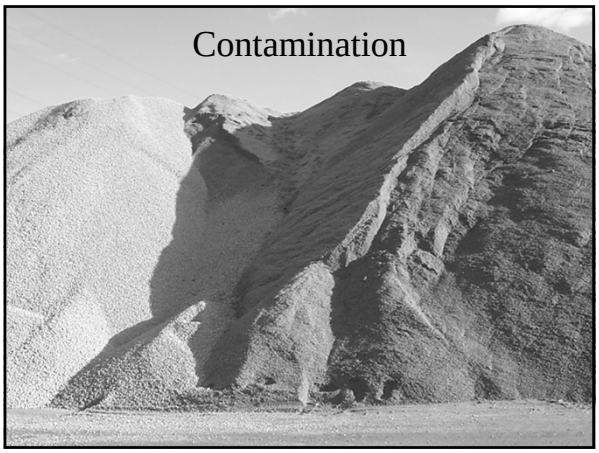
Problem:

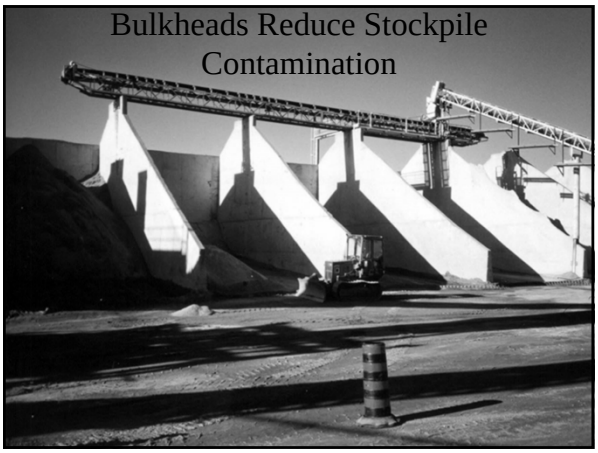
- Aggregate becomes contaminated with dirt and moisture. This wastes fuel to dry the aggregate and could transfer contaminates to the plant

Solutions:

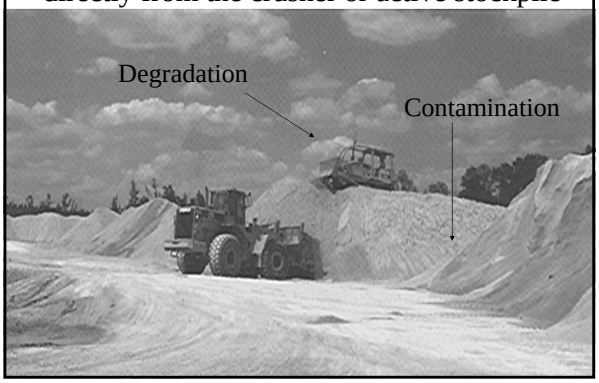
- Stockpiles should be built on clean, free draining pads (paved or aggregate) to keep moisture content low.
- Stockpiles should be spaced properly or have bulkheads built between them.

Build Stockpiles on Clean Stable Base





Care must be taken when charging the plant directly from the crusher or active stockpile



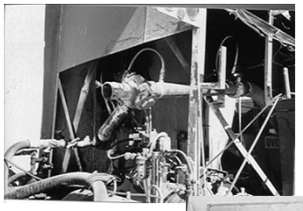
Stockpiles

- Build stockpiles with a loader or a truck
- Build stockpiles in layers, level off and begin another layer
- Set the conveyor height to avoid segregation
- Build on a clean, dry, stable foundation
- Separation between piles to avoid contamination
- The two main concerns in stockpiling are:

Segregation and Contamination

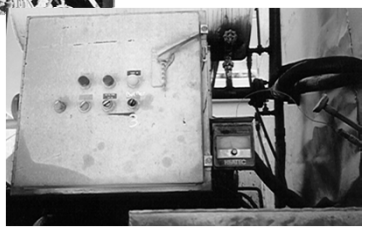
Asphalt Storage and Handling

- Storage tanks must be heated
- Large enough to minimize disruption
- Vertical mixing tanks for PMA
- Multiple tanks for multiple grades
- Sampling Valves
- Tanks should be calibrated to allow for content determination

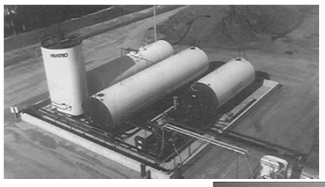


Steam and circulation lines

Continuos temperature monitoring is specified



PMA Should be continuously circulated

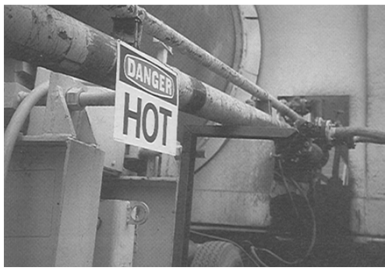


Permanent plant asphalt storage

50,000 gal. portable plant storage tank

Asphalt Sampling

- Be careful !
- Only use designated sampling valves
- Use new, clean metal containers
- Check for contaminated sampling spout
- Never clean cans with solvent or diesel fuel
- Label samples appropriately



Think Safety !

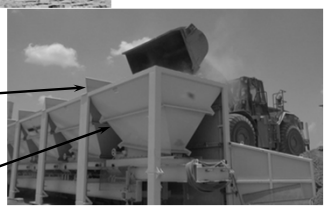
Cold Feed Aggregate Proportioning

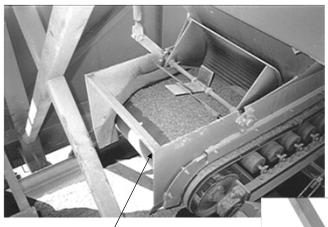
The purpose of the cold feed system is to accurately and uniformly combine the various aggregate stockpiles into a composite blend that meets the mix design specifications

The more cold feed bins, the better the aggregate control

Cold Feed bins should have bin dividers

Steep Bin sides minimize aggregate bridging in the bin

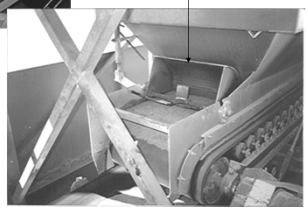


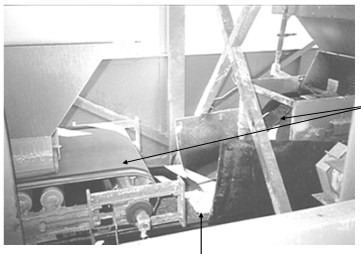


Bin Feed is determined by

Gate Opening

Belt Speed





Variable Speed DC motors on feed belts

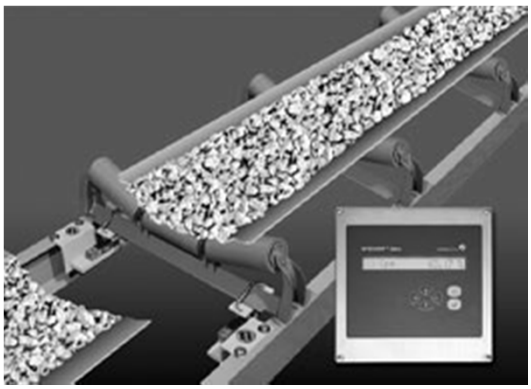
Gathering / Collector Belt

All aggregate feed bins are adjusted and monitored from the control shack

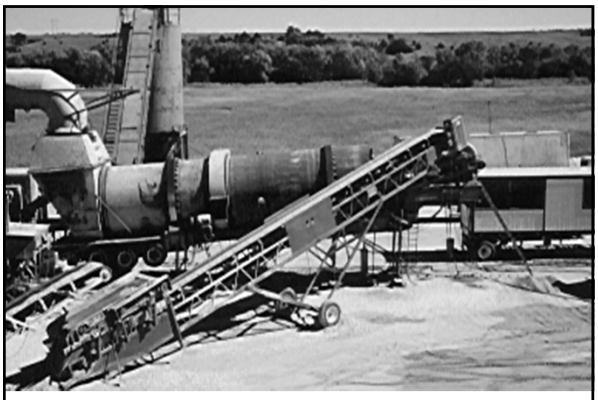
Collector belt delivers proportioned aggregate to scalping screen

In Line Belt Scale

Collector Belt Scale

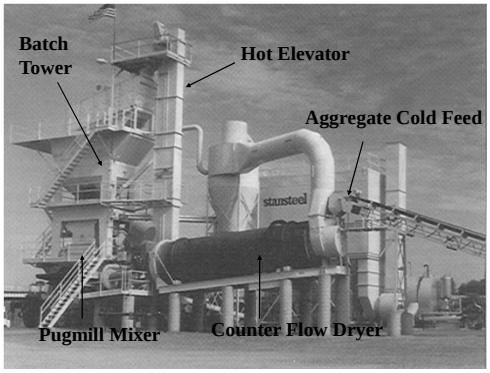


Scalping Screen eliminates foreign matter



Conveyor delivers aggregate to the dryer

Basic Elements of a Batch Plant



Counter flow dryers are the most efficient

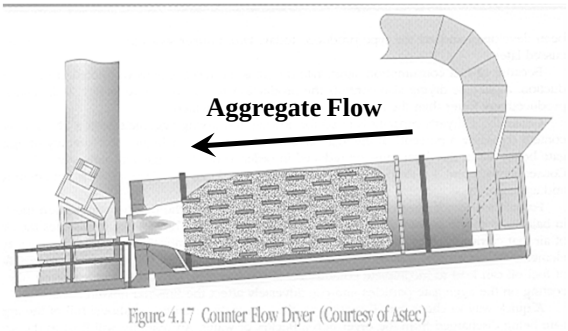
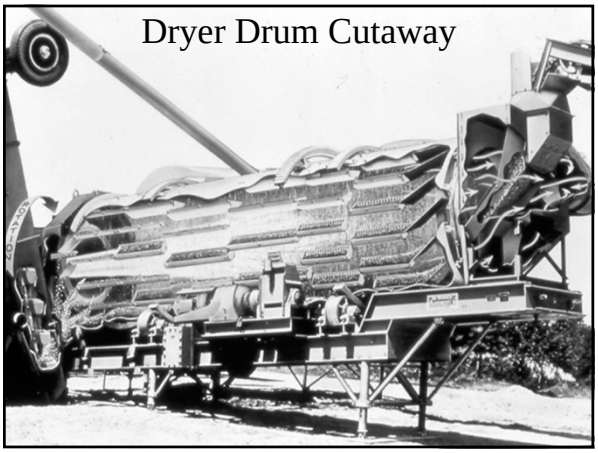
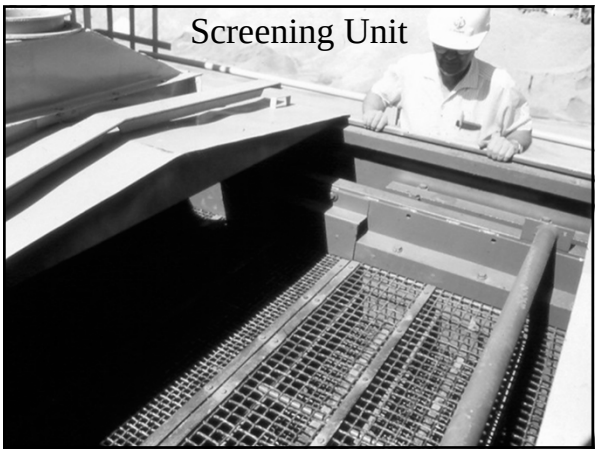


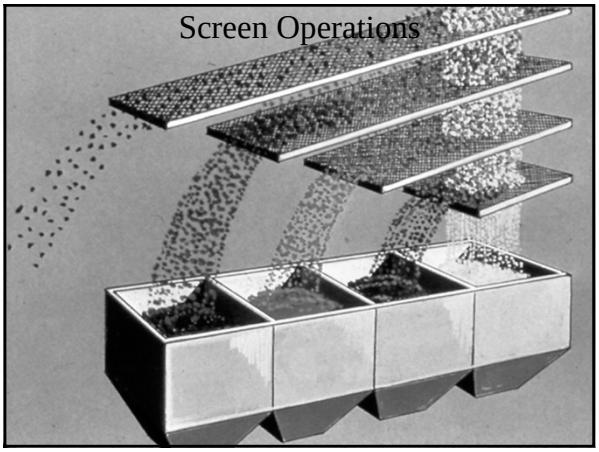
Figure 4.17 Counter Flow Dryer (Courtesy of Astec)

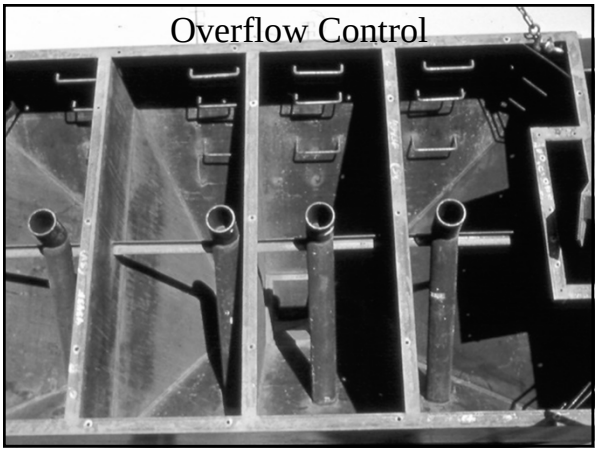
Dryer Drum Cutaway



Screening Unit







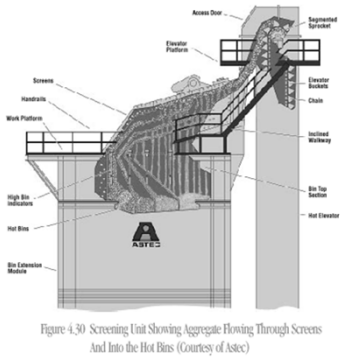
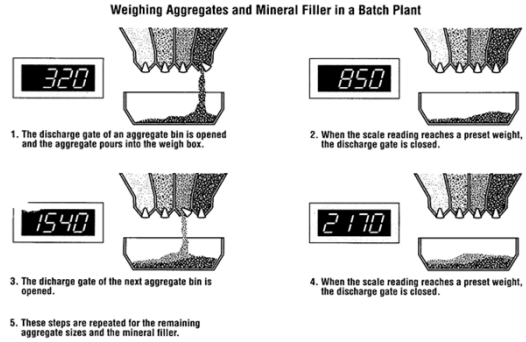


Figure 4.30 Screening Unit Showing Aggregate Flowing Through Screens And Into the Hot Bins (Courtesy of Astec)

SD QC Spec requires a minimum of 2 hot bins, bin vibrators and overflow chutes

Aggregates are individually weighed from the Hot Bins



Hot bin feed % is <u>different</u> than the cold feed bin %

The exact weight of asphalt is added to each batch

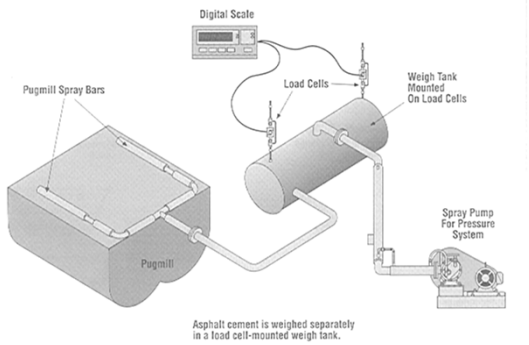


Figure 4.37 Over-Filled Pugmill

Pugmill mixers must always be run at the calibrated capacity

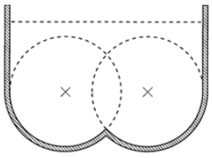
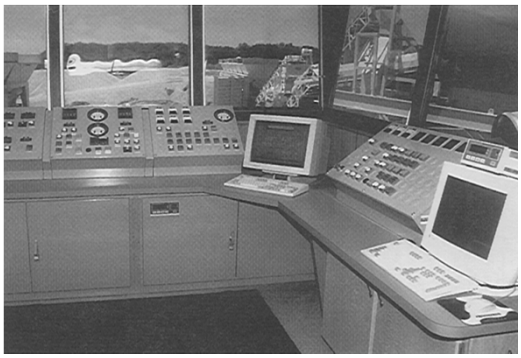


Figure 4.38 Pugmill "Live Zone"

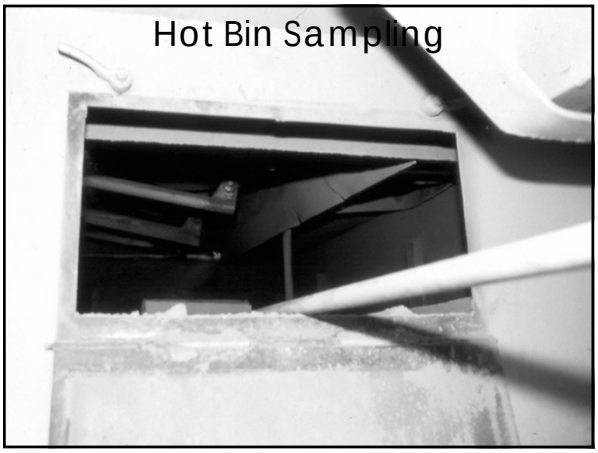
Batch Plants are able to discharge the hot mix directly into hauling units…

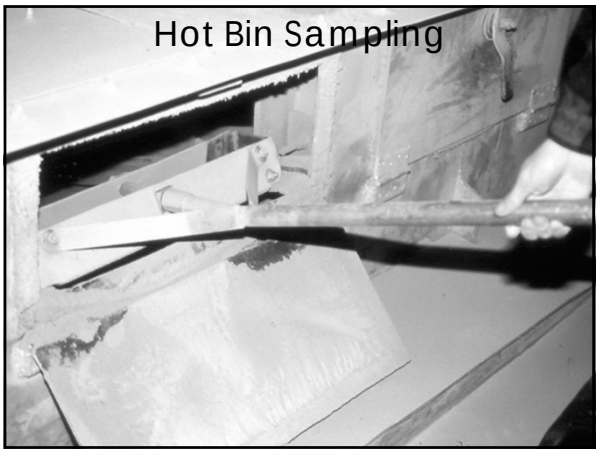
…or store in a silo

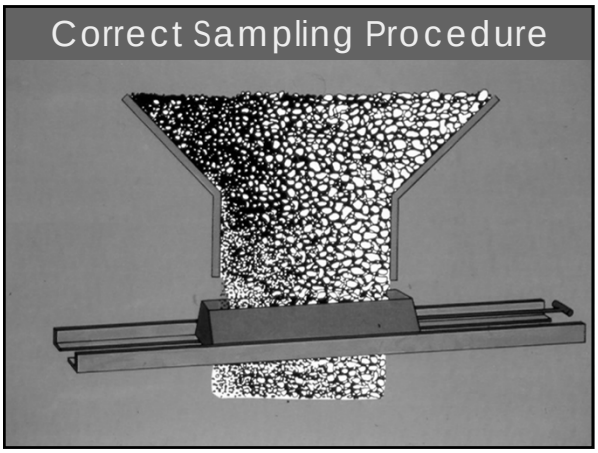
All batching activities are automatically controlled

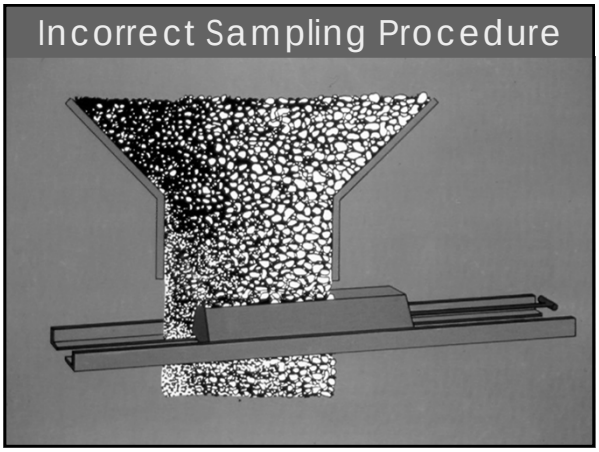


Hot Bin Sampling

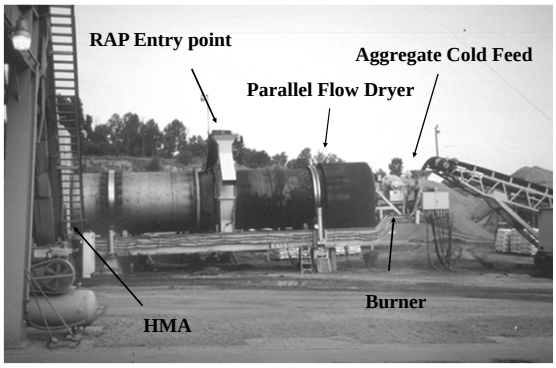




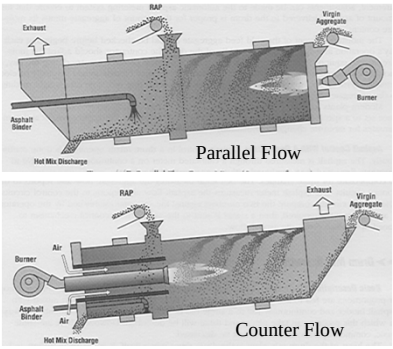


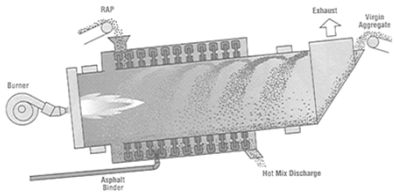


Drum Plants do not have a batch tower

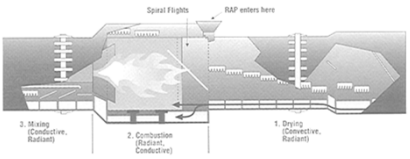


Two common types of Drum Mixers

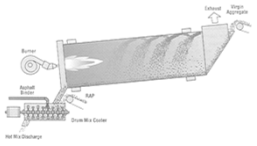




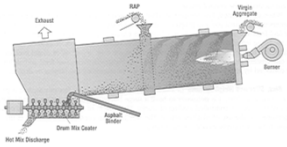
Double Drum Mixer



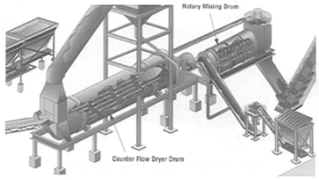
Triple Drum Mixer



Counter Flow w/ coater



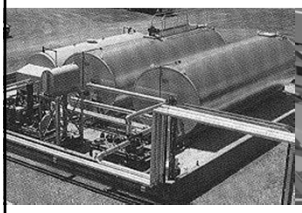
Parallel Flow w/ coater



Many rotary mixers have been retrofitted to older batch plants to increase production

Double - Drum / Mixer

The Aggregate and Asphalt feed rates are interlocked and common to all drum dryer plants



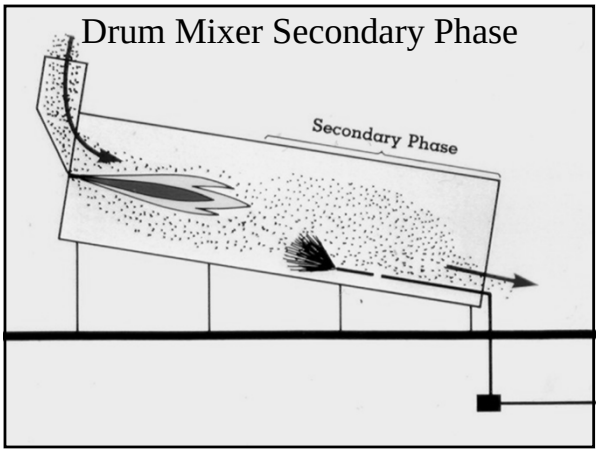
Asphalt Feed Rate must be compensated for Temperature

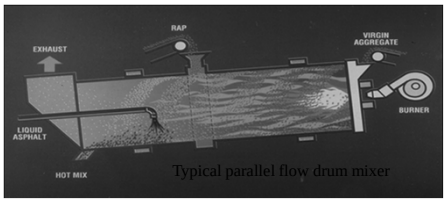
Aggregate Feed Rate must be compensated for what?

Moisture!

Drum Mixer Flights

Drum Mixer Secondary Phase

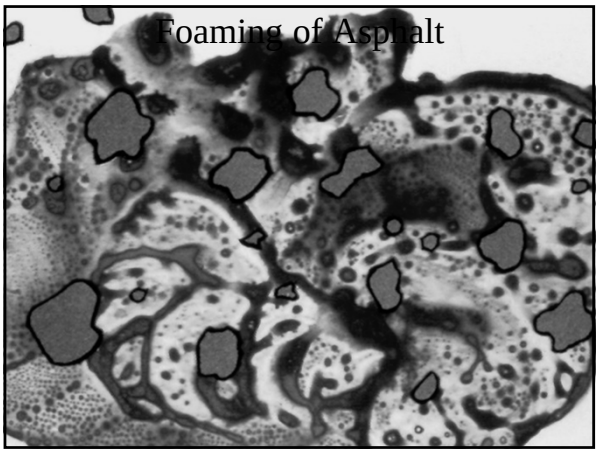




Typical parallel flow drum mixer

Veil pattern is very critical

Maintaining a uniform veil of aggregate in the drum is essential in obtaining efficient heat transfer.



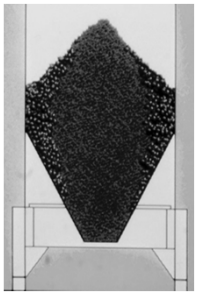
Many batch plants and virtually all drum plants discharge the mixture into a storage silo or system of silos

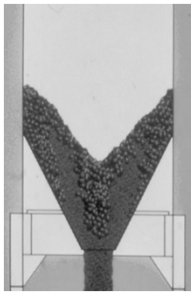
Dust collection

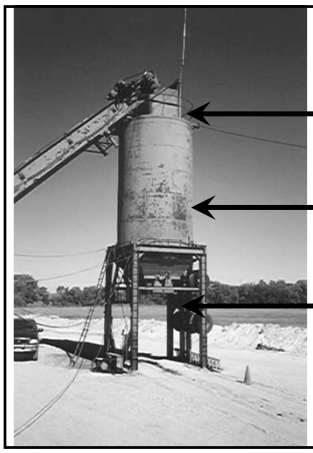
Works with the drying system

- Eliminates dust from plant exhaust
- Two basic types:
  - Wet scrubber
  - Baghouse

Preventing Segregation at the Plant





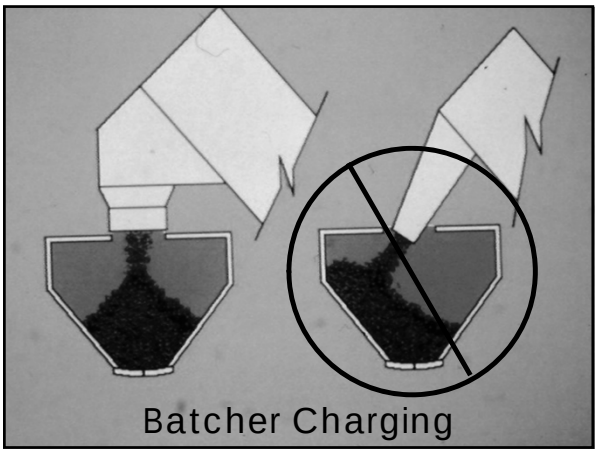


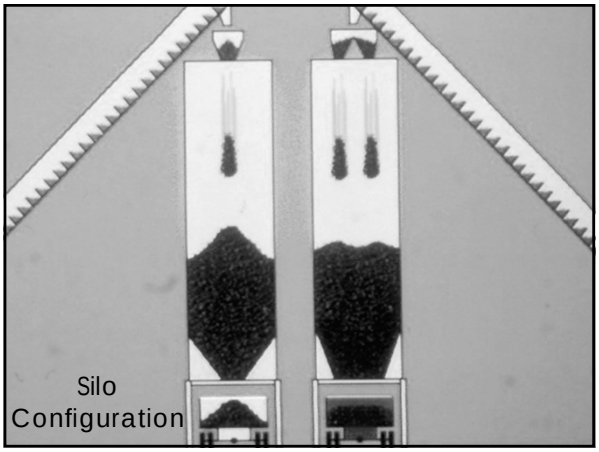
Minimizing Silo Segregation

Always use batcher or "gob" hopper

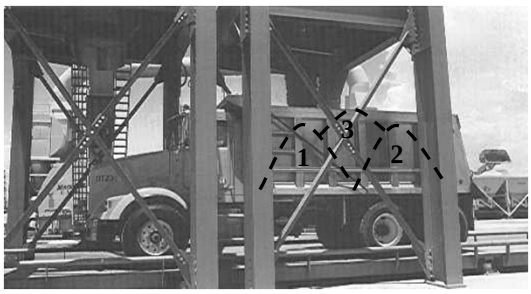
Maintain as uniform height of mix as possible 30-70%

Load out trucks in multiple drops.





Proper loading of trucks helps reduce Segregation



QUESTIONS??

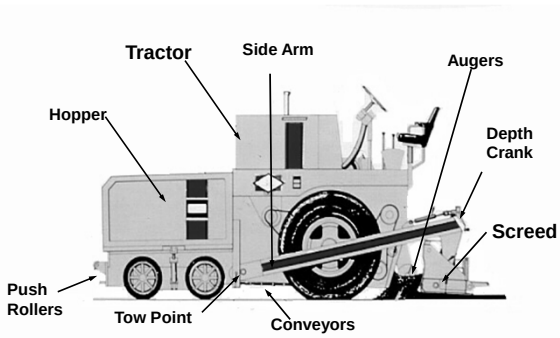
North Dakota TTCP

Paver Operations – Objectives

- Objective of HMA Placement
- Components and Function – Tractor and Screed Unit
- Operational Principles of Screed
- Grade and Slope Control Systems
- Yield-Thickness-Smoothness Relationship

Key Words

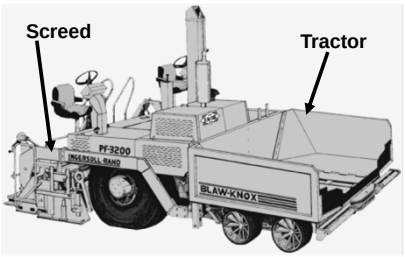
- Tractor
- Screed
- Hopper
- Conveyor
- Flow Gates
- Augers
- Crown (Lead & Tail)
- Screed Arm
- Screed Extension
- Head of Material
- Angle of Attack
- Paving Speed
- Yield
- Thickness
- Smoothness
- Mat
- Blemish

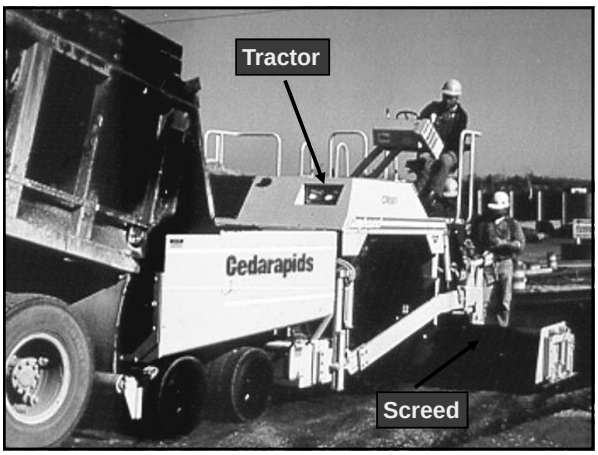


Speak the Same Language - Identify Paver Areas

Asphalt Paver

Two Basic Units





Wheel or Track Pavers

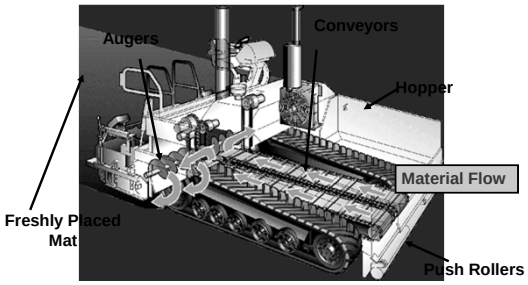
Wheeled Pavers

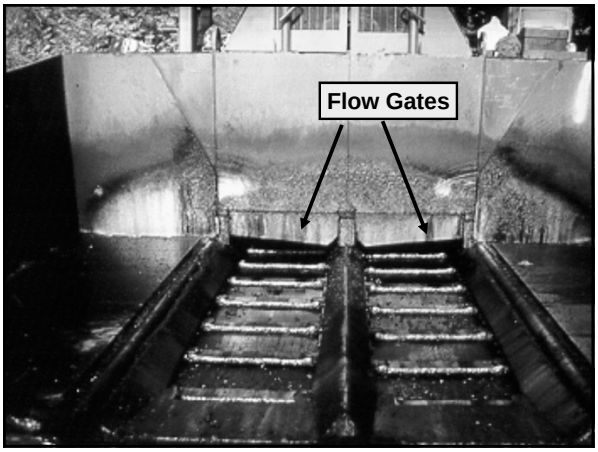
Are easy and inexpensive to maintain. They perform effectively on all paving surfaces except soft bases. Wheeled tractors utilize offset front bogie wheels in tandem for steering and front suspension

Tracked Pavers

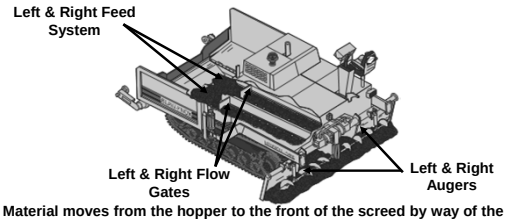
Are propelled by a track system. This tractor is especially advantageous when paving on soft surfaces, such as sandy base, or when paving conditions demand better traction. Tracked tractors are often preferred when laying wide or deep lifts, as well as work on significant uphill and downhill grades.

Material Flow





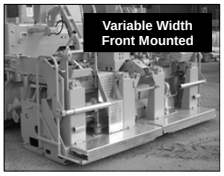
Independent Dual-Feed System



Material moves from the hopper to the front of the screed by way of the independent Dual-Feed System. The auger system is independent of the paving speed, giving the operator complete control over material volume. Left and right-side conveyors chain & bar assemblies move the material rearward to flow gates that meter a uniform flow. The augers then receive the material, delivering a constant volume to the outer ends of the screed--even when operating with an unbalanced screed or at extended widths, and when placing tapered or extra thick mats. The Dual-Feed System can be operated manual or automatic.

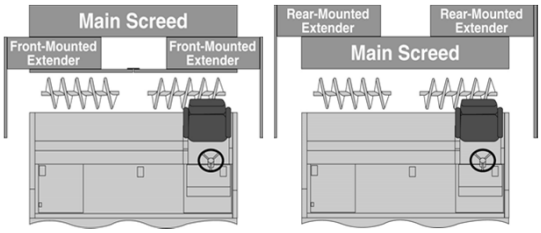
Screeds

- **Variable Widths**
- **Fixed Widths**
- **Extensions**
- **Heating Systems**

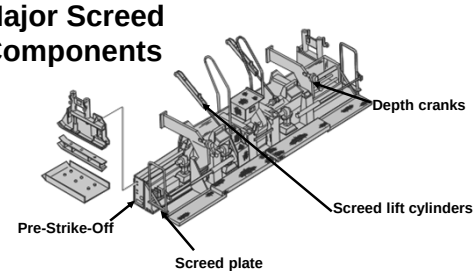


Screeds
-Variable & Fixed Width

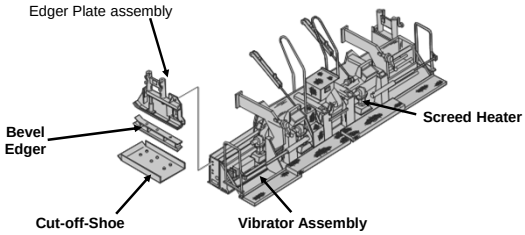
Extender Comparison



Major Screed Components



The bottom plate responsible for smoothing and sealing the mat surface. The pre-strike-off controls the amount of material that reaches the screed plate. Both are high-wear items attached to the screed frame.



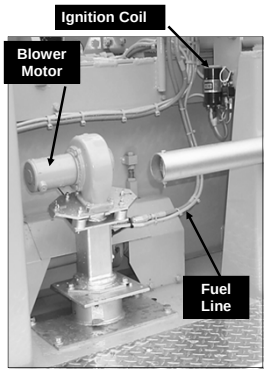
Major Screed Components

(Continued)

Hydraulic Strike Off Extension

Fixed Width Extension (Hard)

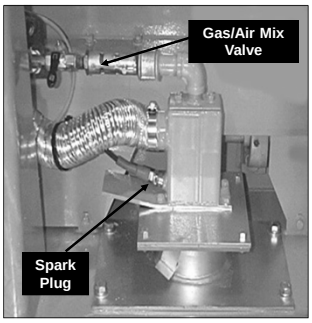
Screed Heating Systems



Diesel Screed Heater

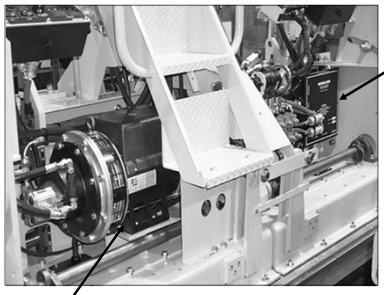
Fuel Pump Switch and Timer at Console

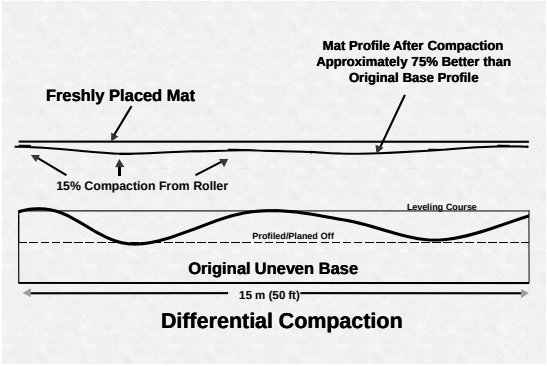
Propane Gas Heaters

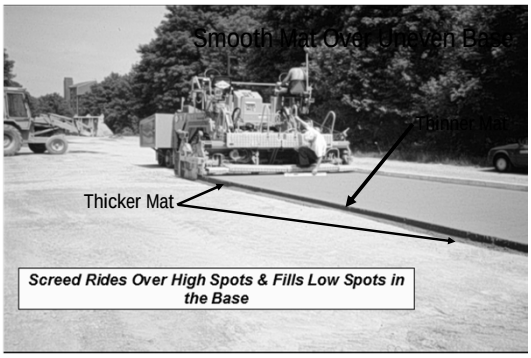


Screed Heater with Controller

Electric Screed Heating



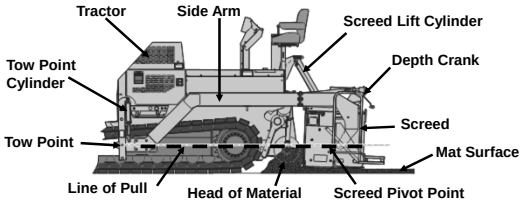




Operational Principles of the Screed

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

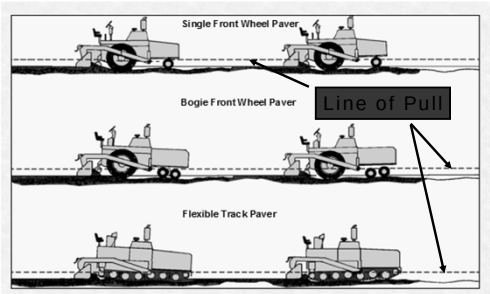
Free-Floating Screed



Two side arms connect the screed to the tractor. They connect to the tractor at the **Tow Point**, and to the screed at the **Pivot Point**. The tow points allow the screed to rise and fall based on paving speed and the amount of material flowing underneath. This self-leveling process allows the screed to compensate for irregularities in the grade or base surface, employing the free-floating principle.

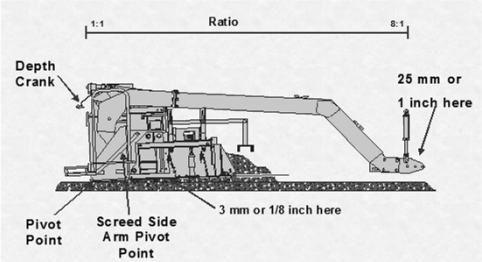
The **Tow Point** and **Pivot Point** combine to produce a **LINE OF PULL** parallel to the plane over which the screed travels.

Developing "The Line of Pull"



Tractor Levelability "***First Step in Smooth Paving***"

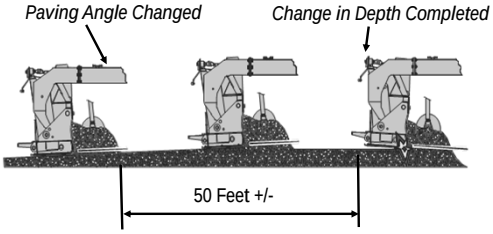
Length of Side Arm



Screed Ratio With Tow Point Operation = 8 : 1

Second Step in Smooth Paving

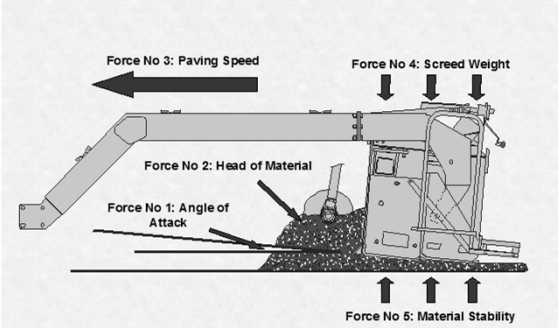
Resultant Change Over 50 Ft. +/-



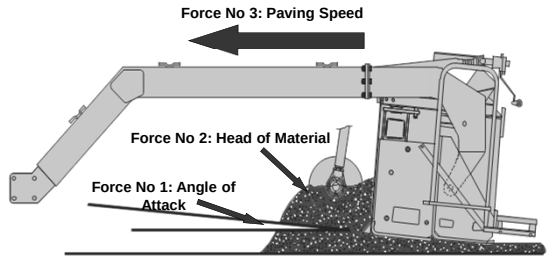
Third & Final Step in Smooth Paving

Forces That Make a "Free Floating Screed" Function

1- Angle of Attack
2- Head of Material
3- Paving Speed (Forward Motion)
4- Screed Weight
5- Material Stability



The Forces That Make a Screed Perform



Angle of Attack + Head of Material = Material Resistance

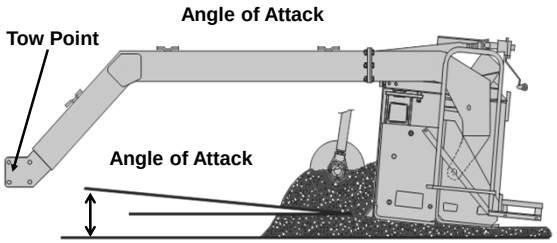
Balancing the Forces

Force # 1

Angle of Attack

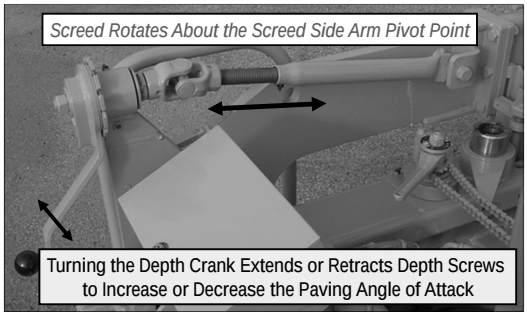
Force # 1

Angle of Attack

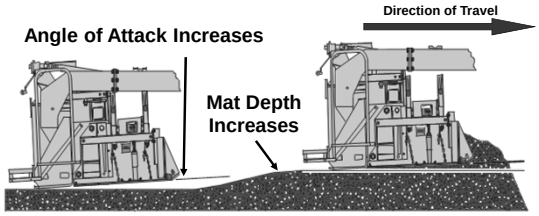


The Angle of Attack is the angle that exists between the bottom of the screed plate and the grade surface. This angle is a primary factor in determining the amount of material that will pass under the screed in a given distanced and is a critical element in controlling mat depth.

Changing the Angle of Attack

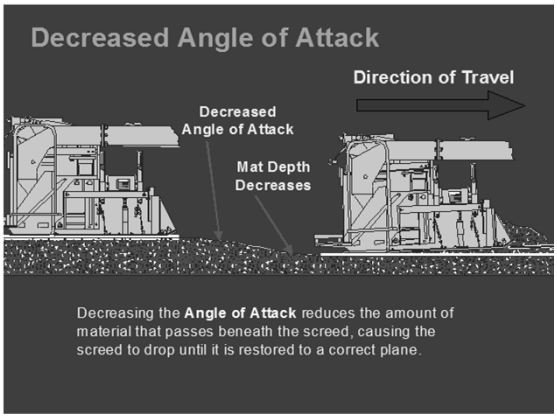


Increasing the Angle of Attack

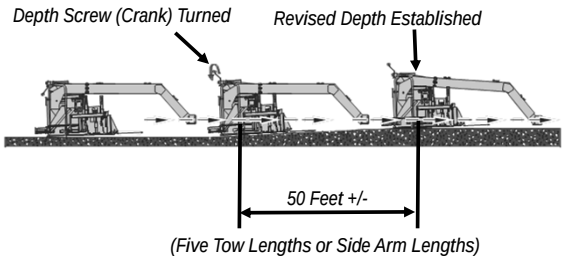


When the **Angle of Attack** is increased, more material passes under the screed. The mat depth will increase until the screed is again moving in a plane that is relatively parallel to the grade surface.

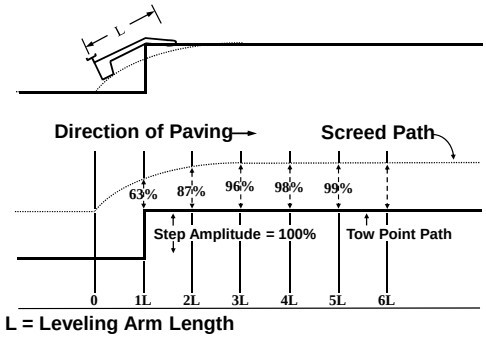
Once the correct mat depth is established and the **Head of Material** and **Paving Speed** remain constant, there is very little need for further A**ngle-of-Attack** adjustments.



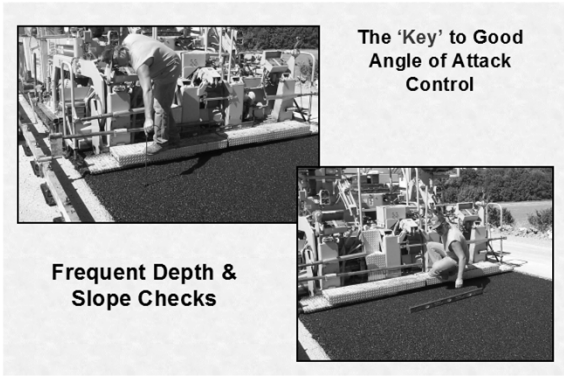
Screed Reaction Time



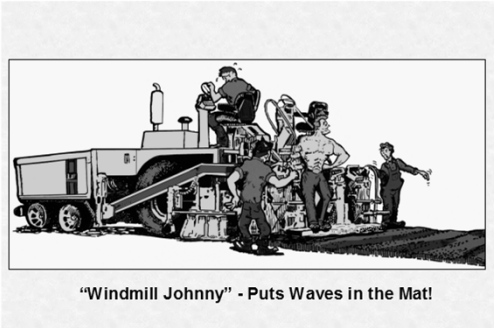
Increasing or Decreasing Mat Dept



Detail of Screed Path

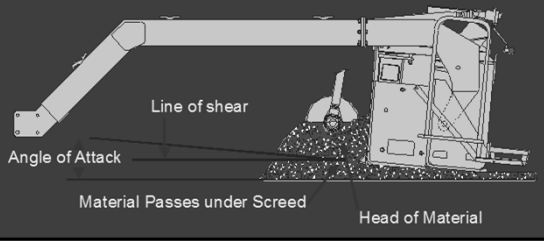


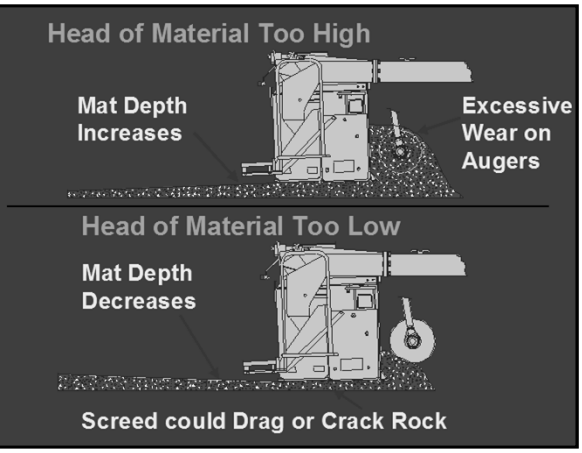
Watch This Guy!

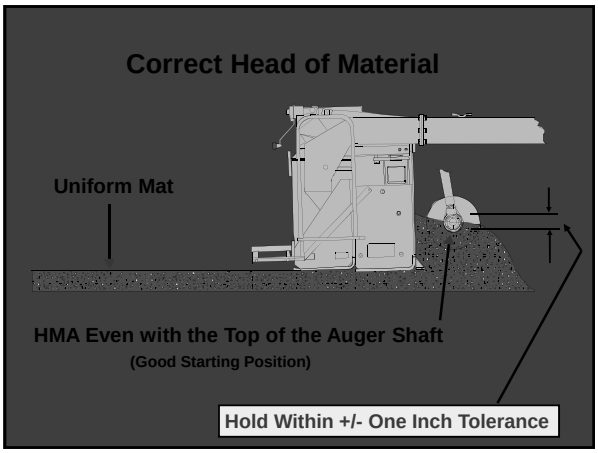


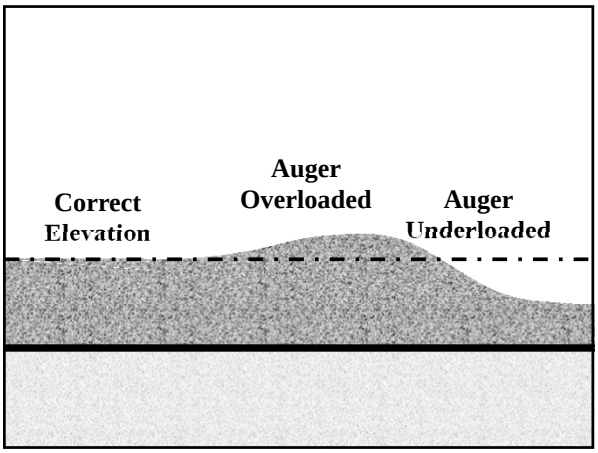
HEAD OF MATERIAL

The Head of Material is the mass of paving material that lies directly in front of and spans the entire width of the screed. ***Ninety-five to Ninety-eight percent of all mat flaws originate from paving with an improper head of material.***





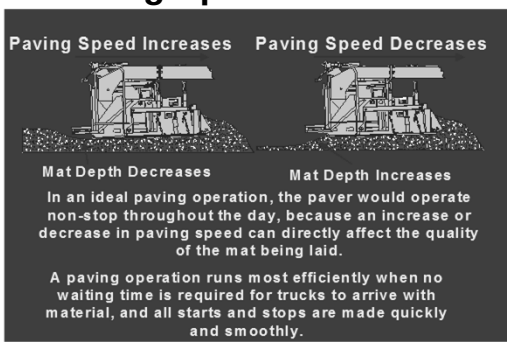




Force # 3

Paving Speed

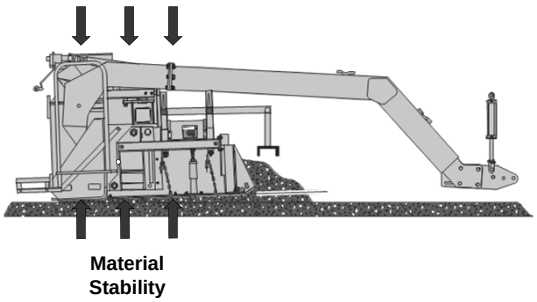
Paving Speed Force #3



Force #4 & 5

- Screed Weight
- Material Stability

Factors 4 & 5



Mat Marks

Try this Screed Lock System

When the Paver Stops For an Extended Length of Time :

Watch Forces 4 & 5!

Trucks Bumping the Paver Can Cause These Marks

Screed Assist

Screed Assist

1. Where the material stability fails to adequately support the screed, then screed assist could be used
2. Hydraulic pressure is applied to both screed lift cylinders through a screed assist valve
3. Screed weight is partially removed from the mat and transferred onto the tractor
4. This allows the mat to be laid and also provides for better traction in soft bases

Screed Assist Counters Factor Number 5. Material Instability

Heavier Screeds May Require Screed Assist

Angle of Attack

Areas to Watch!

Warnings - Angle of Attack

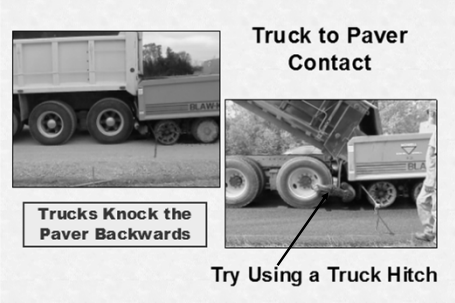
"Windmill Johnny" - Puts Waves in the Mat!

Overcorrecting the Depth Cranks

Warnings - Angle of Attack

Too Many Experts on the Depth Cranks

Warnings - Angle of Attack



Paver Knocked Backwards

Warnings - Angle of Attack

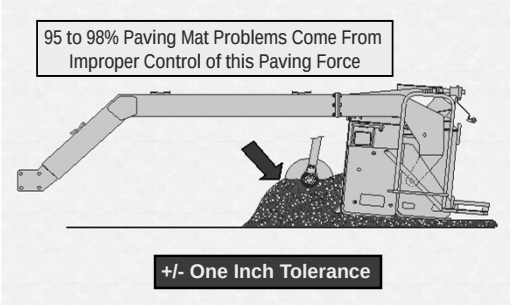
Allow the Paver to do Its Job, Minimize any Screed Depth & Slope Changes!

Automatic Grade & Slope Operation Covered Later

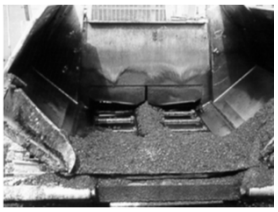
Head of Material

Areas to Watch!

Controlling the Head of Material



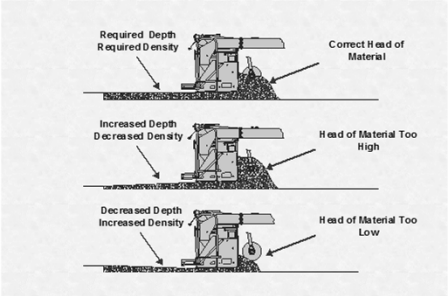
Head of Material Control Starts Here



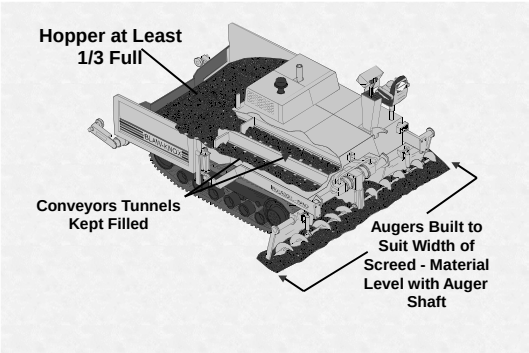
The Receiving Hopper

The Auger Assembly

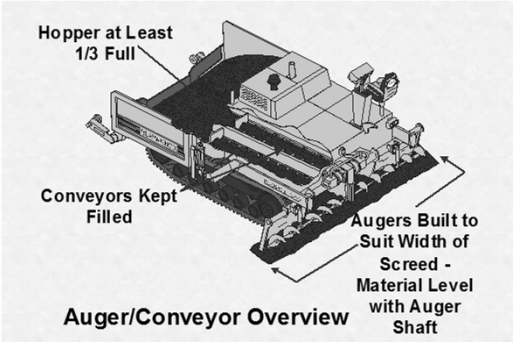
Establish Correct Head of Material & Maintain Volume +/- One Inch



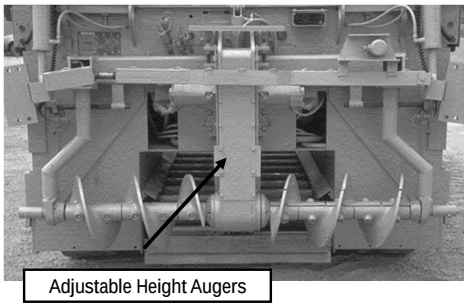
Material Flow Through the Paver



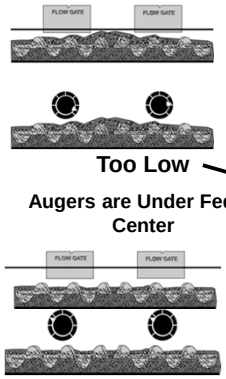
Material Flow Through the Paver



Adjustable Height Augers

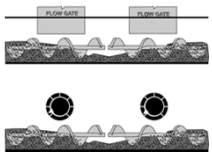


Flow Gate Positions



Too High

Augers are Over Loaded in Center



Too Low

Augers are Under Fed in Center

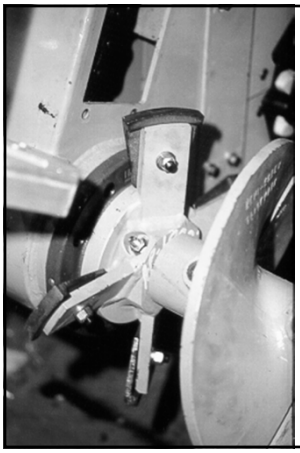
Correctly Positioned

Material Level Maintained At/Near the Top of the Auger Shaft

Use of Auger Confinement Tunnels to Control Material Flow to the Outer Edges of the Screed

No Auger Confinement

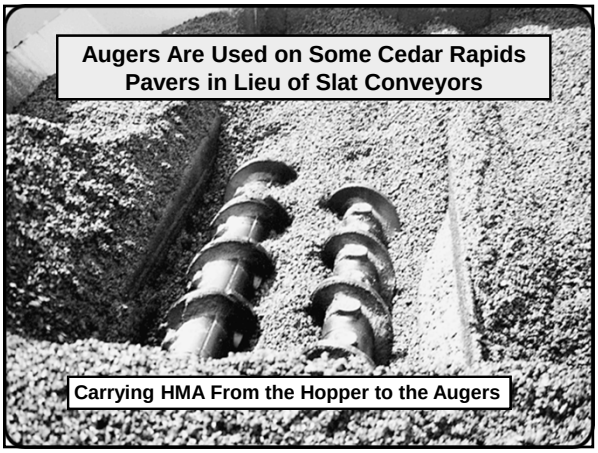
Auger Confinement Used



Kick Back Paddles on Each Auger

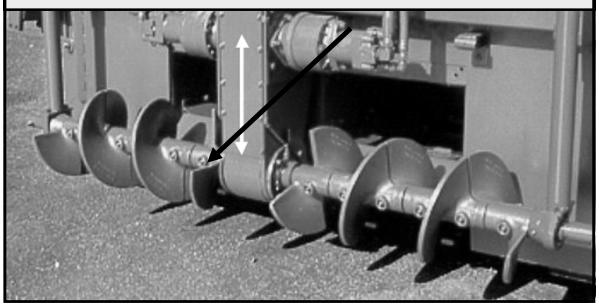
- Make sure They Are in Place
- Watch Worn Condition

Can Cause Centerline Segregation



Some Paver Manufactures Use Reverse Augers in the Center In Place of Kick Back Paddles

Watch Worn Condition!



Paving Speed

Areas to Watch!

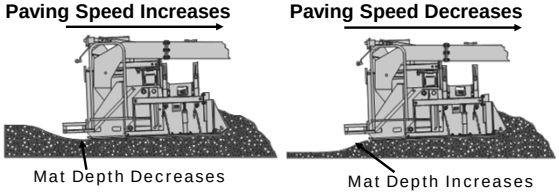
Factors Affecting Paving Speed

1- HMA Delivery
2- Paver Capacity
3- Consumption
4- Compaction Ability

Paver Operator Must Look Out, Down and Back - Keep Areas in Balance Striving for As Much as Possible a "Non-Stop Paving Operation"

Paving Speed

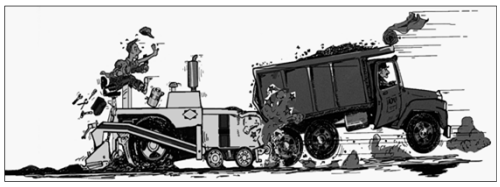
Paving Speed Increases **Paving Speed Decreases**



In an ideal paving operation, the paver would operate non-stop throughout the day, because an increase or decrease in paving speed can directly affect the quality of the mat being laid.

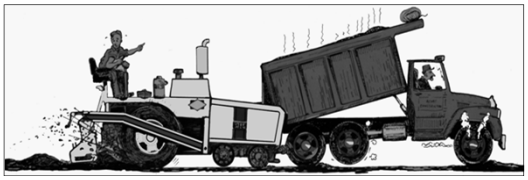
A paving operation runs most efficiently when no waiting time is required for trucks to arrive with material, and all starts and stops are made quickly and smoothly.

Avoid Speed Interruptions



Don't Bump the Paver!

Avoid Speed Interruptions



Watch For Anything That Disturbs the Smooth Forward Motion of the Paver!

Don't Apply the Brakes Too Hard!

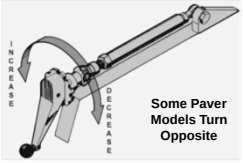
Avoid Slowing Down Extremely Slow Between Trucks

While Switching Trucks Watch Slowing Down so Slow That The Screed Could React (Rise or Fall)

Controlling Angle of Attack Manually

- Screed Operator Anticipates Changes and Manually Makes Changes as Needed
  - Remember Time Delay Between Angle Change and Screed Reaction (Approx 50 Ft.)
  - Watch Overcorrecting the Screed

Manually Adjusting Mat Depth



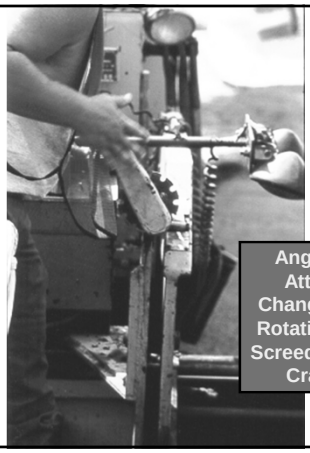
Adjusting manually requires turning the depth cranks to induce the proper change. The amount of response varies from screed to screed, but remember:

➔ Increasing angle of attack increases mat depth--turn cranks (CCW)

➔ Decreasing angle of attack decreases mat depth--turn cranks (CW)

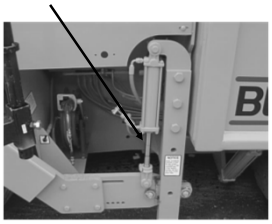
➔ Carefully observe depth crank gauges having achieved proper settings, and record for future mat-depth adjustments.

Manually Controlling Depth Changes



Angle of Attack Changed by Rotating the Screed Depth Crank

TOW POINT CYLINDER

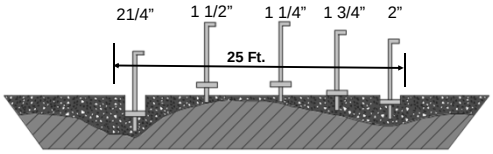


Instead of Using Depth Cranks the Tow Points Are Used to Change the Angle of Attack (Mat Thickness)

Manually Controlling the Tow Point With a Hydraulic Cylinder

Manually Controlling the Mat

As necessary once under way us a depth-check too. Take a minimum of 5 checks about 5 feet apart. Average the totals and compare the result to the specified grade-depth.

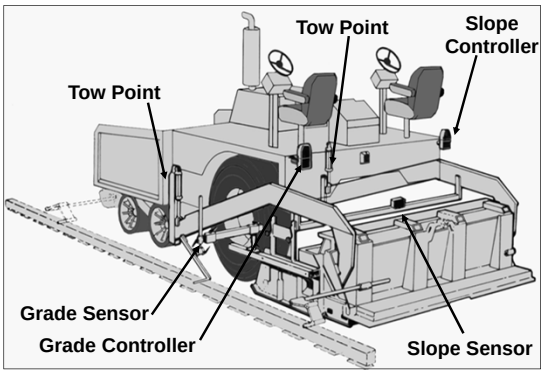


A job specifies a grade-depth of 2" (50mm). The screed-operator takes 5 checks over 25 feet (7.5m). Adding these measurements together and dividing the total by5 equals an average of 1 3/4 inches (43mm). The screed-operator must now increase mat-depth by 1/4 " (6mm).

Controlling the Controllable Basic Paving Principles

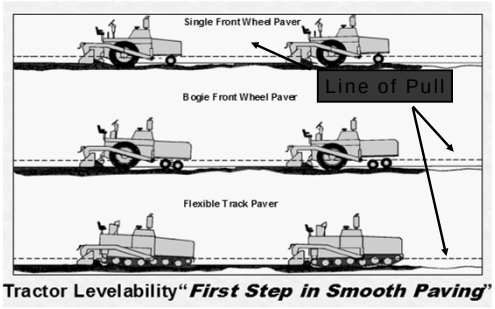
Angle of Attack

Automatically

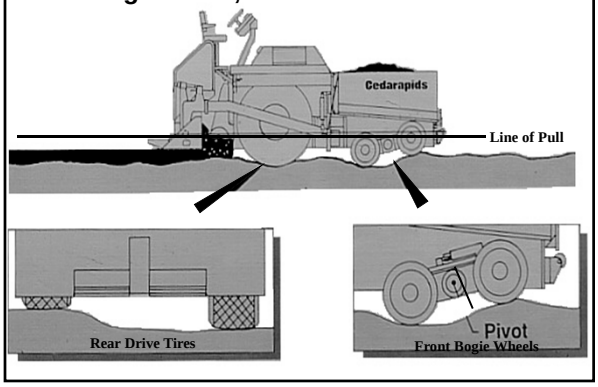


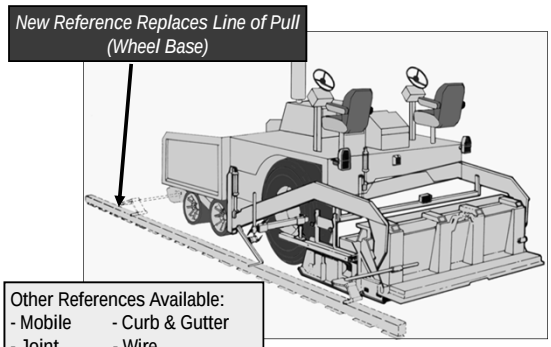
Automatic Grade & Slope (AGS)

Replacing Wheel Base Reference



Floating Screed, Will Take Out Deviations





Other References Available:
- Mobile - Curb & Gutter
- Joint - Wire
- Laser - Sonic Averaging

Grade Sensors

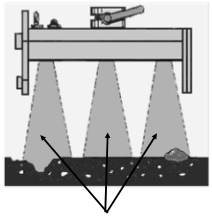
Matching a Joint

Running Off a Wire

Contacting Grade Sensor

Grade Sensors

Non Contacting Grade Sensor



Ultrasonic- One or More Transducers

Mobile References

Mobile Reference

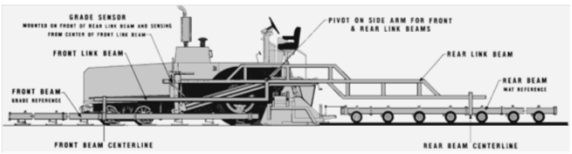
Matching Joint

Mobile References

Tubular Solid With Wire

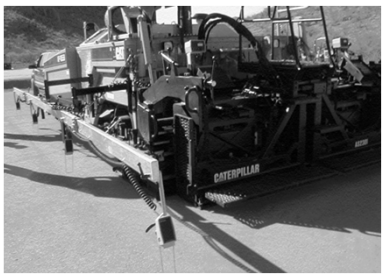
Lever Action

Mobile References



Over the Screed Reference

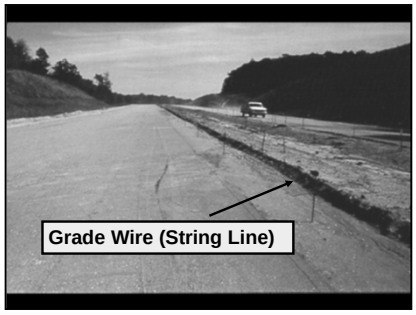
Mobile References



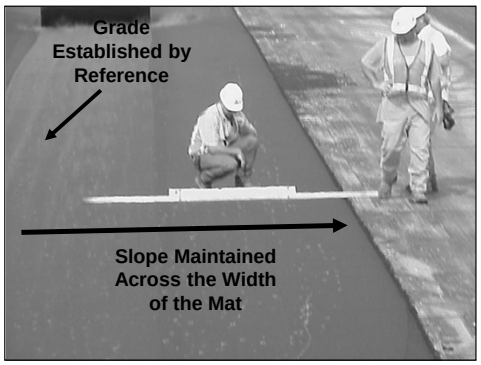
Sonic Averaging Beam

Fixed Reference

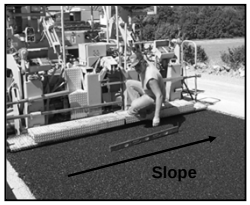
Grade Wire (String Line)



Slope Control

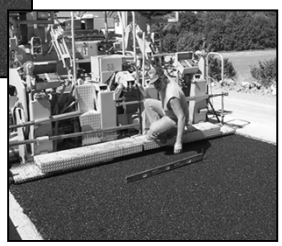


Slope Control

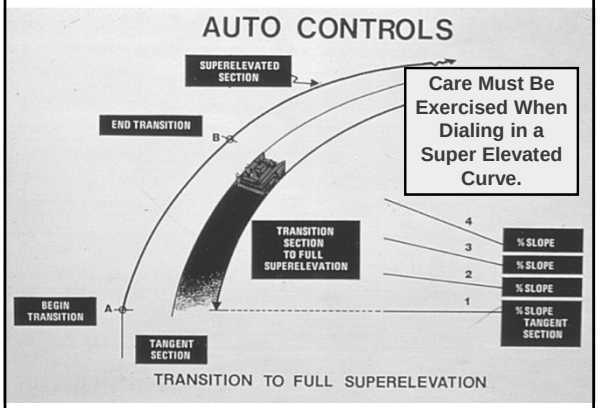


Uses Grade as the Established Profile and Accurately Maintains the Slope From One Side of the Mat to the Other.

The 'Key' to Good Angle of Attack Control



Frequent Depth & Slope Checks

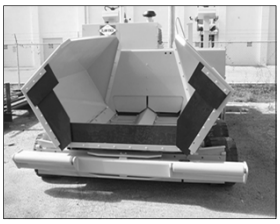


Care Must Be Exercised When Dialing in a Super Elevated Curve.

Remote Slope Controls Are Furnished by Some Manufactures

Angle of Attack Variables

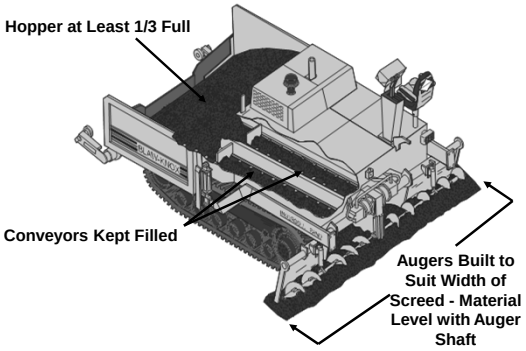
- Overcorrecting Depth Cranks
- Incorrectly Checking Depth
- Loose Bearings/Mountings in Depth Crank Arrangement
- Malfunctioning AGS Control
- Improper Use of References



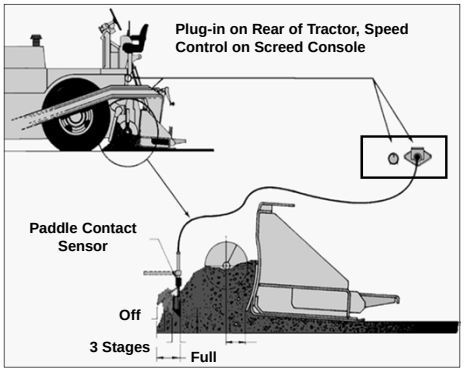
The Receiving Hopper

Head of Material Control Starts Here

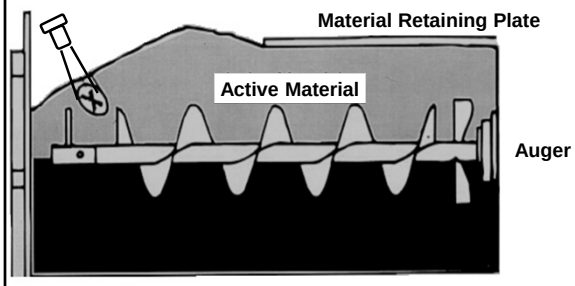
The Auger Assembly



Auger/Conveyor Overview

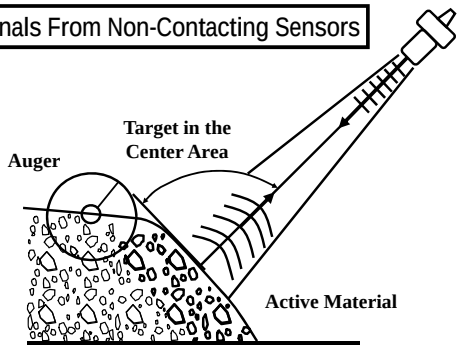


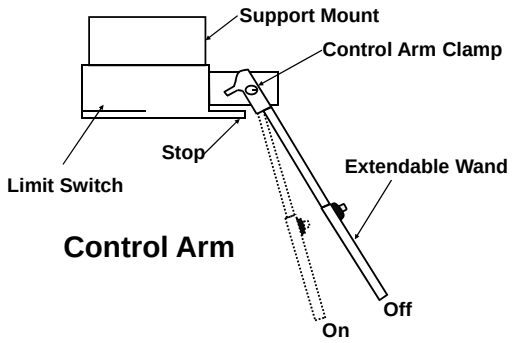
Electrical Switch Controls

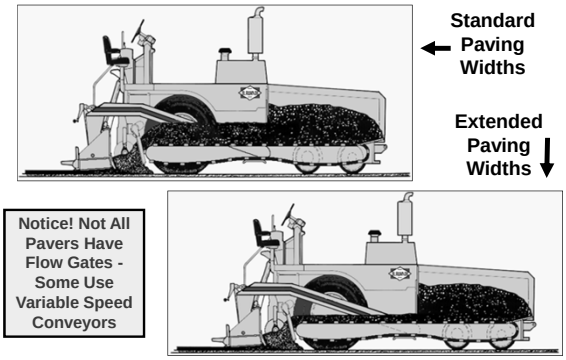


Non Contacting Sensors

Signals From Non-Contacting Sensors

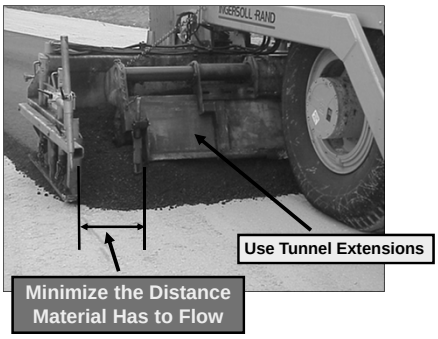




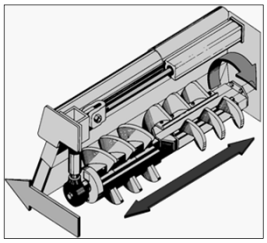


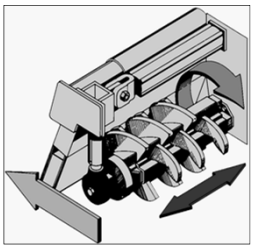
Flow Gate Positioning

Auger Confinement Tunnels

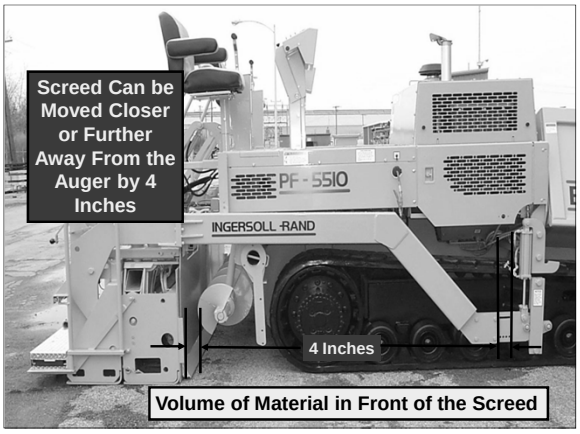


Power Flight Augers

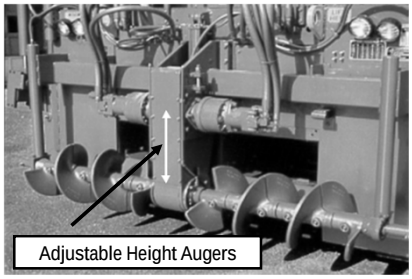




Extend Both Augers & Tunnels



Adjustable Height Augers



Head of Material Variables

- Fluctuating the Volume More Than +/- One Inch
- Running the Hopper Empty Between Loads
- Improper Setting of Material Sensors
- Tunnel Extensions Not Being Used
- Flow Gates Set Incorrectly
- Auger Height

Controlling the Controllable Basic Paving Principles

* Angle of Attack
* Head of Material
* Paving Speed

Balance These Three!

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite
  * Paver Capacity
- Consumption (Width & Depth)
- Compaction Ability

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite

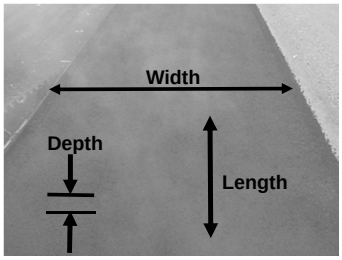
Mix Delivery

- Correct Number of Trucks for Uninterrupted Delivery to Paving Site
- Truck Driver's Training
  - Constant Delivery
  - Getting In and Out of the Paver
  - Expeditious Cycling of Trucks

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite
  - Paver Capacity
  - Consumption (Width & Depth)

Consumption



Length x Width x Depth = Tons

Tons Per Hour Determines the Rate of Speed

Set a Paving Speed to Match

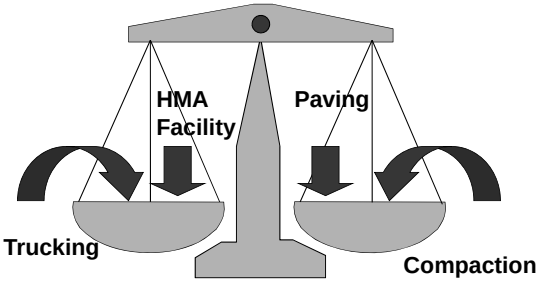
- HMA Delivery Plant to the Jobsite
- Paver Capacity
- Consumption (Width & Depth)
- Compaction Ability

Compaction Ability

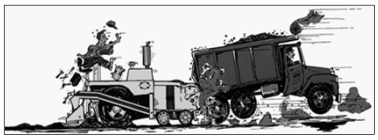
Don't Outrun the Rollers

Balance is the Key!

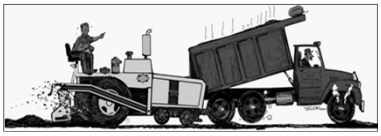
Determines Paving Speed



Watch Out!



Don't Bump the Paver!



Don't Hold Your Brakes!

Paving Speed Variables

- Transportation - Number of Trucks
- Discipline of Truck Drivers
- Don't Allow Trucks to Bunch Up
- Truck Exchanges
- Bumping Paver
- Holding Brakes
- Loosing Traction

Module 4- Screed Adjustments

- Screed Adjustments
  - Crown & Road Width (Profile)
  - Extensions
  - Pre-Strike Offs
  - Slope of Extensions
  - Lead Crown

Variable Width Screed - Flat

Screed Crown & Road Width

(Road Profile)

Variable Width Screed Crowned & Sloped

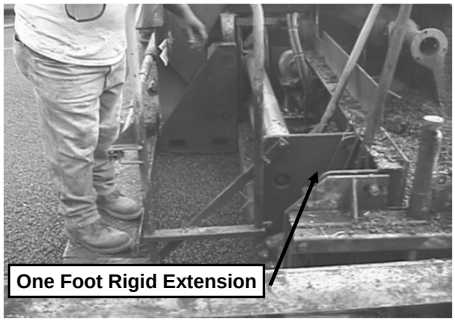
Screed Crown & Road Width

Screed Can be Extended to the Required Road Width

Screed Adjustments

- Screed Adjustments
  - Crown & Road Width (Profile)
  - Extensions
    - > Fixed (Hard)
    - > Variable

When Installed the Fixed Extensions Must be Aligned With Matching Surface



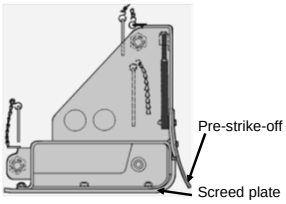
One Foot Rigid Extension

Adjust Strike Off According to Mfg's Recommendations

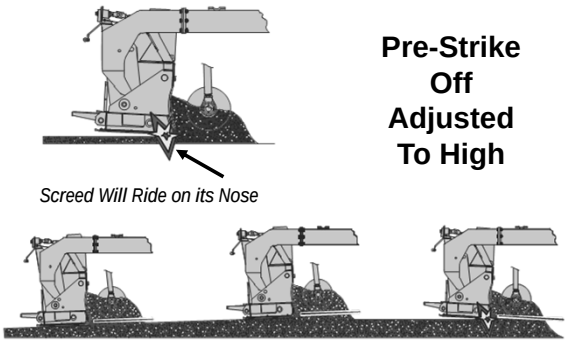
Screed Adjustments

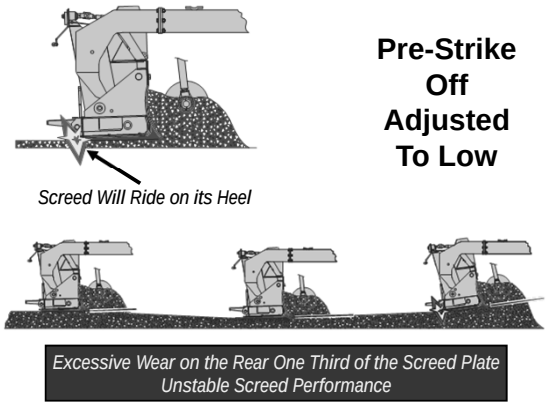
- **Screed Adjustments**
  - **Crown & Road Width (Profile)**
  - **Extensions**
  - **Pre-Strike Offs**

Pre-Strike Off Adjustment



The pre-strike-off shield's position in relation to the screed plate also affects the angle of attack. The pre-strike-off shield controls the amount of material that passes beneath the nose of the screed.





Screed Adjustments

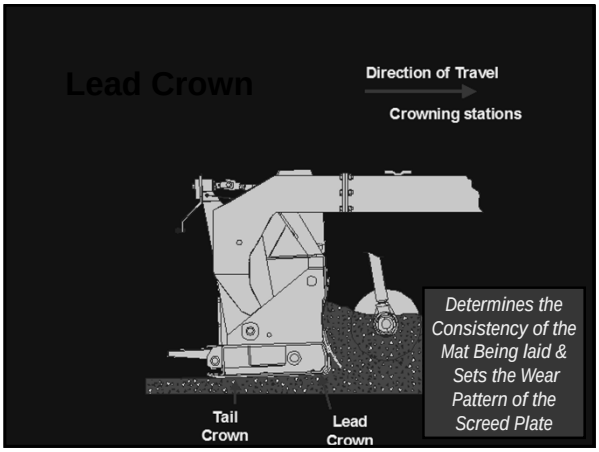
- **Screed Adjustments**
  - **Crown & Road Width (Profile)**
  - **Extensions**
  - **Pre-Strike Offs**
  - **Slope of Extensions**

Slope of Extensions

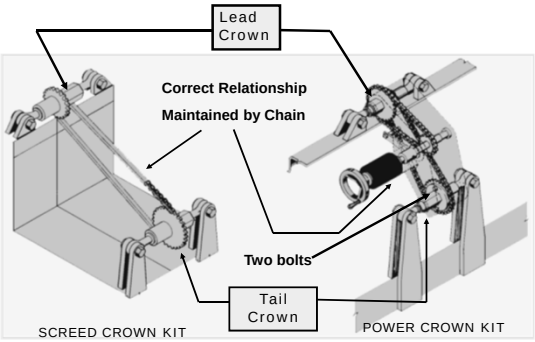
Extensions Can be Sloped to Meet Required Road Profile

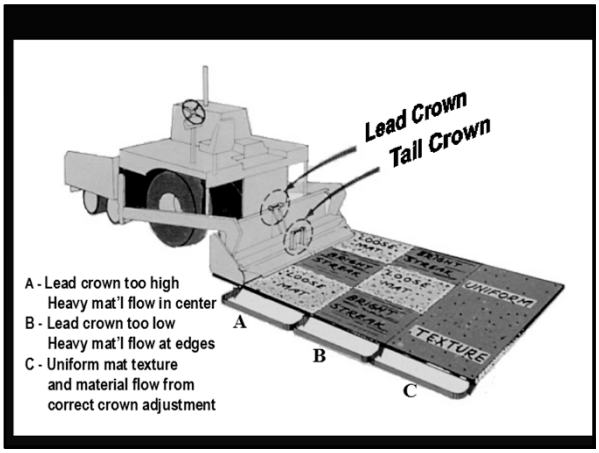
Screed Adjustments

- **Screed Adjustments**
  - **Crown & Road Width (Profile)**
  - **Extensions**
  - **Pre-Strike Offs**
  - **Slope of Extensions**
  - **Lead Crown**



LEAD CROWN VERSES TAIL CROWN





Types of Paving & When to Use Them

- Single Lane - Full Width - Echelon
- Reduced Width - Shoulders

Types of Paving & When to Use Them

- Single Lane

Single Lane

Types of Paving & When to Use Them

- Single Lane - Full Width

Full Width

Types of Paving & When to Use Them

- Single Lane - Full Width - Echelon

Echelon Paving

Types of Paving & When to Use Them

- Single Lane - Full Width - Echelon
- Reduced Width - Shoulders

Reduced Width - Shoulders

Module 4 - Blemish Free Mat

"Reading the Mat"

Streaks - Dragging - Segregation
- Steps - Bright/Dull Texture

Reading The Mat

Mission Statement

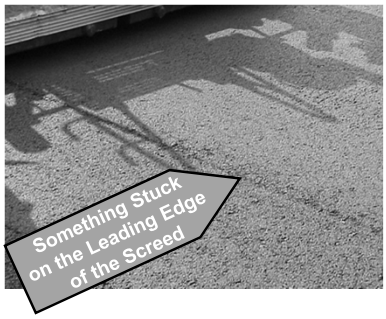
"Produce a Blemish Free Mat Free From Lines (Steps), Streaks, Dragging (Tearing), Segregation, and/or Texture Differential."

Blemish Free Mat

- **Lines or Steps in the Mat**
- **Streaks**
  - **Segregated Streaks**
  - **Texture Differential**
- **Dragging (Tearing)**
- **Segregation**
  - **Random**
- **Texture Differential**
  - **Random**
  - **Streaks**

Lines or Steps in the Mat

Lines in the Mat
Material Stuck in Front of the Screed



Streaks

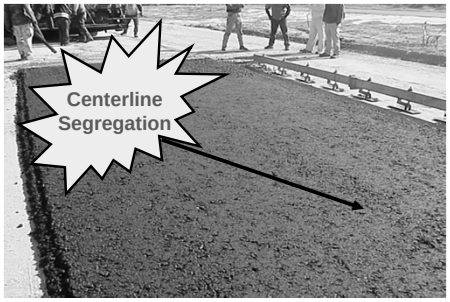
Define Streaks-

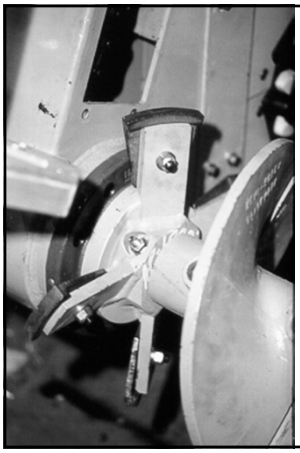
- **Dragging (Tearing) Remains Continuously in One Area Behind the Screed**
- **Segregation on the Surface Running Longitudinally (Large Aggregate is Seen)**
- **Texture Differential in the Mat Running Longitudinally (Texture Brighter in One Area)**

Segregation Vs Texture Streaking

- **Segregation Has Larger Aggregate Particles Showing Up in the Mat Surface. (Segregation is Normally an Auger Feeding Problem)**
- **Texture Streaking is Bright & Dull Streaks Running Longitudinally. (Normally is a Screed Adjustment Problem)**

Segregation Streaking





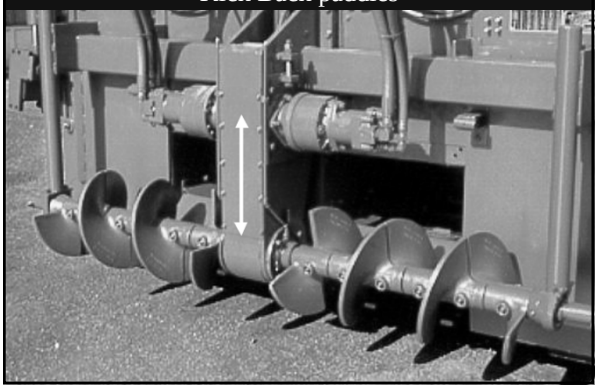
Kick Back Paddles between the two augers

Make sure you have them

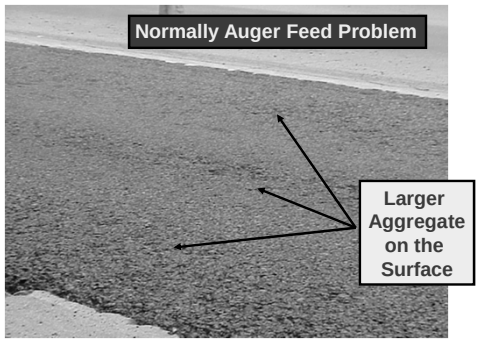
Make sure they are not worn out

one cause of centerline segregation

You might see these reverse screw augers in lieu of Kick Back paddles



Surface Segregation



Segregation on the Outside Edge of the Mat (Streaks)

Segregation at the Edger Plate

Dragging (Tearing)

Define Tearing (Dragging)

- Aggregate Being Crushed Under the Screed
- HMA Sticking to Cold Screed Plate
- As HMA Flows Out of the Auger Area Under the Screed Any Differential in Flow Characteristics Can result in a Dragging of the Mat.
  - Cold Chunks of Material
  - Precompaction in the Head of Material

Screed Crushing Aggregate

Depth 2 to 3 Times Largest Aggregate (Superpave More)

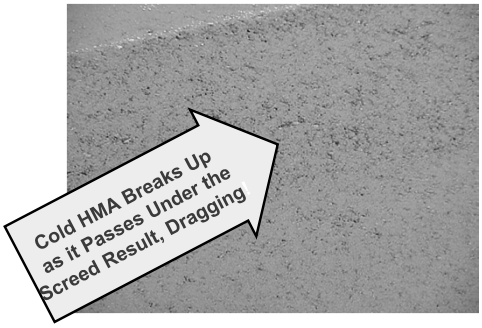
Cold Screed Plate

Screed is Not Heated Properly When You Commence Paving.

- Material Will Stick to the Bottom of Screed Plate and Cause Dragging (Tearing of the Mat Surface).
- Solution is to Heat the Screed Properly Before Beginning to Pave.

Cold Screed Plate

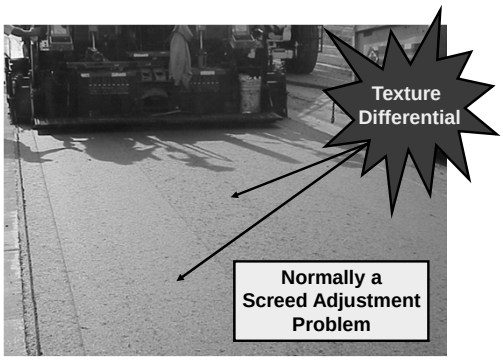
Dragging (Tearing)



Texture Differential

- **Texture of the Mat is Brighter in One Area.**
  - **Normally Runs Longitudinally With the Mat.**
  - **Most Always Can be Corrected By Screed Adjustments.**

Texture Differential



Yield

(Getting the Most Out of Your Tonnage)

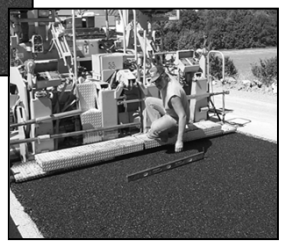
Yield-Thickness-Smoothness

- **Base Condition**
- **Minimum Thickness**
- **Yield**
- **Smoothness**
- **Controlling Yield versus Thickness or Smoothness, Which one would you rather have ?**

Module 4 Yield - Thickness - Smoothness

- **Base Conditions**
- **Minimum Thickness**
- **Yield**
- **Smoothness**
- **Controlling Yield verses Thickness or Smoothness, Which would You Rather Have?**

Check Yield Occasionally



Frequent Depth & Slope Checks

Calculating Yield

- **Why?**
- **Structural Design Thickness**
- **Adjusting Cross-Slope & Grade**

Calculating Yield

$$\text{Yield} = \frac{\text{Amount Used}}{\text{Area Covered}}$$

Calculating Yield- Problem 1

- **Given: The following weigh tickets.**
  42,130 + 39,270 + 37,420 +40,750
  = 159,570

Ending Station 23+50
- Beginning Station 15+30
Area Covered = 820 Ft x 12 Ft = 9840 Sq Ft
9840 / 9 Sq Ft/ Sq Yd = 1, 093.3 Sq Yd

Yield Problem 1

Pounds Used: 159,570 Pounds
Area Covered 1093.3 Sq Yd

Yield = 159,570 Pounds / 1093.3
= 145.95 Lbs.Per Square Yard
= 146.0 lbs/sq. yd. OR
(146/2000) t/sq yd x (12/3) x (5280/3)
= 513.92 ton/lane(ribbon)-mile

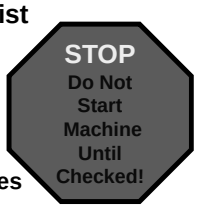
Troubleshooting

Using Common Senses

- **Sight**
- **Hearing**
- **Smell**
- **Touch**
- **Feel**
- **Gut Feeling**

Case in Point

- Go Over Machine Check List
  - Water
  - Engine Oil
  - Hydraulic Oil
  - Transmissions
  - Observe Air Pressure in Tires



Module 4 - Safety

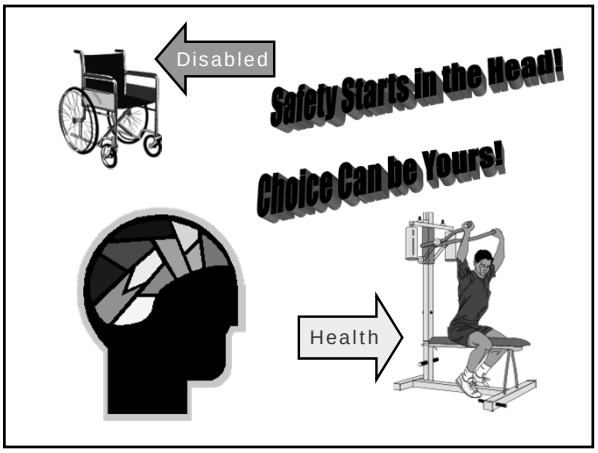
Play it Safe!

Safety

Safety

Is Almost Always Common Sense
In Action!

And Think!!



Seven Safety Zones

Seven Safety Zones

1- Trucks Traffic Pattern to Paving Site
2- Truck Back Into Discharge Position
3- In and Around the Paver
4- Around the Screed
5- Overhead Obstructions
6- Working Under Traffic
7- Rollers

Safety Zone #1

"Hauling Unit Safety"

Safety Zone # 2

Between the Hauling Unit & Paver

On & Around Paver Zone #3

Screedperson & Others Zone #4

Overhead Obstructions Zone #5

Paving Under Traffic Zone #6

Rolling Zone #7

One Thing in Common

"Truck Drivers"

One Thing in Common

"Crew Members"

Questions????

COMPACTION

North Dakota QC/QA

Asphalt Concrete Certification

Pavement Inspection

Compaction

Objectives

- Objective of Compaction
- Engineering Properties Related to Compaction
- Factors Affecting Compaction
- Types of Rollers
- Considerations for Selecting Rollers

Objectives (cont'd)

- Compaction Variables
- Roller Maintenance
- Operating Techniques

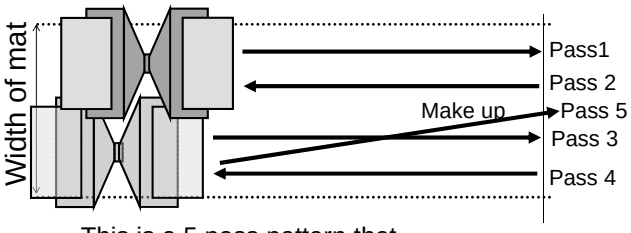
Definitions

- Density
- Compaction
- Pass
- Coverage

What Is Compaction?

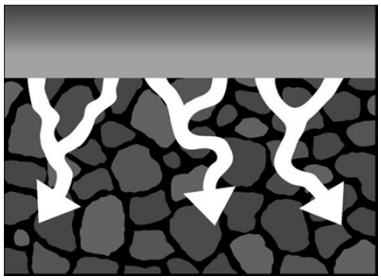
- Mechanically increasing the density of a lift of material
- Increase density by removing air voids
- Dense mat resists rutting and movement
- Each layer must support the load placed on it

Pass & Coverage Defined



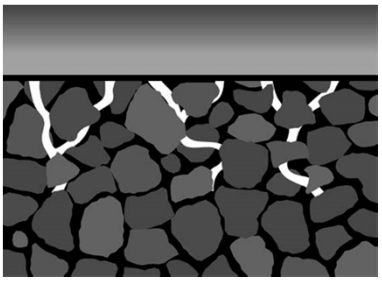
This is a 5 pass pattern that provides 2 complete coverages.

Mat Produced by the Paver



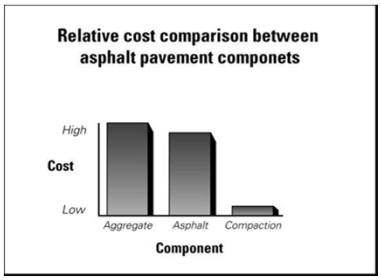
- Normally has about 15% air voids
- High air voids allow water penetration
- Allows deep rutting by traffic loading

Mat after Compaction



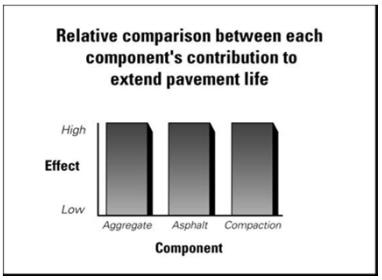
- 2%-7% air voids allow for needed expansion
- Aggregates moved closer together
- Provides cohesion, impermeability, and stability

Cost of Compaction



- Least expensive part of the paving process
- Aggregates and oil are expensive in comparison
- Compactions adds little to the cost of a ton of asphalt

Effect of Compaction



- Compaction is equally important in extending pavement life
- Saves money in maintenance costs
- Understanding compaction is very important

Importance of Compaction

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

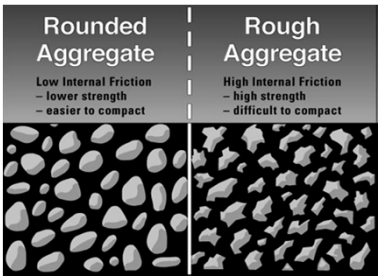
Factors Affecting Compaction

- Properties of the Materials
- Environmental Variables
- Laydown Site Conditions

Properties of the Materials

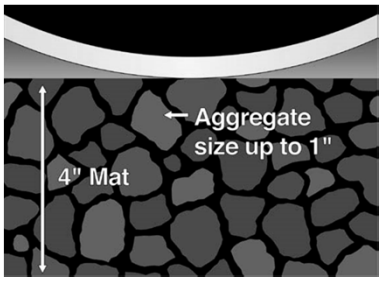
- Aggregate
- Asphalt Cement
- Mix Properties

Aggregate Shape



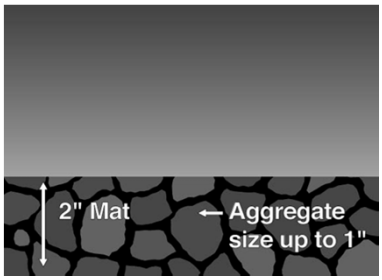
- Shape determines internal friction
- Rounded aggregate moves easily; use less force
- Angular aggregate resists movement; use high force

Aggregate Size vs. Layer Thickness

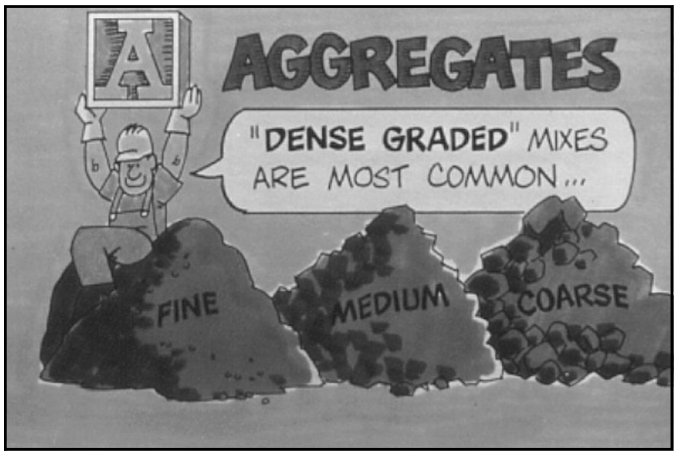


- Ratio affects ability to get density
- 4:1 ratio should easy to work with
- Can use high compactive forces
- Less concern about damaging mat

Aggregate Size vs. Layer Thickness

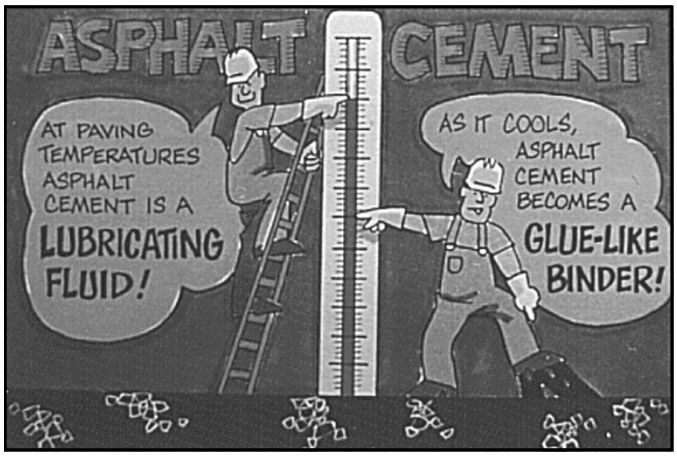


- Small ratio can be hardest to compact
- 2:1 is minimum
- Use low amplitude or static
- Watch for fractured aggregate at surface



Compact effort increases due to

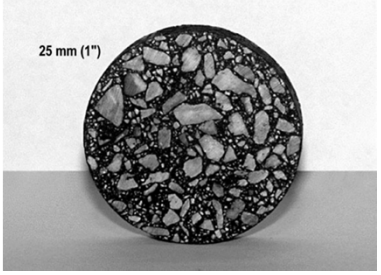
- Crushed content
- Nominal maximum size
- Hardness of the aggregate
- Angularity of aggregate
- Less natural sand
- High dust content mixes
- Note: Typically, Superpave and CMHB mixes will be harder to compact.



Influences on Asphalt Compaction

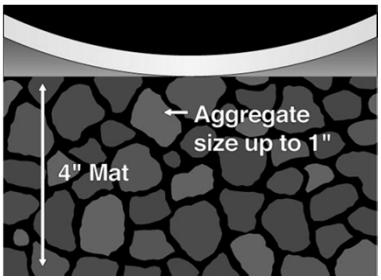
- Many factors, not controlled by operator, influence compaction
- Mix design
- Road design
- Mix temperature
- Climatic conditions
- Know how to respond to these factors

Mix Design



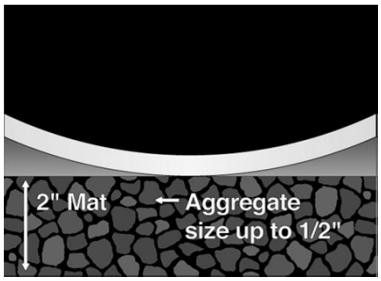
- Mix design affects compaction
- 85%-90% large aggregates, small aggregates, fillers, and sometimes modifiers
- 5%-8% asphalt cement
- 2%-7% air voids

Coarse Mixes



- Larger aggregates and less oil in thick mats
- Many Superpave mixes are coarse
- Considered “harsh”
- Need more force to cause aggregate movement
- High amplitude and heavy pneumatics

Fine Mixes

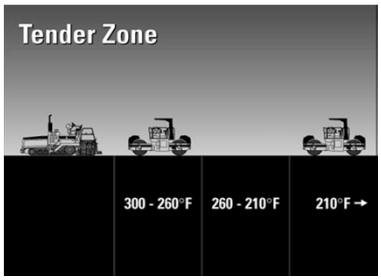


- Smaller aggregates and more oil in thinner mats
- Considered “tender”
- Need less force
- High force can damage mat
- Low amplitude or static force

Mix Temperature

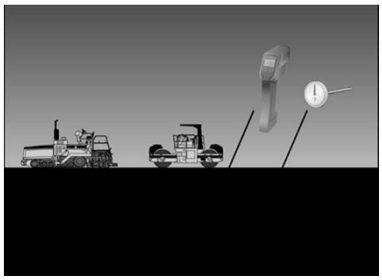
- Major effect on compaction
- Must compact while oil is still fluid enough to allow aggregate movement
- When oil is stiff, aggregates lock

Tender Zone



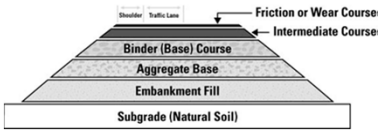
- Prevalent in some Superpave mixes
- Mix gets tender in a temperature range
- Get most density before tender zone
- Stay off mat until tenderness stops
- Mat may remain workable at low temperature

Checking Mat Temperature



- Infrared gun provides fast scan of surface temperature
- Gun shows how fast heat is being lost
- Probe shows internal temperature
- Probe is better indicator of how mix will react to compaction

New Roadway Design

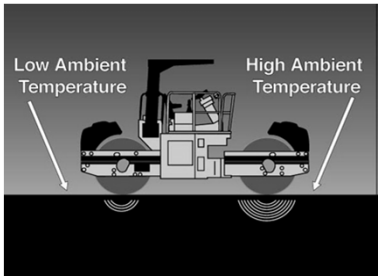


- Most roads have multiple courses
- Base course thick with large aggregate; use highest force
- Intermediate with smaller aggregate needs medium force
- Wear course thin with small aggregate needs least force

Environmental Variables

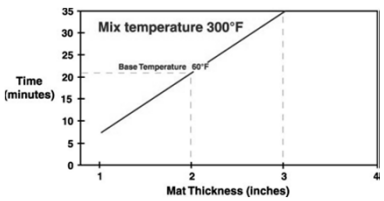
- Layer thickness
- Air and base temperature
- Mix laydown temperature
- Wind velocity
- Solar flux

Climatic Conditions



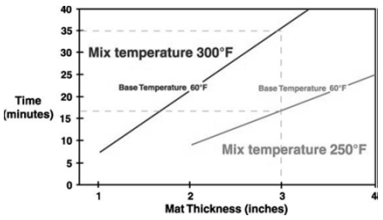
- Hot weather, mix stays workable longer
- Cold weather, crust forms early and force is less effective
- Adjust rolling pattern as conditions change

Time Available for Compaction

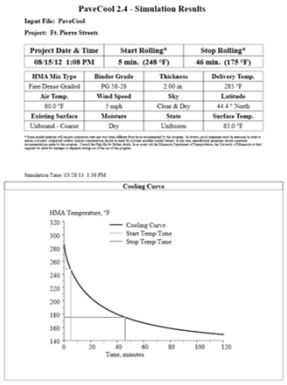


- Thin mat loses heat quickly
- Thicker mat remains workable much longer
- On thin mats, add more rollers; don't use more force; may damage mat

Time Available for Compaction



- Temperature of mat passing under screed affects mat workability
- Work close to paver when mat is cool
- Add rollers when mat is cool
- Use more force if possible



Major Factors Affecting Rolling Time

	allows MORE time	allows LESS time
Mat Thickness	THICK	THIN
Mix Temperature	HIGH	LOW
Base Temperature	HIGH	LOW

Selecting Compaction Force

LOWER AMPLITUDES	Parameter Level	Parameter	Parameter Level	HIGHER AMPLITUDES
	Thin* < 2"	Mat Thickness	Thick > 2"	
	Rigid	Base Support	Flexible	
	Low	AC Viscosity	High	
	Rounded	Aggregate	Angular	
	High	Temperature Base Air	Low	

* For very thin lifts, vibration is not recommended, especially on rigid base supports.

- Consider factors which affect compaction when selecting equipment and setting rolling pattern
- Some factors more important than others

Selecting Compaction Force

LOWER FORCE	Parameter Level	Parameter	Parameter Level	HIGHER FORCE
	2"	Mat Thickness		
	Rigid	Base Support		
		AC Viscosity	High	
		Aggregate	Angular	
		Base Temperature	50°F	

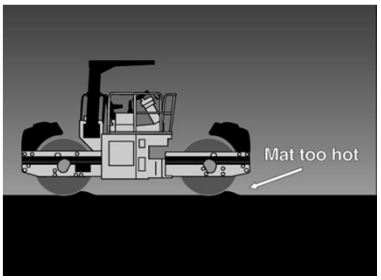
- Two factors for low force; three factors for high force
- Low force factors more important
- High force likely to cause mat damage
- Use low amplitude or static
- Monitor temperature

Selecting Compaction Force

LOWER FORCE	Parameter Level	Parameter	Parameter Level	HIGHER FORCE
		Mat Thickness	3"	
		Base Support	Flexible	
		AC Viscosity	High	
		Aggregate	Angular	
	90°F	Base Temperature		

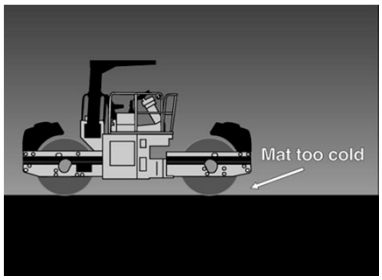
- Four factors for high force; one for low force
- Use high compactive force
- Flexible base very important factor
- Watch for tender zone on Superpave mixes

Mix too Hot



- Look for bulges in front of drums
- Mat will move around and not compact
- Roller leaves deep marks
- Upper limit is about 320 degrees F
- Stay back from paver until mat cools

Mix too Cold



- Lower limit around 185 degrees F
- No aggregate movement possible
- May be able roll out surface marks
- Work closer to paver
- Increase force
- Get more rollers

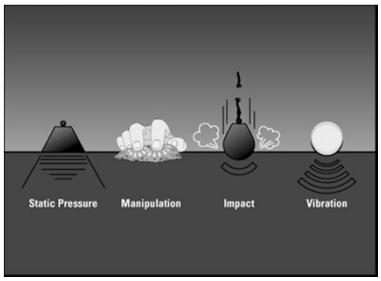
Laydown Site Conditions

- Lift thickness versus aggregate size
- Lift thickness uniformity
- Base Conditions

The Compaction Process

- Just as important as mix production and laydown
- Operator must understand forces of compaction
- Know how to balance weight, tire pressure, amplitude, frequency and rolling speed

Forces of Compaction



- Four forces are used for compaction
- Static pressure and manipulation are low force
- Impact and vibration generate higher forces

Types of Rollers

- Static Steel Wheel
- Pneumatic – Rubber Tired
- Vibratory

Compaction Equipment

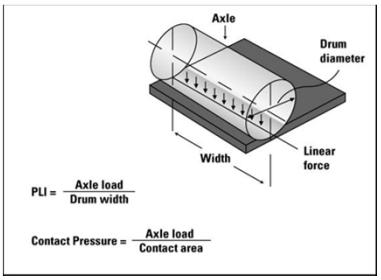
- Screed unit on paver
  - weight of screed
  - tamping/vibratory unit
- Rollers
  - static steel-wheeled
  - pneumatic
  - vibratory steel-wheeled

Static Steel-Wheeled Rollers

- 8-14 ton rollers normally used for HMA compaction
- Lighter rollers used for finish rolling
- Drums must be smooth and clean
- For initial compaction, drive wheel must face paver

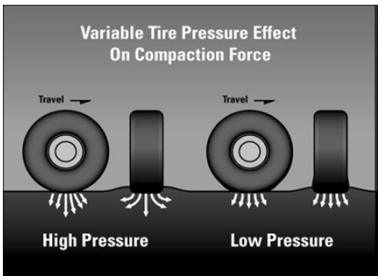
8-14 tons, 54 in. wide

Steel Drum Static Force



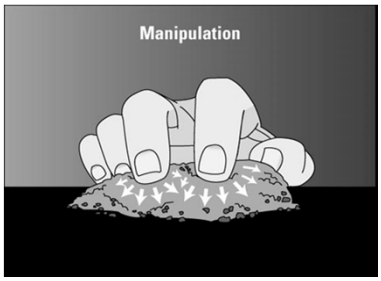
- Force is weight divided by contact area
- Most units are classed by PLI
- PLI is drum weight divided by drum width
- Static pressure is fixed, linear force

Static Pneumatic Force



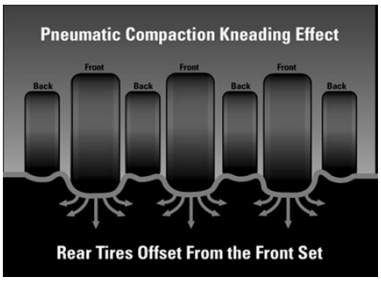
- Pneumatic force is weight at tire divided by tire contact area
- Expressed as PSI
- Vary PSI by varying tire pressure / ballast
- Low tire pressure - low force
- High tire pressure - high force

Force of Manipulation



- Lines of force are not just vertical
- Force sent in many directions
- Helps tighten surface texture
- Normally associated with pneumatic compactors

Pneumatic Tire Manipulation



- Overlap manipulates mat under and between tire
- Tight finish resists moisture penetration
- Manipulation increased by lowering tire pressure
- Static force increased by high tire pressure

Pneumatic-Tired Rollers

- Reorients particles through kneading action
- Tire pressures:
  - ~80 psi (cold) for compaction
  - ~50 psi (cold) for finish rolling
- Tires must be hot to avoid pickup
- Not used for PFC mixes or SMA

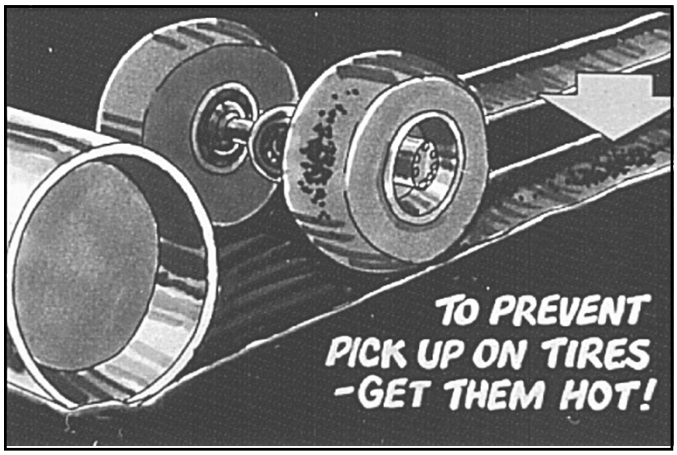
Pneumatic Tired Rollers

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

Tire Inflation Pressure Versus Ground Contact Pressure

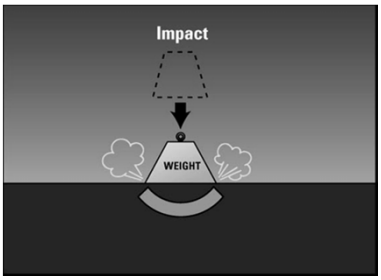
Inflation Pressure and Ground Contact Pressure at Various Wheel Loads and Ply Ratings

Example	*Ply Rating*	*Wheel Load lbs.*	*Tire Pressure psi*	*Contact Area in²*	*Ground Contact Pressure psi*
A	14	1250	130	16	78
	14	2800	130	30	92
B	14	2300	35	41	56
	14	2300	130	26	88
C	10	2800	90	38	73
	14	2800	130	30	92



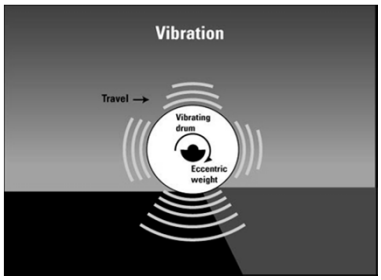
Easy Does it !

Impact Forces



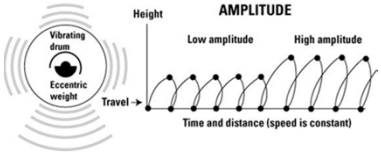
- Impact force is greater than static force
- Falling weight speed converted to energy
- Sends pressure wave into mat
- Impact can damage aggregates - must balance weight and impact

Vibratory Force

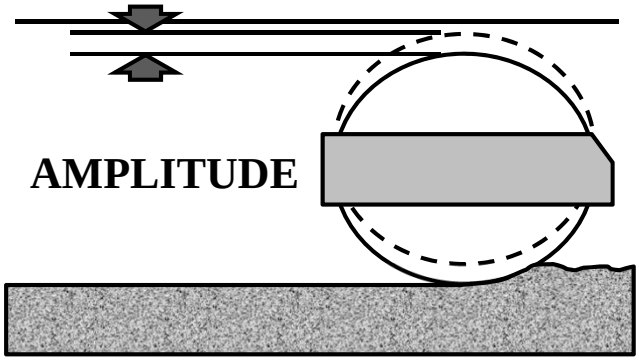


- Assists forces created by weight and impact
- Rapid succession of pressure waves
- Vibration sets aggregates in motion
- Helps aggregates re-orient for better contact

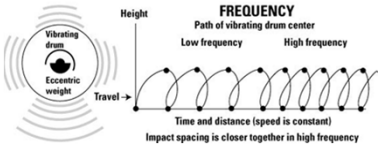
Vibratory Amplitude



- Spinning eccentric weight causes drum movement
- Falling drum adds to compactive force
- Distance drum moves is called amplitude
- Amplitude determines impact force

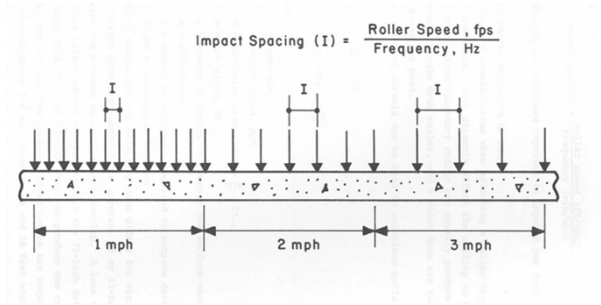


Vibratory Frequency

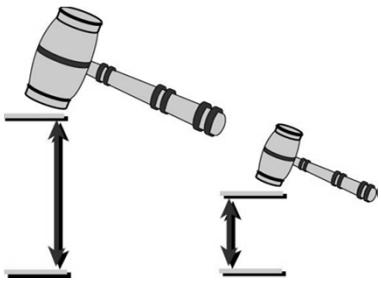


- Frequency is drum impacts per minute
- Working speed must match frequency
- Best results when impact spacing is 10-14 per foot

Frequency



Amplitude vs. Frequency



- High amplitude generates most force
- At same frequency, high amplitude does more work
- Is it logical to use high amplitude with high frequency?

Amplitude vs. Centrifugal Force

Amplitude vs Centrifugal Force

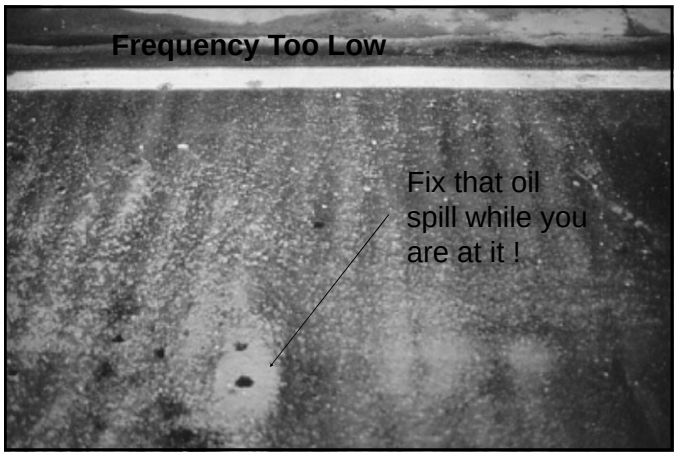
Machine 1		Machine 2
0,5 mm (.02")	Amplitude (lift height)	1,9 mm (.078")
50 Hz (3,000 vpm)	Frequency (number of hits)	25 Hz (1,500 vpm)
18 145 kg (40,000 lb)	Centrifugal Force	18 145 kg (40,000 lb)

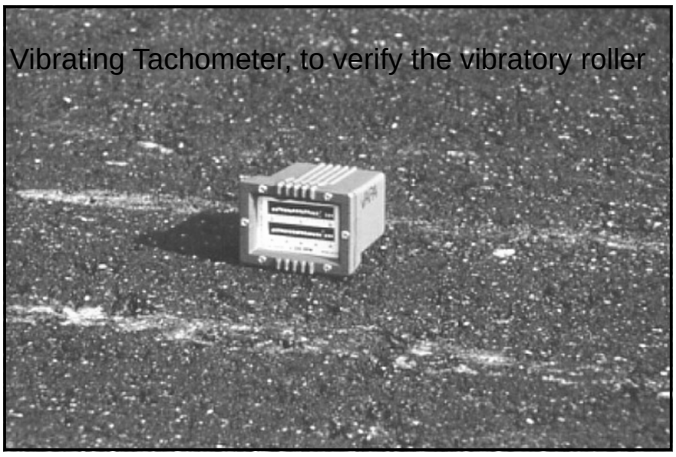
- Amplitude plus frequency creates centrifugal force
- Must be balanced
- Can't have both high amplitude and high frequency
- Each combination has its own application

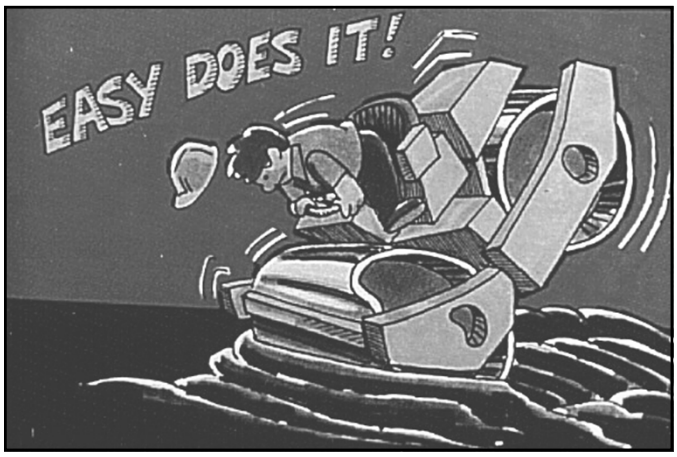
Effects of Vibration

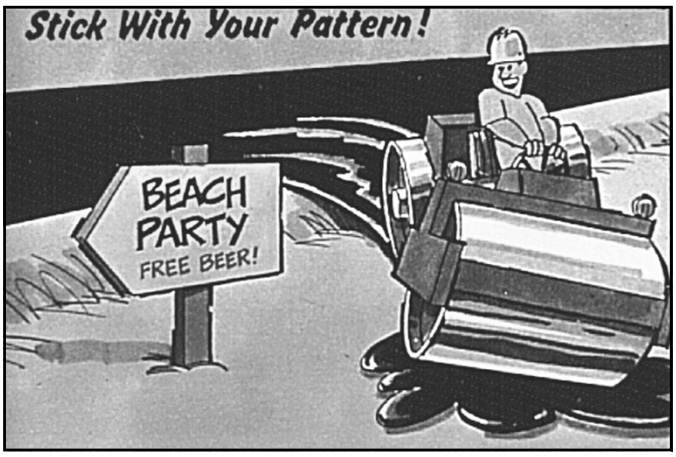
Typical Data for Vibratory Tandem Rollers

Vibratory Steel Tandem ton	*Oper. Wt. lbs.*	*Drum Diam. inch*	*Drum Width inch*	*Static Drum pli*	*Dynamic Drum pli*	*VPM*	*Nom. Amp. in.*
6-8	14700	41.5	56.5	130	260	2,900	0.025
9-1/2-11	20500	48	66	155	380	2,600	0.030
> 13	30000	59	84	185	420	2,400	0.030

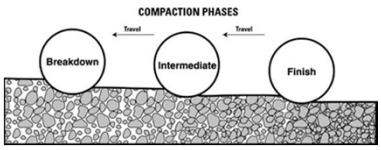








Phases of Compaction

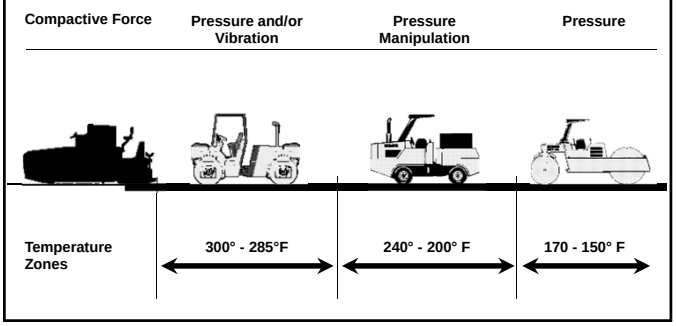


- Breakdown
- Intermediate
- Finish
- Different equipment and different techniques for each phase

Setting up the Compaction Train

- Equipment and techniques vary on each project
- Phases of compaction are the usually the same

Rollers in Compaction Train



Breakdown Compaction

- First step gets most of density
- Begin at highest temperature without mat distortion
- May have to work very close to paver
- Dual drum drive works best

Intermediate Compaction

- Final step in getting density and initial smoothness
- Mat hot enough to allow aggregate movement
- Mat already close to final density
- Too much force will fracture aggregate

Finish Compaction

- Minimal compaction
- Main purpose is smoothness and removal of any marks
- Once smooth, stop rolling

Breakdown Rollers

- Double drum vibratory most common
- Vibration most productive during breakdown
- Pneumatics used sometimes on base course
- Pneumatics can leave deep marks -- hard to roll out

Intermediate Rollers

- Pneumatics can reach final density without damaging the mat
- Pneumatics tighten the surface
- Vibratory rollers used in low amplitude or static

Finish Rollers

- Static steel wheel
- Vibratory double drum in static mode
- Remove marks left by previous rolling
- May need some additional density
- Operate low amplitude, then static

Edge/In-Slope Compaction

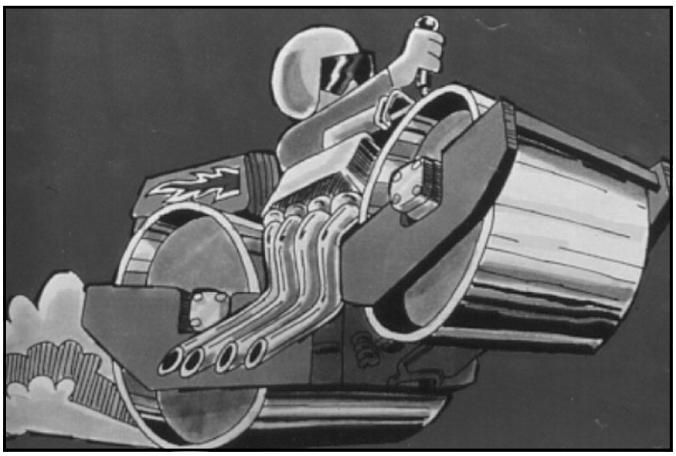
- Static steel wheel
- Tow Roller
- Drag Rollers
- Close Texture of In-Slope
- Control Pressure to Avoid Breaking the Edge
- Protect the Edge!!!

Typical Range of Roller Speeds

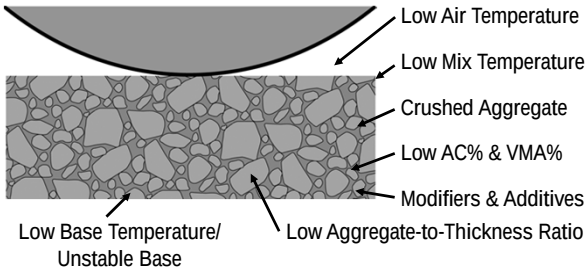
(miles per hour)

Type of Roller	*Breakdown*	*Intermediate*	*Finish*
Static Steel Wheel	**2 to 3.5**	**2.5 to 4**	**3 to 5**
Pneumatic	**2 to 3.5**	**2.5 to 4**	**4 to 7**
Vibratory	**2 to 3.5**	**2.5 to 3.5**	**3 to 5[1]**

[1] Operated in static mode



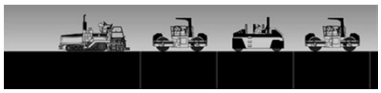
Factors Contributing to Harsh Mixtures



Compacting Harsh Mixes

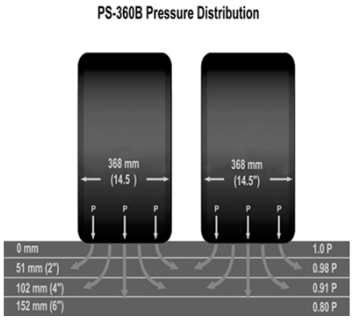
- Heavy pneumatic in breakdown moves large aggregate deep in mat
- Vibratory intermediate gets final density
- Finish with static steel wheel or double drum

Harsh Mix -- Wear Course



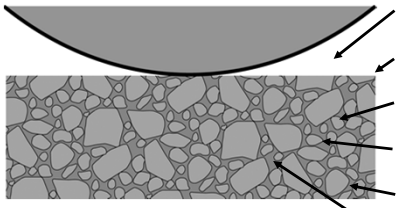
- Move vibratory to breakdown
- Pneumatic to intermediate avoids deep tire marks
- Finish with static roller to clean up marks

Tire Selection -- Harsh Mixes



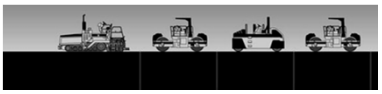
- Wide, flat tire
- Higher possible tire loads
- Greater penetration of ground pressure

Factors Contributing to Tender Mixes



High Air Temperature
High Mix Temperature
Moisture in Aggregate
Thick Film
High AC%
Low Stiffness AC

Tender Mix Throughout

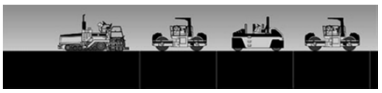


- Vibratory breakdown - watch for excessive movement
- Light pneumatic intermediate - avoids deep marks
- May substitute vibratory as intermediate
- Finish static

Tenderness Due to High Temperature

- Stay back from paver
- Monitor temperature
- Experiment with amplitudes and tire pressures

Tender Zone Rollers

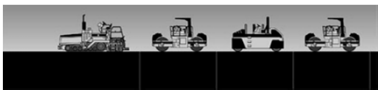


- One or two vibratory rollers in breakdown to get max density
- Intermediate use wide tire pneumatic, or
- Skip intermediate until tenderness leaves
- Final density in finish pass with half vibe/half static

Fragile Mixes

- Soft aggregate (limestone, dolomite) can be crushed during compaction
- Brittle aggregate can be fractured if too much force is used
- Damage more likely if aggregate-to-thickness ratio is 2 or less

Fragile Lift Compaction



- Less force to avoid damage
- Low amplitude or static breakdown
- Can use pneumatic for breakdown
- Pneumatic intermediate
- Static finish

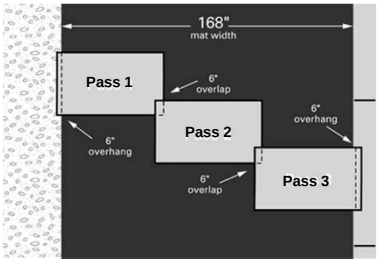
Soft Aggregate Compaction

- Avoid vibratory if damage occurs
- Heavy pneumatic for breakdown
- Light pneumatic for intermediate
- Static finish

Developing a Rolling Pattern

- Match paver production
- Get target density
- Produce smooth, tight finish

Calculating Required Drum Width



- Coverage in 3 passes or less
- 6” overlap & overhang
- 168” wide mat plus 4 x 6” overlaps equals 192” total width
- Total width divided by 3 passes equals 64”
- Minimum drum width is 64” this example

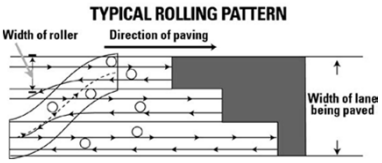
66” / 67” Drum Size Class

- Covers 14’ mat in 3 passes
- Frequency of 2,500 vpm
- Divide frequency by 10 impacts per foot
- Working speed up to 250 fpm

Paver Production & Speed

- 14' mat width
- 3" uncompacted mat depth
- 400 tons/hr available
- Paver speed of 25-30 fpm consumes plant production on this project

Matching Paver Speed



- 7-pass rolling pattern gets target density for breakdown
- Divide compactor speed (250 fpm) by 7 passes
- Average roller speed 36 fpm
- Matches paver speed of 25-30 fpm

Test Strip

- Test strip sets rolling pattern
- Straight run part of project
- Nuclear density gauge checks progress while mat is still hot

Breakdown Roller on Test Strip

- Target 95% of required density
- Check density after each pass
- Roll until density target is achieved
- Confirm pattern matches production requirement

Can't Get Density on Test Strip

- Add passes
- Increase amplitude
- Increase tire pressure / ballast
- Use higher production roller - wider drums
- Work closer to the paver
- Reduce rolling speed

Over-compaction on Test Strip

- Reduce passes. Stop rolling close to but not over density target
- Lower amplitude
- Lower tire pressure / ballast
- Roll in lower temperature zone
- Increase working speed

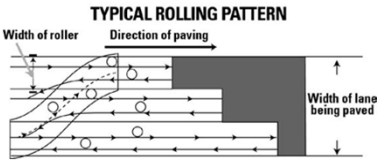
Intermediate Roller on Test Strip

- Roll immediately behind breakdown while mat is till hot
- Increase density to 100% of target or close to it
- Tender zone mixes are the exception
- Finish roller gets final density if tender zone appears

Finish Roller on Test Strip

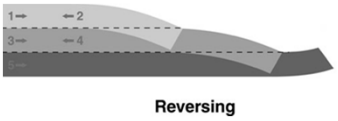
- Primary role is smoothness
- May provide some density gain, especially on Superpave
- Role close enough to intermediate to roll out marks

Rolling Pattern - Confined Edges



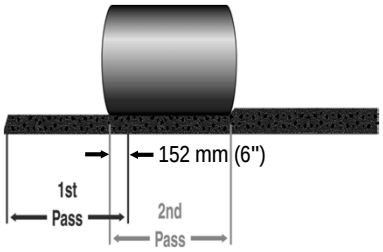
- Start on right or left edge
- Roll to within 20' of paver
- Reverse in same path
- Second path in center
- Third path on opposite edge
- Start next sequence at end of first path

Reversing Direction



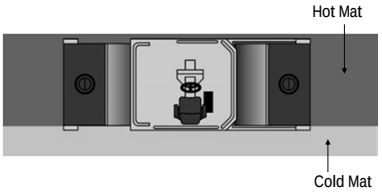
- Avoid straight stops
- Turn toward center of mat
- Don't turn drum while stopped
- Next pass should be able to roll out any marks created by reversing

Overlaps



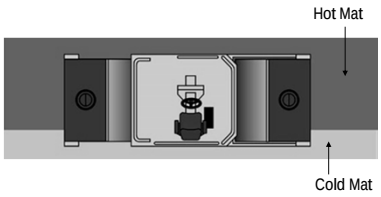
- 6" overlap assures uniform compaction
- Include overlap when selecting drum width
- Roller should cover mat in 3 overlapping passes

Longitudinal Joint Compaction

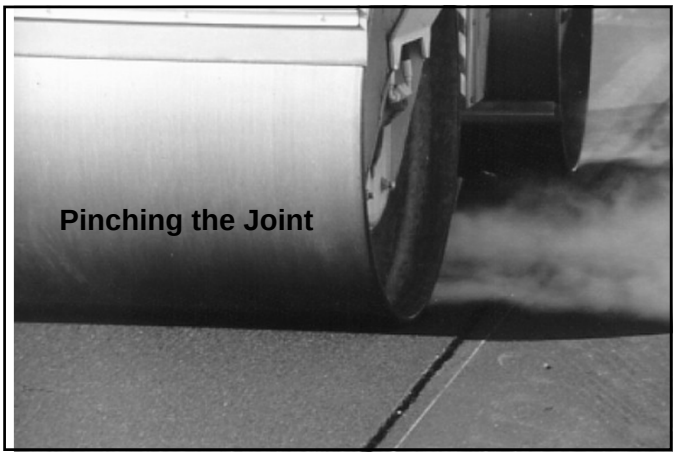


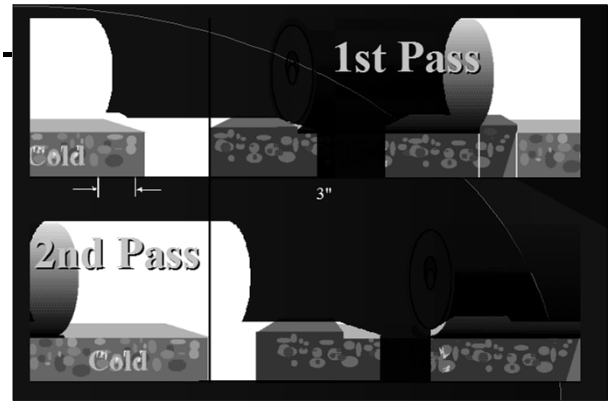
- Both drums on hot side first pass
- Force hot material against joint

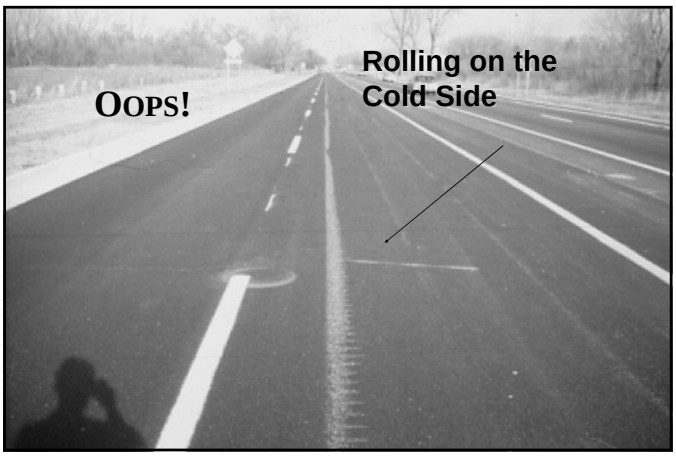
Longitudinal Joint Compaction



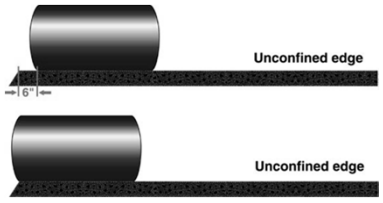
- Overlap cold side 6” second pass
- Roll static to avoid fractured aggregate on cold side





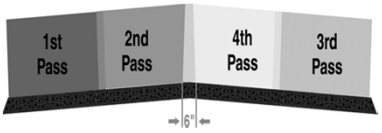


Compacting Unconfined Edges



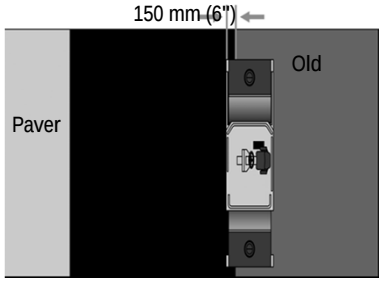
- Unconfined edges may shove out
- First pass 6” from edge to build strength in mat
- Second pass slight overhang
- Compacted portion supports weight of drum

Rolling a Crown



- Never straddle the crown
- Work from bottom toward crown both sides
- Builds strength in mat to support roller on slope
- Overlap crown 6” on last pass

Rolling a Transverse Joint

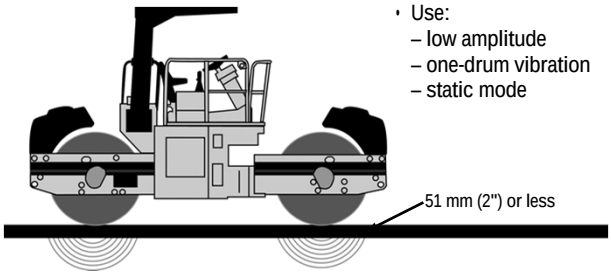


- Roll transverse to avoid bump
- Roll static
- Start with most of drum on cold side
- Gradually move over until drum is all on hot side
- May have to use boards to get on mat

Compaction Issues

- Density and smoothness challenges for the operator

Thin Lift Compaction

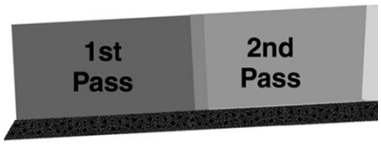


- Use:
  - low amplitude
  - one-drum vibration
  - static mode

Thin Lift Compaction

- Never turn drums while machine is stopped
- Thin mats tear easily

Thin Lift Compaction



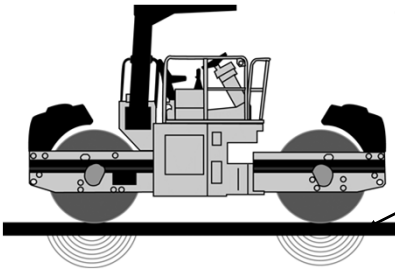
- Always start from bottom and work up on thin sloped mats
- Adds support for successive passes

Thin Lift Compaction

- Work close to paver
- Thin mats lose heat quickly
- Less time to get density
- High frequency allows faster working speeds

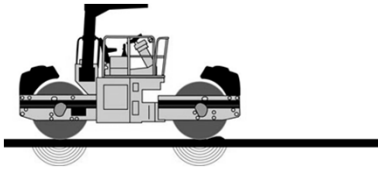
Compacting PFC

Thick Lift Compaction



- Use:
  - High amplitude

Thick Lift Compaction



- Thick mats stay hotter
- Watch for bulge in front of drum
- Roll farther behind paver
- Reduce amplitude
- Use lighter machine

Compaction Issues – Fracturing Aggregate

- Drum straddling the joint
- Amplitude too high
- Roller too heavy
- Vibrating on cool mat

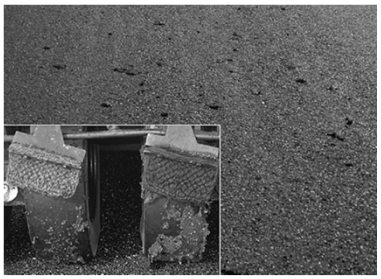
Compaction Issues – Impact Marks

- Amplitude too high
- Vibrating cool mat - roll closer to the paver
- Finish rolling too cool- move closer to intermediate roller
- Finish roller too light

Compaction Issues – Tire Marks

- Pneumatic roller in breakdown position
- Ballast or tire pressure too high
- Rolling too hot
- Finish rolling too cool
- Thick lift, tender mat
- Tire too narrow

Compaction Issues – Tire Pick-up



- Chronic problem on rubber-tire rollers
- Tires too cool - need to be within 30-40 degrees of mat temp
- Modified asphalt is worse problem - sticky

Compaction Issues - Tire Pick-up

- Tire skirts retain heat
- Some used with forced air or infra-red heaters
- Skirts always recommended when pick-up is a problem

Compaction Issues - Tire Pick-up

- Radial tires pick up less than bias ply tires
- Manufacturers working with tire compounds
- Currently no “non-stick” tire

Compaction Issues - Tire Pick-up

- Non-stick emulsions help prevent pick-up
- Hand-held sprayers or on-board water spray
- Apply to clean tires before rolling begins
- Discontinue after tires heat up
- Re-apply if tires cool

Compaction Issues - Tire Pick-up

- Heat tires quickly by operating directly behind paver
- Spray with emulsion first
- Be sure tire marks will roll out
- 3-5 minutes of operation should heat sufficiently

Compaction Issues - Tire Pick-up

- Once tires hot - keep them hot
- Develop good rolling pattern - never stop rolling
- If waiting for trucks, roll on previously compacted mat
- Use tire skirts

Compaction Issues - Dry Drum

- Dry drums pick up hot mix
- Practice proper spray system maintenance

  --use clean water

  -- change filters

  -- check spray nozzles

  -- check distribution mats

Compaction Issues - Stopped on Mat

- Never park a roller on a hot mat
- Deep mark won't roll out
- Park back on compacted mat or on shoulder

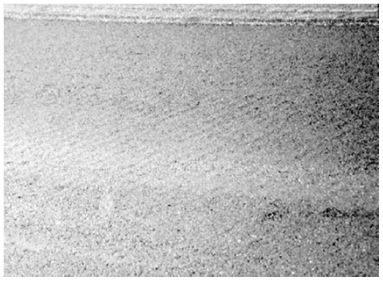
Compaction Issues - Stopped Straight

- Straight stop creates bulge
- Bulge may not roll out
- Stop at 30-45 degree angle and turn toward center of mat

Compaction Issues - Rolling off Edge

- Never roll off unconfined edge
- Collapsed edge will create a joint failure

Compaction Issues - Rippled mat



- Vibration used on thin overlay
- Too much force causes ripples and fractured rock
- Finish roller will not clean up
- Reduce force

Compaction Issues - Washboard

- 4" thick mat
- Excessive force is not the problem
- Excessive speed caused roughness
- Lower speed to get proper impact spacing: 10-14 impacts per foot

Compaction Issues – Rutting

Possible causes:

- Inadequate subgrade or aggregate base compaction
- Inadequate asphalt compaction (density too low, air voids too high)

Compaction Issues – Fatigue Cracks

Possible causes:

- Improper design or compaction of base aggregate
- Excessive compaction of thin asphalt layer (density too high, air voids too low)

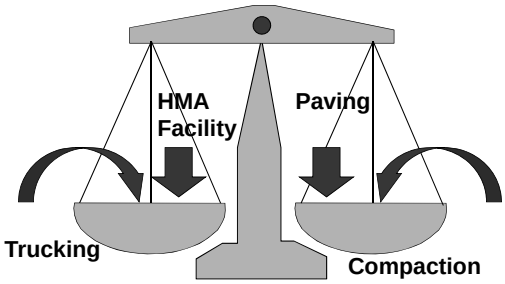
Questions??

Hot Mix Asphalt Production
Balance Problems

Bituminous Certification
Pavement Inspection

Balance is the Key!

Determines Paving Speed



Balance These Three!

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite
  * Paver Capacity
- Consumption (Width & Depth)
- Compaction Ability

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite

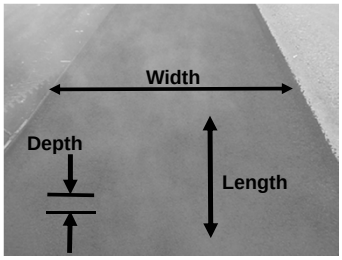
Mix Delivery

- Correct Number of Trucks for Uninterrupted Delivery to Paving Site
- Truck Driver's Training
  - Constant Delivery
  - Getting In and Out of the Paver
  - Expeditious Cycling of Trucks

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite
- Paver Capacity
- Consumption (Width & Depth)

Consumption



Length x Width x Depth x Unit Wt x Conversion

= Tons

Tons Per Hour Determines the Rate of Speed

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite
- Paver Capacity
- Consumption (Width & Depth)
- Compaction Ability

Compaction Ability

Don't Outrun the Rollers

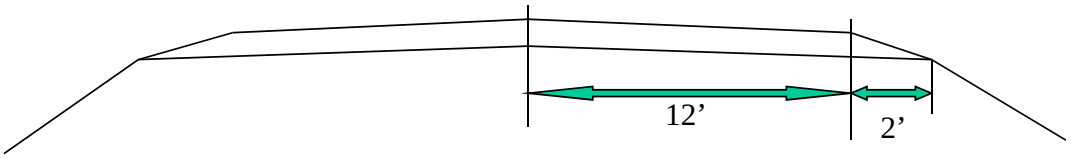
Balance These Three!

Set a Paving Speed to Match

- HMA Delivery Plant to the Jobsite
  - *Paver Capacity/Truck Capacity
- Consumption (Width & Depth)
- Compaction Ability

Spread Rate Problem

The DOT Plans call for 2800 tons of mix per mile placed 26’ wide. If the Contractor produces 300 Tons per hour for 10 hours and is paving one side of the road, how far will the paver go by the end of the day.



DOT Tons per mile is typically for full width

Calculating Paver Production

Paving Time Today = 10 Hours x 60 = _____ minutes

Plant Production Rate = 300 TPH

Tons to be placed today = _____(hrs) X _____ (TPH) = _____ Tons

DOT Spread Rate = 1400 Tons per mile.

Length of Paving in feet = {Total Tons / Tons per mile} x 5280

{ _____ / _____} x 5280 = _____ Feet

Theoretically perfect paving speed = Length(ft) / Paving Time(min) = fpm

_____ft / _____ min = _____ fpm

Paving Efficiency Factor (Eff) is from 0.70 to 0.85

Actual Paver Speed = Theoretical Speed / Efficiency Factor

_____ / 0.85 = _____ fpm

Calculating Mix Delivery Rate

Rate of Mix Available from Plant (Plant Rate) = __300__tph

Hours of Plant Production = __10__

Average Truck Capacity = __23.5__

Daily Production (t) = Plant Rate (tph) x Production Hours =

_____ x _____ = _____ t

# of Loads to Haul Daily Production = Daily Production (t) /Truck Capacity (t)

_____ / _____ = _____ Loads

Truck Cycle Time (Minutes)

Delay At Plant	**__5__**
Loading	**__5__**
Ticket & Tarp	**__3__**
Haul to Job Site	**__70__**
Delay At Job Site	**__4__**
Unload	**__3__**
Return to Plant	**__45__**
Clean & Prep	**__3__**
==========	
Total Time	**_____ Minutes**

Cycle Time per Truck (Hrs) = Truck Cycle Time (Minutes) / 60 min/hr

Cycle Time = _____ / 60 = _____ Hours per Trip

 # Trips per Day per Truck = Production Hours / Truck Cycle Time (Hrs)

 # Trips Per Day = _____ / _____ = _____

Round to Nearest Whole Number = _____

Haul per Truck per Day (Ton) = Truck Capacity (t) x # Trips per Day

_____ x _____ = _____ (Ton) Haul per Truck per Day

 # Trucks Needed = Daily Production (Ton) / Haul per Truck per Day (Ton)

_____ / _____ = _____ Trucks

Calculating Compaction Rates

Recommended Breakdown Rolling Speed = 2-3 mph

Effective Roller Speed is 90% using a Reversal Factor of 10%
Maximum Vibratory Rolling Speed (MVRS) is calculated based on
10-12 Impacts per foot (IPF) and roller frequency (VPM)
MVRS = VPM / IPF = fpm

MVRS = _____ / _____ = _____ fpm
Effective Rolling Speed (ERS) = MVRS x 0.90

ERS = _____ x 0.90 = _____ fpm

Drum Width = _____ inches
Effective Drum width is 6" less due to overlap.

Effective Width = _____ - 6" = _____ inches / 12 in/ft = _____ ft

Paving Width = _____ ft

Calculate number of passes to cover Mat width.
Paving Width / Effective Roller Width = No. of passes

_____ / _____ = _____ passes

Rounding up to the nearest whole number = _____ passes

Number of passes to achieve density from Test Strip = _____

Calculate the Total Number of passes to achieve Density across the full width of the pavement.
Density Passes x Width Passes = Total # of Passes

_____ x _____ = _____ Passes

If the Total number of passes is an even number, add 1 make-up pass

Total number of Passes = _____.
Compaction Production Rate(Comp Rate) = ERS / Total # of Passes

Comp Rate = _____ / _____ = _____ fpm
Roller Efficiency Factor is typically from 0.75 to 0.80

Roller Efficiency Factor (REF) = _____

Effective Compaction Rate = Comp Rate x REF

_____ x _____ = _____ fpm

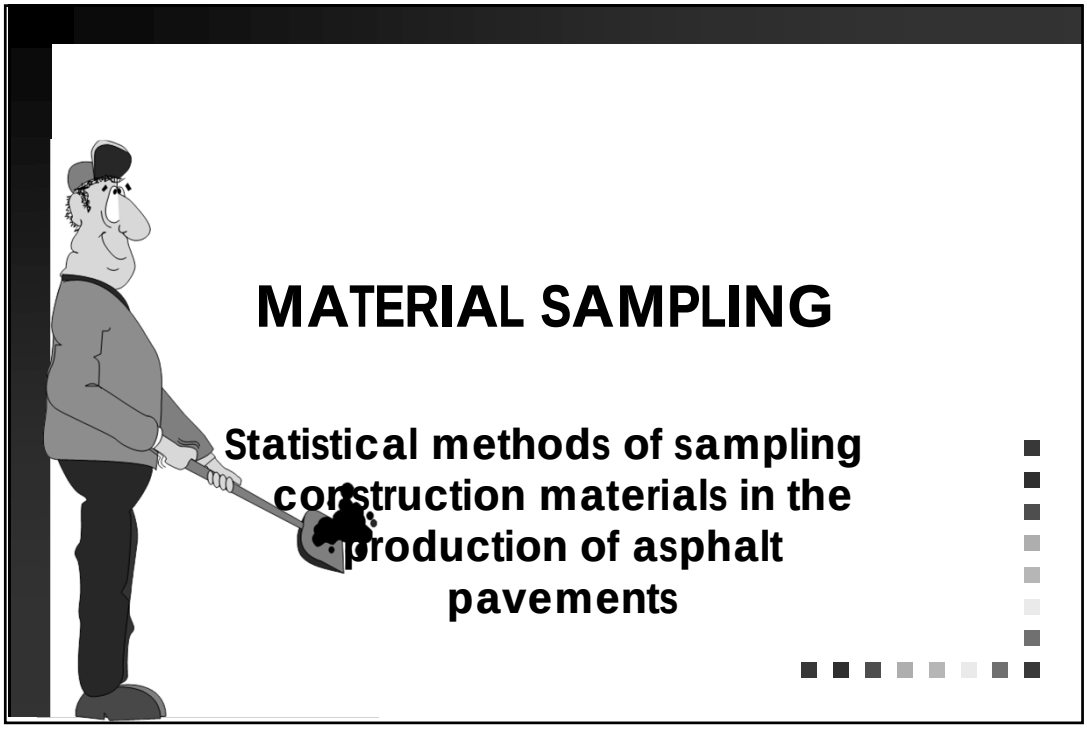
When using 2 Compaction Rollers the above rate may be doubled.

Check Balance

	Tons/Day	Speed	Prod. Rate
Plant			
Trucks			
Paver			
Roller			

Notes:

Solution:



Material Sampling

- **Statistics**
  - The science that deals with the treatment and analysis of data
- **Terms used**
  - Lot
  - Sublot
  - Sample
  - Data

Material Sampling

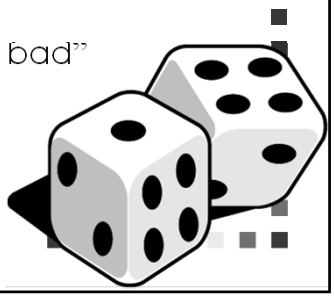
- **Lot**
  - A relatively large quantity of material which is tested for specification compliance
    - Days paving, Aggregate stockpile etc.
- **Sublot**
  - A smaller division of a lot in which sample are obtained for testing
    - 1000 tons HMA, 4 Hours agg. production

Material Sampling

- **Sample**
  - Sometimes referred to as “specimen”
  - A quantity of material used for testing
- **Data**
  - Factual information used as the basis for decision making
    - Test results
    - Measurements
    - Statistics

Material Sampling

- **Random sampling**
  - Any portion of the population has equal chance of being selected
  - Bias is introduced when judgment is used
    - Attempts to include "good and bad" samples
  - Use random number tables



Material Sampling

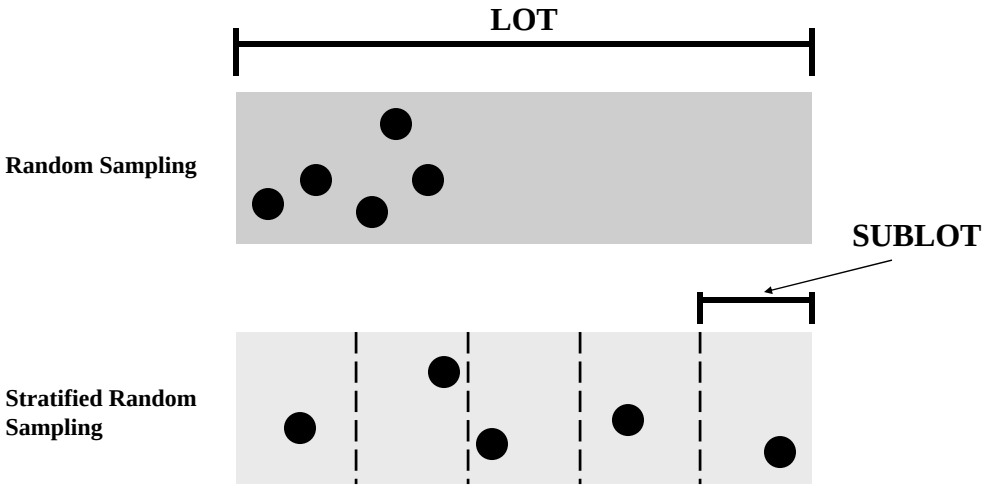
Random Number Table

0.74	0.60	0.01	0.27	0.43	0.29	0.21
0.78	0.11	0.65	0.20	0.98	0.34	0.83
0.87	0.64	.050	0.14	0.09	0.71	0.41

Material Sampling

- **Sampling locations based on:**
  - Time
  - Tonnage
  - Volume
  - Distance etc.
- **Also need to know:**
  - Size of the lot to be sampled
  - Required number of samples

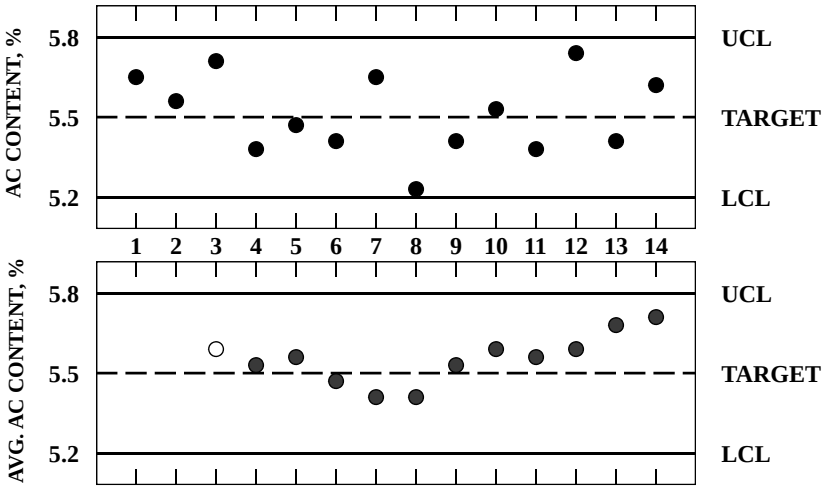
Stratified Random Sampling

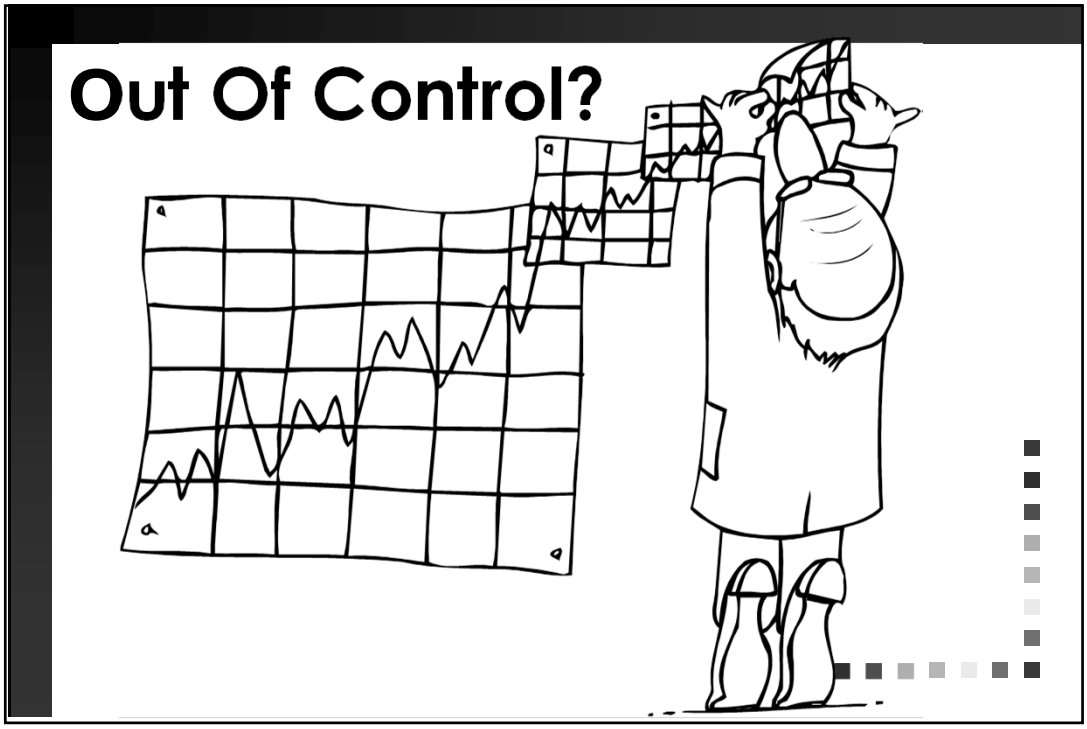


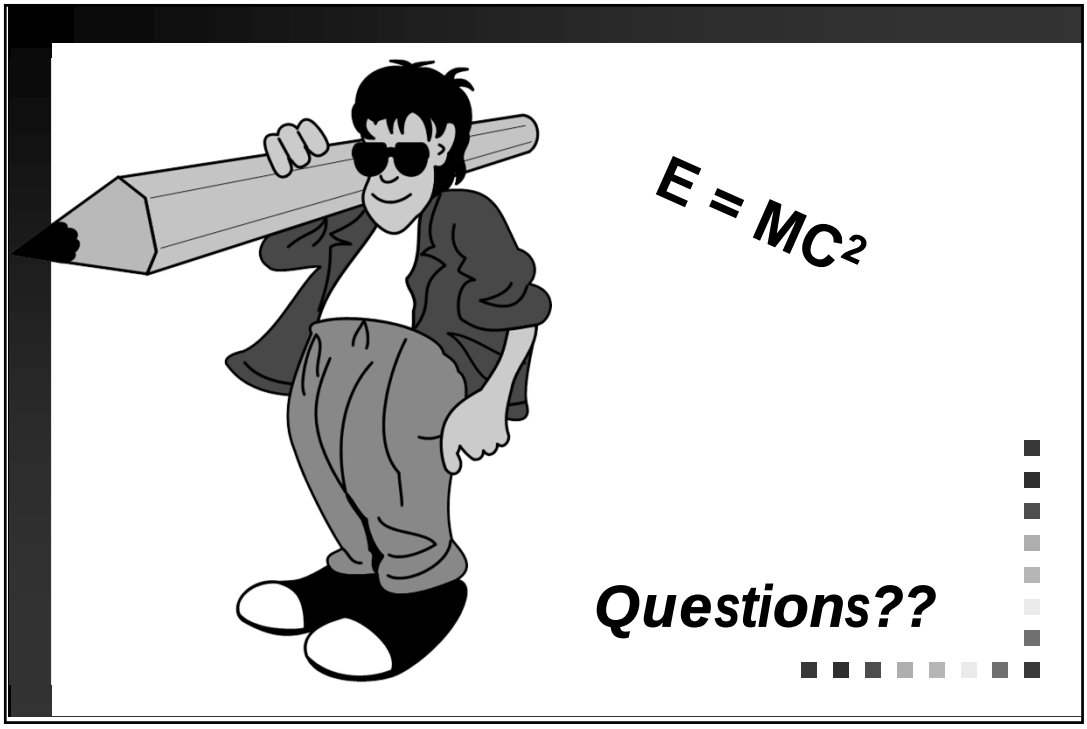
Material Sampling

- **Inspection is still necessary!**
  - **Obviously defective materials must be rejected or corrected**
  - **Possible argument**
    - If the defective material was not part of the random sampling process it cannot be rejected
  - **The fact that the sampling procedure did not result in sampling the defective material does not mean it should be accepted**

Control Charts




Out Of Control?


E = MC2
Questions??

RANDOM SAMPLING AND TESTING

A random sample is a sample taken by the use of a sampling plan in which each unit of a lot has an equal chance of being chosen. Random sampling is based on the use of a random number table to select items such as test sites, test samples, and times for selection of samples. The random number table provides the mean by which an item can be selected using the product of the random number and the dimension of the applicable item. The use of a calculator to generate random numbers is acceptable, but in the following examples the random number table will be used.

Example No. 1

Assume one day's production is a lot. The contractor begins work at 7:00 A.M. and works a 12-hour day. The sampling frequency is four samples selected at random times during the day.

Divide the 12-hour day into four equal sublots of three hours each. The following times result:

7:00 A.M.	-	10:00 A.M.
10:00 A.M.	-	1:00 P.M.
1:00 P.M.	-	4:00 P.M.
4:00 P.M.	-	7:00 P.M.

To determine the sampling times, arbitrarily select a group of digits on the random numbers table (located at the back of this appendix) by placing the point of a pencil on the page with eyes closed. In addition to the number under the pencil point, select three more numbers by going up or down, left or right, or diagonally. The pencil point landed on 0.18 in this example. Prior to the selection of the number it had been decided to go down the column. The three additional numbers are 0.90, 0.93, and 0.73 (Block “A”). Multiply each number by three hours (convert to 180 minutes) and add the result to the beginning time of each sublot to determine the sample times.

0.18 x 180 minutes = 32 minutes
0.90 x 180 minutes = 162 minutes
0.93 x 180 minutes = 167 minutes
0.73 x 180 minutes = 131 minutes

Samples should be obtained at the following times:

32 minutes after 7:00 A.M. or **7:32 A.M**.
162 minutes after 10:00 A.M. or **12:42 P.M.**
167 minutes after 1:00 P.M. or **3:47 P.M.**
131 minutes after 4:00 P.M. or **6:11 P.M**.

Example No. 2

Under Section 408 of the Standard Specifications, the Contractor is to take two cores in each sublot for determining density. The cores are to be taken adjacent to each other and at a random location. A sublot is defined as one paver-width wide (excluding the shoulders), 2,000 ft long, and of the depth specified for the pavement course.

Sample numbers and sublot numbers are established for the full day's production. On SFN 10071, "Compaction Control," record the sample number and the beginning station of the lot. The beginning station of each sublot is 2,000 ft greater than the previous one. Compute the locations to be cored using random numbers to determine the station and offset from the edge of the pavement. Adjust core locations falling within one foot of the pavement edge or select a new random location within the test area.

Use the same procedure as in Example No. 1 to arbitrarily select the digits from the random number table. In this example only three numbers will be chosen (Block "B"). Assume the beginning station of the lot to be 105+00.

Sample No.		Station
1	0.13 x 2000 = 260 ft	Sta. 105+00 + 260 = Sta. 107+60
2	0.94 x 2000 = 1880 ft	Sta. 125+00 + 1880 = Sta. 143+80
3	0.14 x 2000 = 280 ft	Sta. 145+00 + 280 = Sta. 147+80

To select the transverse distance from the right edge of the roadway, three additional consecutive numbers are chosen following the procedure in Example No. 1. Each of the digits in Block "C" is multiplied by the lane width (12 ft).

Sample No.	Transverse Distance from Right Edge
1	0.68 x 12 = 8.2 ft
2	0.26 x 12 = 3.1 ft
3	0.85 x 12 = 10.2 ft

The calculations above result in the following sampling schedule for each sublot:

Sample No.	Sample Location
1	Sta. 107+60 - 8.2 ft from right edge of roadway
2	Sta. 143+80 - 3.1 ft from right edge of roadway
3	Sta. 147+80 - 10.2 ft from right edge of roadway

TABLE OF RANDOM NUMBERS WITH EXAMPLES

0.10	0.09	0.73	0.25	0.33	0.76	0.52	0.01	0.35	0.86	0.34	0.67	0.35	0.48	0.76	0.80	0.95	0.90	0.91	0.17
0.37	0.54	0.20	0.48	0.05	0.64	0.89	0.47	0.42	0.96	0.24	0.80	0.52	0.40	0.37	0.20	0.63	0.61	0.04	0.02
0.08	0.42	0.26	0.89	0.53	0.19	0.64	0.50	0.93	0.03	0.23	0.20	0.90	0.25	0.60	0.15	0.95	0.33	0.47	0.64
0.99	0.01	0.90	0.25	0.29	0.09	0.37	0.67	0.07	0.15	0.38	0.31	0.13	0.11	0.65	0.88	0.67	0.67	0.43	0.97
0.12	0.80	0.79	0.99	0.70	0.80	0.15	0.73	0.61	0.47	0.64	0.03	0.23	0.66	0.53	0.98	0.95	0.11	0.68	0.77
0.66	0.06	0.57	0.47	0.17	0.34	0.07	0.27	0.68	0.50	0.36	0.69	0.73	0.61	0.70	0.65	0.81	0.33	0.98	0.85
0.31	0.06	0.01	0.08	0.05	0.45	0.57	0.18	0.24	0.06	0.35	0.30	0.34	0.26	0.14	0.86	0.79	0.90	0.74	0.39
0.85	0.26	0.97	0.76	0.02	0.02	0.05	0.16	0.56	0.92	0.68	0.66	0.57	0.48	0.18	0.73	0.05	0.38	0.52	0.47
0.63	0.57	0.33	0.21	0.35	0.05	0.32	0.54	0.70	0.48	0.90	0.55	0.35	0.75	0.48	0.28	0.46	0.82	0.87	0.09
0.73	0.79	0.64	0.57	0.53	0.03	0.52	0.96	0.47	0.78	0.35	0.80	0.83	0.42	0.82	0.60	0.93	0.52	0.03	0.44
															A				
0.98	0.52	0.01	0.77	0.67	0.14	0.90	0.56	0.86	0.07	0.22	0.10	0.94	0.05	0.58	0.60	0.97	0.09	0.34	0.33
0.11	0.80	0.50	0.54	0.31	0.39	0.80	0.82	0.77	0.32	0.50	0.72	0.56	0.82	0.48	0.29	0.40	0.52	0.42	0.01
0.83	0.45	0.29	0.96	0.34	0.06	0.28	0.89	0.80	0.83	0.13	0.74	0.67	0.00	0.78	0.18	0.47	0.54	0.06	0.10
0.88	0.68	0.54	0.02	0.00	0.86	0.50	0.75	0.84	0.01	0.36	0.76	0.66	0.79	0.51	0.90	0.36	0.47	0.64	0.93
0.99	0.59	0.46	0.73	0.48	0.87	0.51	0.76	0.49	0.69	0.91	0.82	0.60	0.89	0.28	0.93	0.78	0.56	0.13	0.68
0.65	0.48	0.11	0.76	0.74	0.17	0.46	0.85	0.09	0.50	0.58	0.04	0.77	0.69	0.74	0.73	0.03	0.95	0.71	0.86
0.80	0.12	0.43	0.56	0.35	0.17	0.72	0.70	0.80	0.15	0.45	0.31	0.82	0.23	0.74	0.21	0.11	0.57	0.82	0.53
0.74	0.35	0.09	0.98	0.17	0.77	0.40	0.27	0.72	0.14	0.43	0.23	0.60	0.02	0.10	0.45	0.52	0.16	0.42	0.37
0.69	0.91	0.62	0.68	0.03	0.66	0.25	0.22	0.91	0.48	0.36	0.93	0.68	0.72	0.03	0.76	0.62	0.11	0.39	0.90
0.09	0.89	0.32	0.05	0.05	0.14	0.22	0.56	0.85	0.14	0.46	0.42	0.75	0.67	0.88	0.96	0.29	0.77	0.88	0.22
					C														
0.91	0.49	0.91	0.45	0.23	0.68	0.47	0.92	0.76	0.86	0.46	0.16	0.28	0.35	0.54	0.94	0.75	0.08	0.99	0.23
0.80	0.33	0.69	0.45	0.98	0.26	0.94	0.03	0.68	0.58	0.70	0.29	0.73	0.41	0.35	0.53	0.14	0.03	0.33	0.40
0.44	0.10	0.48	0.19	0.49	0.85	0.15	0.74	0.79	0.54	0.32	0.97	0.92	0.65	0.75	0.57	0.60	0.04	0.08	0.81
0.12	0.55	0.07	0.37	0.42	0.11	0.10	0.00	0.20	0.40	0.12	0.86	0.07	0.46	0.97	0.96	0.64	0.48	0.94	0.39
0.63	0.60	0.64	0.93	0.29	0.16	0.50	0.53	0.44	0.84	0.40	0.21	0.95	0.25	0.63	0.43	0.65	0.17	0.70	0.82
0.61	0.19	0.69	0.04	0.46	0.26	0.45	0.74	0.77	0.74	0.51	0.92	0.43	0.37	0.29	0.65	0.39	0.45	0.95	0.93
0.15	0.47	0.44	0.52	0.66	0.95	0.27	0.07	0.99	0.53	0.59	0.36	0.78	0.38	0.48	0.82	0.39	0.61	0.01	0.18
0.94	0.55	0.72	0.85	0.73	0.67	0.89	0.75	0.43	0.87	0.54	0.62	0.24	0.44	0.31	0.91	0.19	0.04	0.25	0.92
0.42	0.48	0.11	0.62	0.13	0.97	0.34	0.40	0.87	0.21	0.16	0.86	0.84	0.87	0.67	0.03	0.07	0.11	0.20	0.59
0.23	0.52	0.37	0.83	0.17	0.73	0.20	0.88	0.98	0.37	0.68	0.93	0.59	0.14	0.16	0.26	0.25	0.22	0.96	0.63
												B							
0.04	0.49	0.35	0.24	0.94	0.75	0.24	0.63	0.38	0.24	0.45	0.86	0.25	0.10	0.25	0.61	0.96	0.27	0.93	0.35
0.00	0.54	0.99	0.76	0.54	0.64	0.05	0.18	0.81	0.59	0.96	0.11	0.96	0.38	0.96	0.54	0.69	0.28	0.23	0.91
0.35	0.96	0.31	0.53	0.07	0.26	0.89	0.80	0.93	0.54	0.33	0.35	0.13	0.54	0.62	0.77	0.97	0.45	0.00	0.24
0.59	0.80	0.80	0.83	0.91	0.45	0.42	0.72	0.68	0.42	0.83	0.60	0.94	0.97	0.00	0.13	0.02	0.12	0.48	0.92
0.46	0.05	0.88	0.52	0.36	0.01	0.39	0.00	0.22	0.86	0.77	0.28	0.14	0.40	0.77	0.93	0.91	0.08	0.36	0.47
0.32	0.17	0.90	0.05	0.97	0.87	0.37	0.92	0.52	0.41	0.05	0.56	0.70	0.70	0.07	0.86	0.74	0.31	0.71	0.57
0.69	0.23	0.46	0.14	0.06	0.20	0.11	0.74	0.52	0.04	0.15	0.95	0.66	0.00	0.00	0.18	0.74	0.39	0.24	0.23
0.19	0.56	0.54	0.14	0.30	0.01	0.75	0.87	0.53	0.79	0.40	0.41	0.92	0.15	0.85	0.66	0.67	0.43	0.68	0.06
0.45	0.15	0.51	0.49	0.38	0.19	0.47	0.60	0.72	0.46	0.43	0.66	0.79	0.45	0.43	0.59	0.04	0.79	0.00	0.33
0.94	0.86	0.43	0.19	0.94	0.36	0.16	0.81	0.08	0.51	0.34	0.88	0.88	0.15	0.53	0.01	0.54	0.03	0.54	0.56
0.98	0.08	0.62	0.48	0.26	0.45	0.24	0.02	0.84	0.04	0.44	0.99	0.90	0.88	0.96	0.39	0.09	0.47	0.34	0.07
0.33	0.18	0.51	0.62	0.32	0.41	0.94	0.15	0.09	0.49	0.89	0.43	0.54	0.85	0.81	0.88	0.69	0.54	0.19	0.94
0.80	0.95	0.10	0.04	0.06	0.96	0.38	0.27	0.07	0.74	0.20	0.15	0.12	0.33	0.87	0.45	0.01	0.62	0.52	0.98
0.79	0.75	0.24	0.91	0.40	0.71	0.96	0.12	0.82	0.96	0.69	0.86	0.10	0.25	0.91	0.74	0.85	0.22	0.05	0.39
0.18	0.63	0.33	0.25	0.37	0.98	0.14	0.50	0.65	0.71	0.31	0.01	0.02	0.46	0.74	0.05	0.45	0.56	0.14	0.27
0.74	0.02	0.94	0.39	0.02	0.77	0.55	0.73	0.22	0.70	0.97	0.79	0.01	0.71	0.19	0.52	0.52	0.75	0.80	0.21
0.54	0.17	0.84	0.56	0.11	0.80	0.99	0.33	0.71	0.43	0.05	0.33	0.51	0.29	0.69	0.56	0.12	0.71	0.92	0.55
0.11	0.66	0.44	0.98	0.83	0.52	0.07	0.98	0.48	0.27	0.59	0.38	0.17	0.15	0.39	0.09	0.97	0.33	0.34	0.40
0.48	0.32	0.47	0.79	0.28	0.31	0.24	0.96	0.47	0.10	0.02	0.29	0.53	0.68	0.70	0.32	0.30	0.75	0.75	0.46
0.69	0.07	0.49	0.41	0.38	0.87	0.63	0.79	0.19	0.76	0.35	0.58	0.40	0.44	0.01	0.10	0.51	0.82	0.16	0.15

TABLE OF RANDOM NUMBERS

0.10	0.09	0.73	0.25	0.33	0.76	0.52	0.01	0.35	0.86	0.34	0.67	0.35	0.48	0.76	0.80	0.95	0.90	0.91	0.17
0.37	0.54	0.20	0.48	0.05	0.64	0.89	0.47	0.42	0.96	0.24	0.80	0.52	0.40	0.37	0.20	0.63	0.61	0.04	0.02
0.08	0.42	0.26	0.89	0.53	0.19	0.64	0.50	0.93	0.03	0.23	0.20	0.90	0.25	0.60	0.15	0.95	0.33	0.47	0.64
0.99	0.01	0.90	0.25	0.29	0.09	0.37	0.67	0.07	0.15	0.38	0.31	0.13	0.11	0.65	0.88	0.67	0.67	0.43	0.97
0.12	0.80	0.79	0.99	0.70	0.80	0.15	0.73	0.61	0.47	0.64	0.03	0.23	0.66	0.53	0.98	0.95	0.11	0.68	0.77
0.66	0.06	0.57	0.47	0.17	0.34	0.07	0.27	0.68	0.50	0.36	0.69	0.73	0.61	0.70	0.65	0.81	0.33	0.98	0.85
0.31	0.06	0.01	0.08	0.05	0.45	0.57	0.18	0.24	0.06	0.35	0.30	0.34	0.26	0.14	0.86	0.79	0.90	0.74	0.39
0.85	0.26	0.97	0.76	0.02	0.02	0.05	0.16	0.56	0.92	0.68	0.66	0.57	0.48	0.18	0.73	0.05	0.38	0.52	0.47
0.63	0.57	0.33	0.21	0.35	0.05	0.32	0.54	0.70	0.48	0.90	0.55	0.35	0.75	0.48	0.28	0.46	0.82	0.87	0.09
0.73	0.79	0.64	0.57	0.53	0.03	0.52	0.96	0.47	0.78	0.35	0.80	0.83	0.42	0.82	0.60	0.93	0.52	0.03	0.44
0.98	0.52	0.01	0.77	0.67	0.14	0.90	0.56	0.86	0.07	0.22	0.10	0.94	0.05	0.58	0.60	0.97	0.09	0.34	0.33
0.11	0.80	0.50	0.54	0.31	0.39	0.80	0.82	0.77	0.32	0.50	0.72	0.56	0.82	0.48	0.29	0.40	0.52	0.42	0.01
0.83	0.45	0.29	0.96	0.34	0.06	0.28	0.89	0.80	0.83	0.13	0.74	0.67	0.00	0.78	0.18	0.47	0.54	0.06	0.10
0.88	0.68	0.54	0.02	0.00	0.86	0.50	0.75	0.84	0.01	0.36	0.76	0.66	0.79	0.51	0.90	0.36	0.47	0.64	0.93
0.99	0.59	0.46	0.73	0.48	0.87	0.51	0.76	0.49	0.69	0.91	0.82	0.60	0.89	0.28	0.93	0.78	0.56	0.13	0.68
0.65	0.48	0.11	0.76	0.74	0.17	0.46	0.85	0.09	0.50	0.58	0.04	0.77	0.69	0.74	0.73	0.03	0.95	0.71	0.86
0.80	0.12	0.43	0.56	0.35	0.17	0.72	0.70	0.80	0.15	0.45	0.31	0.82	0.23	0.74	0.21	0.11	0.57	0.82	0.53
0.74	0.35	0.09	0.98	0.17	0.77	0.40	0.27	0.72	0.14	0.43	0.23	0.60	0.02	0.10	0.45	0.52	0.16	0.42	0.37
0.69	0.91	0.62	0.68	0.03	0.66	0.25	0.22	0.91	0.48	0.36	0.93	0.68	0.72	0.03	0.76	0.62	0.11	0.39	0.90
0.09	0.89	0.32	0.05	0.05	0.14	0.22	0.56	0.85	0.14	0.46	0.42	0.75	0.67	0.88	0.96	0.29	0.77	0.88	0.22
0.91	0.49	0.91	0.45	0.23	0.68	0.47	0.92	0.76	0.86	0.46	0.16	0.28	0.35	0.54	0.94	0.75	0.08	0.99	0.23
0.80	0.33	0.69	0.45	0.98	0.26	0.94	0.03	0.68	0.58	0.70	0.29	0.73	0.41	0.35	0.53	0.14	0.03	0.33	0.40
0.44	0.10	0.48	0.19	0.49	0.85	0.15	0.74	0.79	0.54	0.32	0.97	0.92	0.65	0.75	0.57	0.60	0.04	0.08	0.81
0.12	0.55	0.07	0.37	0.42	0.11	0.10	0.00	0.20	0.40	0.12	0.86	0.07	0.46	0.97	0.96	0.64	0.48	0.94	0.39
0.63	0.60	0.64	0.93	0.29	0.16	0.50	0.53	0.44	0.84	0.40	0.21	0.95	0.25	0.63	0.43	0.65	0.17	0.70	0.82
0.61	0.19	0.69	0.04	0.46	0.26	0.45	0.74	0.77	0.74	0.51	0.92	0.43	0.37	0.29	0.65	0.39	0.45	0.95	0.93
0.15	0.47	0.44	0.52	0.66	0.95	0.27	0.07	0.99	0.53	0.59	0.36	0.78	0.38	0.48	0.82	0.39	0.61	0.01	0.18
0.94	0.55	0.72	0.85	0.73	0.67	0.89	0.75	0.43	0.87	0.54	0.62	0.24	0.44	0.31	0.91	0.19	0.04	0.25	0.92
0.42	0.48	0.11	0.62	0.13	0.97	0.34	0.40	0.87	0.21	0.16	0.86	0.84	0.87	0.67	0.03	0.07	0.11	0.20	0.59
0.23	0.52	0.37	0.83	0.17	0.73	0.20	0.88	0.98	0.37	0.68	0.93	0.59	0.14	0.16	0.26	0.25	0.22	0.96	0.63
0.04	0.49	0.35	0.24	0.94	0.75	0.24	0.63	0.38	0.24	0.45	0.86	0.25	0.10	0.25	0.61	0.96	0.27	0.93	0.35
0.00	0.54	0.99	0.76	0.54	0.64	0.05	0.18	0.81	0.59	0.96	0.11	0.96	0.38	0.96	0.54	0.69	0.28	0.23	0.91
0.35	0.96	0.31	0.53	0.07	0.26	0.89	0.80	0.93	0.54	0.33	0.35	0.13	0.54	0.62	0.77	0.97	0.45	0.00	0.24
0.59	0.80	0.80	0.83	0.91	0.45	0.42	0.72	0.68	0.42	0.83	0.60	0.94	0.97	0.00	0.13	0.02	0.12	0.48	0.92
0.46	0.05	0.88	0.52	0.36	0.01	0.39	0.00	0.22	0.86	0.77	0.28	0.14	0.40	0.77	0.93	0.91	0.08	0.36	0.47
0.32	0.17	0.90	0.05	0.97	0.87	0.37	0.92	0.52	0.41	0.05	0.56	0.70	0.70	0.07	0.86	0.74	0.31	0.71	0.57
0.69	0.23	0.46	0.14	0.06	0.20	0.11	0.74	0.52	0.04	0.15	0.95	0.66	0.00	0.00	0.18	0.74	0.39	0.24	0.23
0.19	0.56	0.54	0.14	0.30	0.01	0.75	0.87	0.53	0.79	0.40	0.41	0.92	0.15	0.85	0.66	0.67	0.43	0.68	0.06
0.45	0.15	0.51	0.49	0.38	0.19	0.47	0.60	0.72	0.46	0.43	0.66	0.79	0.45	0.43	0.59	0.04	0.79	0.00	0.33
0.94	0.86	0.43	0.19	0.94	0.36	0.16	0.81	0.08	0.51	0.34	0.88	0.88	0.15	0.53	0.01	0.54	0.03	0.54	0.56
0.98	0.08	0.62	0.48	0.26	0.45	0.24	0.02	0.84	0.04	0.44	0.99	0.90	0.88	0.96	0.39	0.09	0.47	0.34	0.07
0.33	0.18	0.51	0.62	0.32	0.41	0.94	0.15	0.09	0.49	0.89	0.43	0.54	0.85	0.81	0.88	0.69	0.54	0.19	0.94
0.80	0.95	0.10	0.04	0.06	0.96	0.38	0.27	0.07	0.74	0.20	0.15	0.12	0.33	0.87	0.45	0.01	0.62	0.52	0.98
0.79	0.75	0.24	0.91	0.40	0.71	0.96	0.12	0.82	0.96	0.69	0.86	0.10	0.25	0.91	0.74	0.85	0.22	0.05	0.39
0.18	0.63	0.33	0.25	0.37	0.98	0.14	0.50	0.65	0.71	0.31	0.01	0.02	0.46	0.74	0.05	0.45	0.56	0.14	0.27
0.74	0.02	0.94	0.39	0.02	0.77	0.55	0.73	0.22	0.70	0.97	0.79	0.01	0.71	0.19	0.52	0.52	0.75	0.80	0.21
0.54	0.17	0.84	0.56	0.11	0.80	0.99	0.33	0.71	0.43	0.05	0.33	0.51	0.29	0.69	0.56	0.12	0.71	0.92	0.55
0.11	0.66	0.44	0.98	0.83	0.52	0.07	0.98	0.48	0.27	0.59	0.38	0.17	0.15	0.39	0.09	0.97	0.33	0.34	0.40
0.48	0.32	0.47	0.79	0.28	0.31	0.24	0.96	0.47	0.10	0.02	0.29	0.53	0.68	0.70	0.32	0.30	0.75	0.75	0.46
0.69	0.07	0.49	0.41	0.38	0.87	0.63	0.79	0.19	0.76	0.35	0.58	0.40	0.44	0.01	0.10	0.51	0.82	0.16	0.15

COMPACTION CONTROL

North Dakota Department of Transportation, Construction
SFN 10071 (Rev. 12-99)

Project Number **Project Number**

INSPECTOR'S SIGNATURE

CONTRACTOR	CLASS AGGR.	GRADE AC	BRAND AC
Contractor	**Superpave**	**64/28**	**Flint Hills**

LOT NUMBER	LANE	DATE PAVED	WIDTH OF ROAD
10	**EB Driving Lane**	**August 13, 2014**	**12**

SAMPLE NO.	BEGIN STATION	RANDOM NUMBERS LENGTH	RANDOM NUMBERS WIDTH	SAMPLE LOCATION STATION	SAMPLE LOCATION OFFSET	WT. IN AIR (A)	WT. IN WATER (B)	SURFACE DRY (C)	VOL. (D) (C-B)	BULK S.G. (E) A / D	MAT DENSITY (F) (E x 62.4)	MAXIMUM THEORTICAL DENSITY (G)	AIR VOIDS (H) 100 - (F x 100) G
86	899506	0.6800	0.4000	900866	4.8	903.5	509.7	904.4	394.70	2.289	142.8		7.6
B						925.1	515.2	926.2	411.00	2.251	140.5		9.1
										Average	**141.7**	154.6	**8.4**
87	901506	0.1500	0.6800	901806	8.2	923.3	514.7	924.1	409.40	2.255	140.7		9.0
B						946.9	536.5	947.2	410.70	2.306	143.9		6.9
										Average	**142.3**	154.6	**8.0**
88	903506	0.8800	0.4200	905266	5.0	864.8	492.6	865.5	372.90	2.319	144.7		6.4
B						950.2	539.3	951.1	411.80	2.307	144.0		6.9
										Average	**144.4**	154.6	**6.7**
89	905506	0.5800	0.2600	906666	3.1	851.9	482.5	852.8	370.30	2.301	143.6		7.1
B						899.6	511.7	900.2	388.50	2.316	144.5		6.5
										Average	**144.1**	154.6	**6.8**
90	907506	0.6700	0.5800	908846	7.0	897.4	502.9	898.4	395.50	2.269	141.6		8.4
B						778.4	436.5	779.7	343.20	2.268	141.5		8.5
										Average	**141.6**	154.6	**8.5**
91	909506	0.7200	0.6400	910946	7.7	905.7	511.3	906.5	395.20	2.292	143.0		7.5
B						929.1	524.4	930.0	405.60	2.291	143.0		7.5
										Average	**143.0**	154.6	**7.5**
92	911506	0.4600	0.4300	912426	5.2	984.7	559.8	985.4	425.60	2.314	144.4		6.6
B						1004.0	569.0	1005.0	436.00	2.303	143.7		7.1
										Average	**144.1**	154.6	**6.9**
93	913506	0.2800	0.8000	914066	9.6	957.0	537.8	957.8	420.00	2.279	142.2		8.0
B						1001.6	564.5	1002.5	438.00	2.287	142.7		7.7
										Average	**142.5**	154.6	**7.9**
													#VALUE!
													#VALUE!
										Average	**0.0**	154.6	**#VALUE!**
													#VALUE!
													#VALUE!
										Average	**0.0**	154.6	**#VALUE!**

Chapter 9 – Handouts

Temperature Volume Correction for Asphalt 1-2

Temperature Volume Correction for Emulsified Asphalt 3

Guide for Loading Asphalt Products 5

Paving Foreman's Cheat Sheet

Hot Bituminous Paving Checklist

Table 2.03 Temperature-Volume Corrections for Asphalt

Observed Temp °F	Volume Correction Factor to 60^0 F		Observed Temp °F	Volume Correction Factor to 60^0 F		Observed Temp °F	Volume Correction Factor to 60^0 F		Observed Temp °F	Volume Correction Factor to 60^0 F	
	A	B		A	B		A	B		A	B
280	0.9253	0.9157	335	0.9073	0.8956	390	0.8896	0.8760	445	0.8721	0.8567
281	0.9250	0.9153	336	0.9070	0.8952	391	0.8892	0.8756	446	0.8718	0.8564
282	0.9246	0.9149	337	0.9066	0.8949	392	0.8889	0.8753	447	0.8715	0.8560
283	0.9243	0.9146	338	0.9063	0.8945	393	0.8886	0.8749	448	0.8714	0.8557
284	0.9240	0.9142	339	0.9060	0.8942	394	0.8883	0.8746	449	0.8709	0.8554
285	0.9236	0.9138	340	0.9057	0.8938	395	0.8880	0.8742	450	0.8705	0.8550
286	0.9233	0.9135	341	0.9053	0.8934	396	0.8876	0.8738	451	0.8702	0.8547
287	0.9230	0.9131	342	0.9050	0.8931	397	0.8873	0.8735	452	0.8699	0.8543
288	0.9227	0.9127	343	0.9047	0.8927	398	0.8870	0.8731	453	0.8696	0.8540
289	0.9223	0.9124	344	0.9044	0.8924	399	0.8867	0.8728	454	0.8693	0.8536
290	0.9220	0.9120	345	0.9040	0.8920	400	0.8864	0.8724	455	0.8690	0.8533
291	0.9217	0.9116	346	0.9037	0.8917	401	0.8861	0.8721	456	0.8687	0.8529
292	0.9213	0.9-113	347	0.9034	0.8913	402	0.8857	0.8717	457	0.8683	0.8526
293	0.9210	0.9109	348	0.9031	0.8909	403	0.8854	0.8717	458	0.8680	0.8522
294	0.9207	0.9105	349	0.9028	0.8906	404	0.8851	0.8710	459	0.8677	0.8519
295	0.9204	0.9102	350	0.9024	0.8902	405	0.8848	0.8707	460	0.8674	0.8516
296	0.9200	0.9098	351	0.9021	0.8899	406	0.8845	0.8703	461	0.8671	0.8512
297	0.9197	0.9094	352	0.9018	0.8895	407	0.8841	0.8700	462	0.8668	0.8509
298	0.9194	0.9097	353	0.9015	0.8891	408	0.8838	0.8696	463	0.8665	0.8505
299	0.9190	0.9087	354	0.9011	0.8888	409	0.8835	0.8693	464	0.8661	0.8502
300	0.9187	0.9083	355	0.9008	0.8884	410	0.8832	0.8689	465	0.8658	0.8498
301	0.9186	0.9080	356	0.9005	0.8881	411	0.8829	0.8686	466	0.8655	0.8495
302	0.9181	0.9076	357	0.9002	0.8877	412	0.8826	0.8682	467	0.8652	0.8492
303	0.9177	0.9072	358	0.8998	0.8873	413	0.8822	0.8679	468	0.8649	0.8488
304	0.9174	0.9069	359	0.8995	0.8870	414	0.8819	0.8675	469	0.8646	0.8485
305	0.9171	0.9065	360	0.8992	0.8866	415	0.8816	0.8672	470	0.8643	0.8481
306	0.9167	0.9061	361	0.8989	0.8863	416	0.8813	0.8668	471	0.8640	0.8478
307	0.9164	0.9058	362	0.8986	0.8859	417	0.8810	0.8665	472	0.8636	0.8474
308	0.9161	0.9054	363	0.8982	0.8856	418	0.8806	0.8661	473	0.8633	0.8471
309	0.9158	0.9050	364	0.8979	0.8852	419	0.8803	0.8658	474	0.8630	0.8468
310	0.9154	0.9047	365	0.8976	0.8848	420	0.8800	0.8654	475	0.8627	0.8464
311	0.9151	0.9043	366	0.8973	0.8845	421	0.8797	0.8651	476	0.8624	0.8461
312	0.9148	0.9039	367	0.8949	0.8841	422	0.8794	0.8647	477	0.8621	0.8457
313	0.9145	0.9036	389	0.8966	0.8838	423	0.8791	0.8644	478	0.8618	0.8454
314	0.9141	0.9032	369	0.8963	0.8834	424	0.8787	0.8640	479	0.8615	0.8451

Observed Temp °F	Volume Correction Factor to 60^0 F		Observed Temp °F	Volume Correction Factor to 60^0 F		Observed Temp °F	Volume Correction Factor to 60^0 F		Observed Temp °F	Volume Correction Factor to 60^0 F	
315	0.9138	0.9028	370	0.8960	0.8831	425	0.8784	0.8637	480	0.8611	0.8447
316	0.9135	0.9025	371	0.8957	0.8827	426	0.8781	0.8633	481	0.8608	0.8444
317	0.9132	0.9021	372	0.8953	0.8823	427	0.8778	0.8630	482	0.8605	0.8440
318	0.9128	0.9018	373	0.8950	0.8820	428	0.8775	0.8628	483	0.8602	0.8437
319	0.9125	0.9014	374	0.8947	0.8816	429	0.8772	0.8623	484	0.8599	0.8433
320	0.9122	0.9010	375	0.8944	0.8813	430	0.8768	0.8619	485	0.8596	0.8430
321	0.9118	0.9007	376	0.8941	0.8809	431	0.8765	0.8616	486	0.8593	0.8427
322	0.9115	0.9003	377	0.8937	0.8806	432	0.8762	0.8612	487	0.8590	0.8423
323	0.9112	0.9000	378	0.8934	0.8802	433	0.8759	0.8609	488	0.8587	0.8420
324	0.9109	0.8996	379	0.8931	0.8799	434	0.8756	0.8605	489	0.8583	0.8416
325	0.9105	0.8992	380	0.8928	0.8795	435	0.8753	0.8602	490	0.8580	0.8413
326	0.9102	0.8989	381	0.8924	0.8792	436	0.8749	0.8599	491	0.8577	0.8410
327	0.9099	0.8985	382	0.8921	0.8988	437	0.8746	0.8595	492	0.8574	0.8406
328	0.9096	0.8981	383	0.8918	0.8784	438	0.8743	0.8592	493	0.8571	0.8403
329	0.9092	0.8978	384	0.8915	0.8781	439	0.8740	0.8588	494	0.8568	0.8399
330	0.9089	0.8974	385	0.8912	0.8777	440	0.8737	0.8585	495	0.8565	0.8396
331	0.9086	0.8971	386	0.8908	0.8774	441	0.8734	0.8581	496	0.8562	0.8383
332	0.9083	0.8967	387	0.8905	0.8770	442	0.8731	0.8578	497	0.8559	0.8389
333	0.9079	0.8963	388	0.8902	0.8767	443	0.8727	0.8574	498	0.8556	0.8386
334	0.9076	0.8960	389	0.8899	0.9763	444	0.8724	0.8571	499	0.8558	0.8383
									500	0.8549	0.8379

Use column A for factors asphalts with API gravity at 60^oF of 14.9^o or less or with specific gravity $60/60^oF$ of 0.967 or higher.

Use column B factors for asphalts with API gravity at 60° F from 15.0^o to 34.9^o or with specific gravity $60/60^oF$ from 8.850 to 0.966.

Temperature Volume Corrections for Emulsified Asphalts

°C	°F	M	°C	°F	M	°C	°F	M
10.0	50	1.00250	35.0	95	0.99125	60.0	140	0.98000
10.6	51	1.00225	35.6	96	0.99100	60.6	141	0.97975
11.1	52	1.00200	36.1	97	0.99075	61.1	142	0.97950
11.7	53	1.00175	36.7	98	0.99050	61.7	143	0.97925
12.2	54	1.00150	37.2	99	0.99025	62.2	144	0.97900
12.8	55	1.00125	37.8	100	0.99000	62.8	145	0.97875
13.3	56	1.00100	38.3	101	0.98975	63.3	146	0.97850
13.9	57	1.00075	38.9	102	0.98950	63.9	147	0.97825
14.4	58	1.00050	39.4	103	0.98925	64.4	148	0.97800
15.0	59	1.00025	40.0	104	0.98900	65.0	149	0.97775
15.6	60	1.00000	40.6	105	0.98875	65.6	150	0.97750
16.1	61	0.99975	41.1	106	0.98850	66.1	151	0.97725
16.7	62	0.99950	41.7	107	0.98825	66.7	152	0.97700
17.2	63	0.99925	42.2	108	0.98800	67.2	153	0.97675
17.8	64	0.99900	42.8	109	0.98775	67.8	154	0.97650
18.3	65	0.99875	43.3	110	0.98750	68.3	155	0.97625
18.9	66	0.99850	43.9	111	0.98725	68.9	156	0.97600
19.4	67	0.99825	44.4	112	0.98700	69.4	157	0.97575
20.0	68	0.99800	45.0	113	0.98675	70.0	158	0.97550
20.6	69	0.99775	45.6	114	0.98650	70.6	159	0.97525
21.1	70	0.99750	46.1	115	0.98625	71.1	160	0.97500
21.7	71	0.99725	46.7	116	0.98600	71.7	161	0.97475
22.2	72	0.99700	47.2	117	0.98575	72.2	162	0.97450
22.8	73	0.99675	47.8	118	0.98550	72.8	163	0.97425
23.3	74	0.99650	48.3	119	0.98525	73.3	164	0.97400
23.9	75	0.99625	48.9	120	0.98500	73.9	165	0.97375
24.4	76	0.99600	49.4	121	0.98475	74.4	166	0.97350
25.0	77	0.99575	50.0	122	0.98450	75.0	167	0.97325
25.6	78	0.99550	50.6	123	0.98425	75.6	168	0.97300
26.1	79	0.99525	51.1	124	0.98400	76.1	169	0.97275
26.7	80	0.99500	51.7	125	0.98375	76.7	170	0.97250
27.2	81	0.99475	52.2	126	0.98350	77.2	171	0.97225
27.8	82	0.99450	52.8	127	0.98325	77.8	172	0.97200
28.3	83	0.99425	53.3	128	0.98300	78.3	173	0.97175
28.9	84	0.99400	53.9	129	0.98275	78.9	174	0.97150
29.4	85	0.99375	54.4	130	0.98250	79.4	175	0.97125
30.0	86	0.99350	55.0	131	0.98225	80.0	176	0.97100
30.6	87	0.99325	55.6	132	0.98200	80.6	177	0.97075
31.1	88	0.99300	56.1	133	0.98175	81.1	178	0.97050
31.7	89	0.99275	56.7	134	0.98150	81.7	179	0.97025
32.2	90	0.99250	57.2	135	0.98125	82.2	180	0.97000
32.8	91	0.99225	57.8	136	0.98100	82.8	181	0.96975
33.3	92	0.99200	58.3	137	0.98075	83.3	182	0.96950
33.9	93	0.99175	58.9	138	0.98050	83.9	183	0.96925
34.4	94	0.99150	59.4	139	0.98025	84.4	184	0.96900
						85.0	185	0.96875

Legend: t=observed temperature in degrees Celsius (Fahrenheit)
M=multiplier for correcting columes to the basis of 15.6°C (60°F)
*Multiplier (M) for °C is a close approximation.

Guide for Loading Asphalt Products

Product to Be Loaded

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

*Any material remaining will produce dangerous conditions

Dakota Asphalt Pavement Association Inc.

"Build with Asphalt"

Paving Foreman's Cheat Sheet

Paver Operations Best Management Practices

Courtesy of Tom Skinner,
Skinner Consulting Services
Provided by Dakota Asphalt Pavement Association

Making It Smooth

Following items must be followed to improve smoothness.

- Never run the hopper empty between loads. *(Level of material in the hoppers should never be allowed to fall below the bottom of flow gates.)*
- Establish and maintain a continuous paving speed. *(Establish paving speed by balancing delivery of material, capacity of the paver and the compaction process.)*
- "Head of material" controlled within +/- one inch tolerance.
- Don't allow trucks to bump the paver.
- Don't dump excess material on the grade. *(When directly dumping into the paver hopper.)*
- Don't fold the hoppers into an empty conveyor system. *(Fold the hoppers often enough to keep material above placement temperature and fold them while the paver is moving forward.)*
- Practice the rapid start/stop of the paver. (*Only two speeds on a paver, paving speed or stopped.)*
- Check for looseness in the dept control screws fairly often.
- Watch overcorrecting depth screws.
- Make sure edger plate is free to move.

Making Good Longitudinal Joints

Following items must be followed to improve longitudinal joints.

- Strive to minimize segregation at the outside edges of the mat being laid.
- Steer a straight line the first pass.
- Utilize the proper overlap of the cold mat being matched. *(The overlap should be reduced to a steering tolerance only ½ to ¾ inch overlap.)*
- The depth of the mat being laid should be approx 25% greater in depth than mat being matched. *(This will give sufficient material for roll down and density.)*
- Watch that material is not allowed to flow out & under the edger gate. *(This excess material can make getting a good joint impossible.)*
- If luting is required push material back to joint only and do not cast material across the mat.
- Use proper rolling procedures. *(Roll form hot to cold with a 6" overlap or stay in 6" on the hot mat and catch unrolled portion with the return pass.)*

Making Good Transverse Joints

Following items must be followed to improve transverse joints.

- Proper shutdown on original pass. *(The mat left must be at the proper depth and slope. Check with a ten foot straightedge.)*
- Construct a wedge using some type of bond breaker material. *(Paper, sand, dirt or perhaps try a heavy plastic material.)*
- Wedge should continue six to eight inches flat with the original surface being laid then taper off the nothing. *(This prevents rounding off the joint edge to be matched.)*
- Remove wedge and prepare the area where the joint is to be made. *(Clean all dirt or loose rock, tack the area if required.)*
- Align the paver with previously laid mat.
- Heat the screed properly.
- Use lathes or starting blocks. *(Allow for proper roll down.)*
- Null out the screed properly.
- Fill the augers properly. *(Shovel material to fill outside corners.)*
- Begin paving check for depth and slope and correct if needed.
- Check and then roll at the joint.

Reducing Segregation in the Paver Hopper

Following items must be followed to reduce segregation in the paver hopper.

- Break the load before backing into discharge position. *(If possible, this will reduce first and last out segregation if the hauling units have been loaded improperly.)*
- Never allow the material level in the paver hopper to fall below the bottom of the flow gates. *(This will Prevent Segregation. The lower the material level the greater the "break and run" distance, which increases the chances for segregation.)*
- Never fold the hoppers when the conveyor system is low or empty. *(Doing so will increase the chances for segregation as the larger rocks will flow into the paving stream possibly causing streaks in the mat being laid.)*
- Fold the hopper often enough to keep the material above the required laying temperature. *(Fold the hoppers while the paver is moving forward and stop when it is fully extended.)*
- Minimize material dropping on the grade. *(Watch and maintain overflow guards.)*

Establishing & Maintaining Proper Head of Material

- Set the flow gates at about half open. *(If applicable, without flow gates set the conveyor speed at about 75% of maximum speed.)*
- Set the conveyor/auger speed 75% maximum level.
- Make sure the material sensors are operating properly.
- Install tunnel extensions so they reach a distance of 12 to 18 inches from the edger gate.
- Lower the auger to lowest position and set the screed approximately 2 to 4 inches from the screed. *(If applicable.)*
- Position, heat and null out the screed properly on the starting laths.
- Charge the auger areas with material, allowing the augers to turn until they stop automatically. *(Use a shovel and safely fill any void at the outside of the edger assembly)*
- Begin paving making head of material adjustments to match the paving width, depth and paving speed.
- Set and maintain volume in the augers area within +/- 1-inch. *(Using speed of augers, setting of material sensors and flow gates)*

Reducing Segregation in the Auger Area

- Use the proper length of tunnel extensions. There should be approximately 12-18 inches between the extensions and the edger plate. *(This should minimize the "break and run" distance and reduce the chances of segregation at the outside edge of the screed.)*
- Don't allow the head of material to drop below its established volume*. (This allows the material to drop down and possibly let segregated or cooler material into the paving stream causing streaks of segregation either rock or thermal.)*
- Don't over feed the auger system. *(Over feeding allows the material to build up and fall back and in the process larger aggregate will flush to the surface and accumulate in a volume to show up as segregation in the mat and also increase roughness.)*
- Watch how much material is being dragged back under the paver by the conveyor. *(If enough is drawn back under the paver it can segregate on the bottom side of the mat.)*

Reducing Segregation in the Loading of the Hauling Unit

- Watch loading hauling units when using a sensitive mix. *(Define a sensitive mix--broadcast a shovel full of your mix across a flat surface and if the larger aggregate leaves the fines by at least 2 to 3 feet you have a sensitive mix that will be prone to segregate.)*
- If your mix is sensitive use the multi-dump procedure for loading the hauling unit. (*Make your first dump close to the front of the truck bed, the second dump toward the rear and finally the third dump in the middle. This minimizes the "break and run" where larger aggregate flushes to the surface and accumulates at the front and rear of the truck which can give you load to load segregation.)*
- Tarp your load to minimize heat loss. *(Use a good tarp, free of holes, and large enough to overlap the sides of the bed preventing heat loss.)*
- Clean the hauling units between loads to prevent chunks of cold material reaching the mat.
- Use approved release agent.

Reducing Segregation in the Presentation of Material - Truck to Paver Hopper

- "Break the load" if it can be done safely. (*This will move the mass of material to the rear of the hauling unit and when the tailgate is opened it causes the material to "move in a mass" minimizing segregation.)*
- Follow the signals from the paver operator and dump person, back into discharge position stopping 6 to 12 inches short of the paver. *(When you feel contact of the moving paver release the tailgate making sure you apply enough brake that will prevent truck moving forward and dumping the load on the grade.)*
- Raise the bed as quickly as possible to full extension as directed by the paver operator or dump person. (*This should prevent last minute dribbles which can show up as load to load segregation.)*
- Exit safely and expeditiously when given the signal. *(This will reduce time loss and chances of the hopper running low between truck exchanges.)*

Hot Bituminous Paving Checklist

1. Upon receipt of plans, specifications, and proposal.
   A. Examine the Plans and make notes of any questions that you have. If there is a conflict Plans will govern over specifications. Special Provisions will govern over Plans.
      a. Scope of work.
      b. Get an overview of the paving to be done on the project to understand where the work is to be done.
   B. Notes.
      a. Read the General Notes to determine details that are project specific and not included in the specifications that apply to HBP Paving. Plan notes supersede specifications if there is a conflict.
   C. Typical sections.
      a. Typical sections are defined by their stationing. There may be more than one typical section on a project. Examine all typical sections.
      b. New pavement thickness.
      c. Cross slope of the paved surface.
      d. Number of lifts needed to achieve thickness.
      e. Locations where the typical section changes.
      f. Type of HBP mix.
   D. Basis of Estimate.
      a. Plan quantity of Bid Items for the project. Bid Items are listed by specification section and code.
      b. Density of material used to determine quantities.
      c. Type and grade of asphalt cement.
      d. Asphalt cement content used to determine quantities.
      e. Type and grade of emulsified asphalt for tack coat.
      f. Application rate of emulsified asphalt for tack coat.
      g. Superelevation table to locate areas of super elevation. A table should be made for both ends of each transition showing stations and slopes for the start and end of the transitions and intermediate points to check to achieve a smooth transition.
   E. Plan and Profile.
      a. Check out how the paving fits in with other construction on the project.
      b. Locate where the superelevations and transitions are located.
      c. Prior to placing the final lift locate fixtures that are to be adjusted.
   F. Paving Layout.
      a. Check where typical sections change.
      b. Examine transitions to determine how to get from one section to the other.
      c. Determine areas that will be paved outside the typical sections such as intersections, widenings, turn lanes, sideroads or approaches.
   G. Standard Details.
      a. Find standard details that pertain to paving operations such as intersection layouts and traffic control operations for paving.
   H. Standard Specifications.

a. Review Section 400 of the Standard Specifications to refresh knowledge of requirements for the work.
    1. Section 401 covers the Description, Materials, Equipment, Construction Requirements, Method of Measurement, and Basis of Payment for Prime, Tack and Fog Seal.
    2. Section 430 covers Description, Equipment, Materials, Construction Requirements, Method of Measurement, and Basis of Payment for Bituminous Pavement.
    3. Review all specifications referenced within Section 400. Often another specification will be referenced within a specification to save duplication. The reference specification becomes part of the specification referencing it. Materials specifications pertaining to the work will be referenced.

I. Proposal.
    a. Look at Supplemental Specifications to be aware if any specification updates from the Standard Specifications have been made. Supplemental Specifications will govern over the Standard Specifications.
    b. Examine the proposal to find Special Provisions regarding paving operations. Special Provisions are specific to the project and cover items and conditions that are not included in the Standard Specifications. Special Provisions govern over Plans, Supplemental Specifications and Standard Specifications.

J. Check the quantities of the bid items involved in the work. Plans are generally accurate but errors do happen and it is much better to find them early to avoid problems.
    a. Organize calculations to identify where material is placed.
        1. Mainline
        2. Shoulders
        3. Turn Lanes
        4. Acceleration/Deceleration Lanes
        5. Sideroads
        6. Approaches
        7. Etc.
    b. Determine a spread rate for mainline paving. Determine the volume of the pavement section in one station and multiply it by the density of the mix to determine the tons/sta that will be the target to meet plan quantity.

K. Prepare any necessary documentation to document the work.

L. Organize the documentation required for materials acceptance.
    a. Determine what materials are accepted by certification and which need sampling or testing.
    b. Prepare a list of materials that are accepted by certification and a testing and sampling frequency for materials that require them.

2. Prior to start of paving.
    A. Make sure mix design is approved.
    B. Check stockpiles.
        a. Identify type of material and location of stockpiles for mix production.
        b. Check for contamination.
        c. Check for segregation.
        d. Check that stockpiles are separated to prevent intermingling.

C. Bin Feeders

a. Check that bins are separated to prevent intermingling of material caused by overloading the bins.
b. Make sure that the feeder gates are equipped with chains or some device to assure uniform feed.
c. Check calibration of feed bins.
d. Make sure a scalping screen is in place to prevent oversize material from entering the drum dryer.

D. Asphalt Plant. Refer to Section 154.01 of the Standard Specifications.

a. Check the slope of the drum to be sure it is within the manufacturer's recommendations.
b. See that the plant is equipped with temperature recording equipment that automatically and continually controls mix temperature.
c. Get calibration of the flow meter from the contractor.
d. Consult with the contractor to determine how samples will be taken during production.
e. Visit the control shack to become familiar with plant settings and operation.
f. Check scale certification.
g. Check the condition of storage tanks to verify there are no leaks and in good condition.

E. Equipment.

a . Rollers -- Refer to Section 151 of the Standard Specifications for Roller requirements.

1. Rollers must be of sufficient weight to meet specifications for applied force. Determine the method for checking the frequency and amplitude for vibratory rollers.
2. Check pneumatic roller tires to make sure they are inflated to the pressure range in the specifications. Tire pressure cannot vary more than 5 psi between any of the tires.

b. Trucks – Refer to Section 152 of the Standard Specifications for truck requirements.

1. DistributorCheck the condition of the distributor and become familiar with the operation and instrumentation necessary to monitor tack application.
2. Truck boxes should be checked to make sure they will not leak or have imperfections that may cause mix buildup. They should have tarps available to cover loads in the case of cold temperatures. Tarps should be capable of completely covering the box and free of holes and tears.

3. During paving.

A. Plant Inspector.

a. Complete documentation of production and paving.
    1. Maintain up to date and accurate records including Inspection Reports, Mix Bitumen Cut Off Reports, mix temperature charts, delivered asphalt cement, plant settings, scale checks, and others.
    2. Visit the control shack to observe plant operation. Note mix temperature and plant settings to make sure things are running smoothly and plant settings have not changed without proper notification. Mix temperatures that are too high will break down the asphalt cement and reduce the life of the pavement.
b. Monitor the Contractor's operations at the plant site.
    1. Stockpiles should be checked to make sure the loader operator is not getting material from below the pile or segregating the pile as he removes material.
    2. Cold feed bins and conveyors should be examined to make sure material is being fed consistently in the correct proportions to the drum and is not segregating.
    3. Trucks should be checked to make sure they have been cleaned out and diesel fuel is not being used as a release agent.
    4. Look at the surge bin or silo to make sure it is not leaking material.

5. Observe trucks' being loaded to make sure segregation is not being caused.
6. Check that tarps are available to cover loads in cool or wet weather. Tarps should be free of rips and tears as well as be large enough to completely cover the box.
7. In general, try to be aware of anything that may cause problems to the mix or on the road.

c. Sample and test materials according to the Field Sampling and Testing Manual.

B. Paving Inspector

a. Distributor
1. Check the amount of tack in the distributor.
2. Check the temperature of the tack. If it is too cool it will not spray properly and if it is too hot it may begin to break in the distributor.
3. Collect samples as required.
4. Make sure the spray bar is heated.
5. Know what the dilution rate is.
6. Make sure the paving surface is clean. Tack will bond to dust and dirt on the roadway and could be picked up by trucks and the paver.
7. Check that all nozzles are working properly.
8. Check the bar height to make sure coverage of the paving surface is uniform.
9. Make sure any vertical surfaces are tack coated.
10. Record the beginning and ending stations of each tack shot.
11. After tack is applied check the amount of tack left in the distributor to check and record the rate of application.

b. Rollers
1. Make sure there are enough rollers to properly compact the pavement.
2. Check to see that spray bar uniformly applies water to the roller drum.
3. Check that vibrators are working properly and check the amplitude and frequency of the vibrators.
4. Verify the manufacturers recommended contact pressure for pneumatic rollers. Check tire pressures and make sure all tires are inflated to the same pressure; there should be no more than 5 psi difference between any of the tires.

c. Paver.
1. Check that grade control system is in place.
2. Check that screed is preheated.
3. Check that screed vibrators are working and in use while paving.
4. Make sure the hopper has no mix from previous paving or other material that may contaminate the mix.
5. Make sure there is no diesel fuel on the paver to clean hand tools.
6. Check the augers to make sure they extend to within one foot of the width of the screed.

d. Paving.
1. Make sure there are is enough trucks and material to allow continuous paving. Make sure traffic control is in place and everything is in order to safely control the work zone.
2. Ideally the paver should never stop.
3. Check that there is adequate guidance for the paver operator to follow to produce straight tangents and smooth curves.
4. Collect haul tickets for each load of mix delivered.
5. Check the mix temperature. Cold mix or a cold screed will result in tearing pavement surface.

6. Check that there are blocks provided for the screed to set on to allow material for rolldown at the joint.
7. Make sure handwork for the longitudinal joint is done promptly so compaction can occur before the material cools. Handwork should be kept to a minimum and excess material should be wasted not spread across the newly paved surface.
8. Check the transverse joint to make sure there is no bump after it is compacted.
9. If paving to match an adjacent lift make sure to allow enough material for 20-25% rolldown to achieve proper compaction at the longitudinal joint. If there is not enough material the joint may look smooth and sealed but not have adequate compaction to prevent early failures.
10. Check the pavement surface behind the paver. The surface should be uniform and free of segregation, streaks, drags or shadows. If any irregularities are found request the contractor to correct them.
11. Check the width of the pavement surface to verify the plan width will result.
12. Check thickness to verify that the desired thickness will be achieved after compaction.
13. Check the cross slope to determine if the proper camber is in the screed. A good starting point is one-half inch camber in the middle of the section. This allows for rolldown resulting in constant slope after compaction.
14. Check the sloughs to make sure they are at the proper slope and compacted.
15. Check the level of material in front of the screed. The level should be constant at the midpoint of the augers.
16. The hopper should be at least half full at all times.
17. Segregation will occur in the hopper as it is loaded. The wings should not be dumped during paving.
18. Where freshly placed pavement is not confined by curb and gutter, or an adjacent lift, begin compaction approximately six inches inside the pavement edge. Where the pavement is confined begin compaction overlapping the edges. Compact toward the middle of the section.
19. Check the speed of the pavers with the frequency and amplitude of the vibrators to get the best ride results. It is important to achieve 8-10 impacts per foot, less than that may produce a rippling effect in the pavement. Excessive impacts or amplitude may cause checking.
20. After a compaction sequence has been determined make sure the roller operators follow the pattern. If conditions change and a new compaction sequence is necessary determine a pattern that works and follow that.
21. Check the pavement temperature to make sure the compaction sequence is complete before the temperature drops below 185 degrees.
22. Check behind the rollers to verify plan width is being produced. Check that the slope across the section is uniform, if it is not adjust the camber in the screed to correct it.
23. Check the surface after compaction to make sure it is uniform, dense, and free from irregularities. There should be no segregation, streaks, tearing, steel roller marks, or checking.
24. Monitor the rate of application of the paving operation to make adjustments to the spread rate to keep on pace to meet plan quantity. Compare the results to the calculated spread rate. This should be done approximately every 500 tons. Make

gradual changes to bring the rate in line. Spread rates are defined by the tons of mix placed divided by the number of stations between the beginning and ending stations. It is also important to track the cumulative spread rate. If the contractor is asked to increase thickness because the spread rate is low the idea is to get back on track to meet plan quantity. If the adjustment is too rapid or lasts too long another correction will be necessary. It is not good practice to constantly change thickness.

25. Prior to each days paving deduct the amount of mix previously placed from plan quantity and recalculate a new spread rate.

QR Codes for common web links

NDDOT Field Sampling and Testing Manual

NDDOT Standard Specifications

NDDOT Forms

NDDOT Technician Registry

NDDOT Materials and Research Web Page

Dakota Asphalt Pavement Assoc.

SECTION 430
HOT MIX ASPHALT (HMA)

430.01 DESCRIPTION

This work consists of constructing bituminous pavement.

Sample and test as outlined in the *Field Sampling and Testing Manual*.

430.02 EQUIPMENT

Equipment	Section
Rollers	151
Bituminous Trucks	152.01 D
Bituminous Tank Trucks	152.01 E
Bituminous Equipment	154

430.03 MATERIALS

Item	Section
Bituminous Material	818

A. **Asphalt Cement.**
The Engineer will accept asphalt cement as outlined in the Combined State Binder Group agreement for North Dakota. The Contractor shall obtain samples of this material under the observation of the Engineer. The Engineer will take immediate possession of the samples.

B. **Aggregate.**
Develop a mix design that contains an aggregate gradation that conforms to the requirements in Table 430-01.

Table 430-1
Aggregate Gradation for Mix Design

Sieve Size	1/2 Inch Nominal Maximum Aggregate Size[1] Percent Passing	
	Min.	Max.
5/8 Inch	100	100
1/2 Inch	90	100
#4	40	70
#30	15	35
#200	2.0	7.0

[1]Nominal aggregate size is defined as 1 sieve size larger than the first sieve to retain more than 10 percent.

Provide aggregate that meets the requirements in Table 430-02.

Table 430-02		
Test Designation	**Test Name**	**Criteria**
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	40% minimum
ND D 4791	Test Method for Flat Particles, Elongated Particles, or Flat Elongated Particles in Coarse Aggregate	10% maximum
AASHTO T 96	Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine	40% maximum
ND T 113	Lightweight Pieces in Virgin Aggregate	5.0% maximum

C. **Superpave Mix Properties.**
Provide mix that meets the requirements of Table 430-03. Base the fine aggregate angularity (FAA) on the designation of the bid item.

Table 430-03 Superpave Mix Properties						
Property	**FAA 40**	**FAA 41**	**FAA 42**	**FAA 43**	**FAA 44**	**FAA 45**
Fractured Particles in Course Aggregate Angularity (minimum)	75%	75%	75%	75%	85%	85%
Fine Aggregate Angularity (minimum)	40%	41%	42%	43%	44%	45%
Gyratory Effort, # of Gyrations	N_{ini} = 7, N_{des} = 75, N_{max} = 115					
Voids filled with Bitumen	65-78%	65-78%	65-78%	65-78%	65-75%	65-75%
$\%G_{mm}$ @ N_{ini} (maximum)	90.5%	90.5%	89%	89%	89%	89%

The superpave mix properties shown in Table 430-03 will be determined according to the methods shown in Table 430-04.

Table 430-04 Methods for Determining Superpave Mix Properties	
Fractured Particles in Coarse Aggregate	NDDOT 4
Fine Aggregate Angularity	ND T 304
Gyratory Effort, # of Gyrations	AASHTO R 35
Voids filled with Bitumen	AASHTO M 323, NDDOT T 166
$\%G_{mm}$ @ N_{ini}	AASHTO M 323, NDDOT T 166

D. **Preparation of Aggregates.**
When using a drum-dryer mixer, prepare aggregate to that the moisture content of the bituminous mixture is less than 1 percent.

Screen aggregates used in a cold-feed control into two or more fractions consisting of at least 1 fine and 1 coarse aggregate stockpile. Feed aggregate from the stockpile into separate compartments for accurate proportioning into the mixer.

E. **Recycled Asphalt Pavement (RAP).**
When a mix contains RAP, obtain the recycled material from the project or from a source specified for the project by the Department. The Engineer will approve recycled material from a different source only if that source is another Department project.

RAP may be incorporated into mix used for mainline pavement at a rate between 10 and 25 percent of the mix, by weight.

RAP may be incorporated into mix used for shoulder pavement at a rate between 10 and 35 percent of the mix, by weight.

Provide recycle material with a maximum particle size of 1.5 inch.

Introduce recycled material so that it does not come into direct contact with the burner flame. Add binder to the combined virgin aggregate and recycled material.

If using a mix with RAP and a mix without RAP, submit mix designs for both mixes.

When obtaining material from the roadway to determine the RAP mix design, the Engineer will designate the location used to obtain material.

F. **Commercial Grade Hot Mix Asphalt.**
Provide commercial grade asphalt that meets the requirements of any of the FAA designations in Section 430.03 C, “Superpave Mix Properties.”

The requirements of the following sections will not be applied to commercial grade asphalt:

– Section 430.04 A, “Contractor Quality Control Plan;”

– Section 430.04 B, “Engineer’s Quality Assurance Plan;”

– Section 430.04 C.2, “Determination of Specific Gravity;” and

– Section 430.04 E, “QC Testing.”

Section 430.04 D "Mix Design" is replaced with the follwing requirements:

Submit a mix design that was previously approved under another Department contract. Include the project number and PCN of the previous project.

If a previously approved mix design is not available, submit a new mix design to the Engineer at least 10 calendar days before placement of material. The Engineer may request materials to use in mix design verification before approving the mix design.

430.04 CONSTRUCTION REQUIREMENTS

A. **Contractor Quality Control (QC).**

1. **Quality Control Personnel.**
   Provide the following personnel:

   – Certified Aggregate Field Lab Tester to be on the project during aggregate production;

   – Certified Aggregate Field Lab and Asphalt Mix Tester to be on the project during asphalt mix production;

   – Certified Asphalt Pavement Inspector to be on the project during paving operations; and

   – Certified Asphalt Mix Controller to be on the project during paving operations.

   Ensure that all personnel performing tests on materials used in the paving operation are certified as outlined in the Department's Technical Certification Program (TCP). The requirements of the TCP can be found on the Department's website at www.dot.nd.gov.

2. **Quality Control Plan.**
   Before beginning work, submit a copy of the QC plan to the Engineer. Provide and maintain copies of the plan at the Quality Assurance (QA) and QC laboratories. Provide the following minimum information in the Plan:

   a. The names and phone numbers of the individuals responsible for the QC program.

   b. A listing of the personnel responsible for the QC testing and their Technician ID and qualifications.

   c. An organizational chart indicating lines of authority, including names and phone numbers.

   d. Details of the QC plan addressing the following items:

      – Pit operations and methods used to control uniformity, limiting segregation, and efficiently utilizing the aggregate resources of the pit;

      – Plant operations listing proposed equipment and method of operations;

      – Site plan drawing of plant;

- Testing frequency for both aggregate production and mix production; and
- Discussion of how the QC program responds to the need for corrective action.

An example quality control plan is available on the Department's website.

B. **Engineer's Quality Assurance Plan.**
The Engineer will provide a quality assurance plan to the Contractor at the time the Contractor submits the quality control plan specified in Section 430.04 A.2, "Quality Control Plan." The quality assurance plan will contain:

- The names and phone numbers of the individuals responsible for the QA program.
- A listing of the personnel responsible for the QA testing and their Technician ID and qualifications.
- An organizational chart indicating lines of authority, including names and phone numbers.

C. **Pit Operations and Stockpiling of Aggregate.**

1. **General.**
Perform the tests required in Section 430.02 A.2, "Contractor Testing" in the *Field Sampling and Testing Manual*. Provide copies of test results for each stockpile of aggregate by noon the day following the tests.

Before the start of bituminous mix production, stockpile sufficient aggregate at the plant to produce the lesser of:

- 25,000 tons of bituminous mixture; or
- 50 percent of the required quantity of bituminous mixture.

During bituminous mix production, maintain sufficient aggregate in the stockpiles to produce at the lesser of:

- 5,000 tons of bituminous mixture; or
- 25 percent of the required quantity of bituminous mixture to finish production.

2. **Determination of Specific Gravity.**
If the specific gravity values determined by the Contractor and Engineer as required by Section 430.02, "Quality Control Testing" of the *Field Sampling and Testing Manual* correlate within 0.040, proceed with developing a mix design using the Contractor's averaged specific gravity values.

If the specific gravity values determined by the Contractor and Engineer as required by Section 430.02, "Quality Control Testing" of the *Field Sampling and Testing Manual* do not correlate within 0.040, choose one of the following options:

- Perform the tests together with the Engineer at an agreed upon location; or
- Resolve the testing differences according to the dispute resolution proce-

dures in Section 430.04, "Dispute Resolution" of the *Field Sampling and Testing Manual*.

Once resolved, proceed with the development of a mix design using the determined number for the tests performed with the Engineer or the number determined by the dispute resolution procedure.

D. **Mix Design.**

1. **General.**
Develop the mix design using the Department's mix design program. The Department mix design program is available at www.dot.nd.gov. Do not begin production of hot bituminous pavement before the Department approves the mix design.

If the project will contain both recycled and non-recycled pavements, submit one mix design containing recycled material and one without recycyled material.

Submit the mix design a minimum of 10 calendar days before beginning paving operations. If the Engineer does not approve the mix design, revise the mix design and submit the revised mix design. Allow 10 calendar days for the Department to review the revised mix design before beginning paving operations.

When making the blend determinations for the mix design, use the average of the production samples value for each sieve from each stockpile.

Base the mix design on the criteria specified in Table 430-05 and develop the mix design according to the standards outlined in Table 430-06.

Table 430-05
Hot Mix Asphalt Testing Criteria

Procedure/Property/Test	Criteria	Reference
Voids in Mineral Aggregate	14.0 Minimum for ½ Inch Nominal Maximum Aggregate	AASHTO M 323 ND T 166
% G_{mm} @ N_{max}	98.0 Maximum	AASHTO M 323 ND T 166
Dust/Effective Asphalt Ratio	0.6 - 1.3 (top lift) 0.6 - 1.4 (bottom lifts)	AASHTO M 323 ND T 166
Desired Moisture Sensitivity, Min. % Strength Retention[1,2]	70 @ 7.0 ± 1% Air Voids	AASHTO T 283 AASHTO R 30
Asphalt Film Thickness[1] (Microns)	7.5 - 13	Determined by Department's mix design program.

[1]Desired value, the Department will make a final determination based on the mix design.
[2]Only required when specified on the Plans.

Table 430-06 AASHTO Superpave Mix Design Standards	
Designation	**Title**
ND T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO R 35	Practice for Superpave Volumetric Design for Hot Mix Asphalt
AASHTO R 30	Mix Conditioning of Hot Mix Asphalt (HMA)
AASHTO M 323	Specification for Superpave Volumetric Mix Design
ND T 166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens

Submit a revised mix design if:

– Utilizing aggregate from sources not initially submitted;

– Processing the aggregate using a different crusher; or

– Using a different type or grade of bitumen.

Allow 10 calender days for the Department to review the revised mix design before incorporating the material into the work.

If the source of bitumen changes from the approved mix design, immediately notify the Engineer of the change and provide the relevant information related to the new source. The Engineer may request a new mix design. If the Engineer requests a new mix design, submit the necessary materials and allow 10 days for the Department to review the revised mix design before incorporating the material into the work.

2. **Items to be Submitted.**
Submit the following items with each mix design:

a. An aggregate sample representing each stockpile used for the mix design. The total weight of material shall be approximately 150 lbs.

b. Eight one-quart cans of PG asphalt. The PG asphalt shall be the same grade specified on the Plans and from the supplier that will be used on the project.

When multiple grades of PG asphalt are specified, one grade may be supplied, but it must be the same grade used to develop the mix design.

c. Approximately 30 pounds of loose asphaltic concrete mix prepared at the optimum asphalt content recommended by the mix design.

d. The Contractor shall submit a mix design that contains the following elements:

(1) The percentage of aggregate passing each of the specified sieves.

(2) The percent asphalt cement to be added to the mixture.

(3) The target air voids will be 4%.

(4) The maximum specific gravity of the mixture obtained in the laboratory.

(5) The bulk specific gravity of the mixture obtained in the laboratory.

(6) The percent VMA of the mixture obtained in the laboratory.

(7) Calculated film thickness (microns).

(8) Calculated dust/asphalt ratio.

(9) $\%G_{mm}$ @ $N_{ini.}$

(10) $\%G_{mm}$ @ N_{max}.

E. **QC Testing.**

1. **General.**
During production of the bituminous mix, perform sampling and testing on the aggregate and bituminous mix as the mix is being produced and placed on the roadway.

Perform the tests specified in Section 430.02, "Quality Control Testing" of the *Field Sampling and Testing Manual* at the designated frequencies. During aggregate production, test results must be made available by noon the day following the test. During mix production, furnish copies of test results upon completion of the test.

If the QC test results for ND T 176 or ND T 113 indicate uniform results, the Engineer may issue a written notice reducing the frequency of these tests.

2. **Determination of Asphalt Content.**
Under the observation of the Engineer, determine the asphalt content each time a gradation test is taken. Base the asphalt content on readings from the totalizers for the aggregate and the asphalt as outlined in *Asphalt Content and Virgin Aggregate Determination (SFN 18674)*.

3. **Sample Splitting.**
The Engineer will take possession of one half of the split QC sample and will perform testing on a portion of the material, as necessary.

The portion of the sample submitted to the Engineer will be retained for 24 hours after the QA test representing the lot of material has been performed. Either the Engineer or Contractor may request to have the remaining portion of the sample tested within the 24-hour timeframe. If a request is made, the Engineer will test the remaining portion of the QC sample and the Engineer's results will be used as the basis for acceptance of the aggregate.

4. **Documentation.**
Maintain complete records of all process quality control tests. Record all test results and calculations and document results on Department provided forms. The required forms are available on the Department's website at www.dot.nd.gov. The proper forms for individual tests are listed in the *Field*

Sampling and Testing Manual.

Maintain control charts at the QC laboratory. Record test results on the control charts immediately upon completion of the test. Record the following parameters on the control charts:

- Gradation of the control sieves (1/2 Inch, #4, #30, and #200), (ND T 27 and ND T 11);
- Asphalt Content;
- Theoretical Maximum Specific Gravity, (ND T 209);
- Bulk Specific Gravity, (ND T 166);
- Percent Air Voids of field Gyratory samples;
- Daily average Air Voids percentage of the cores;
- Average Daily Density;
- Fines/Asphalt Ratio;
- Asphalt Film Thickness (microns); and
- Fine Aggregate Angularity.

Control charts must display:

- Single test control limits for each test parameter;
- Individual test results;
- Moving average control limits; and
- Moving average of the last four tests.

Color code the moving average results and control limits, and the single tests and control limits.

Make the control charts available at the QC laboratory and accessible for review by the Engineer during the paving operations. Submit complete control charts upon completion of the paving operations.

5. **Control Limits.**
The field test results may vary from the mix design target values as shown in Table 430-07.

The Engineer will allow a 2.0 percent of the material to be retained on the 5/8 inch sieve providing all material passes the 3/4 inch sieve.

Table 430-07 Allowable Working Ranges			
Test/Assessment		**Single Test Target Value Control Limit**	**Moving Average Target Value Control Limit**
Asphalt Content (based on totalizer reading)		±0.30	±0.24
ND T 11 and ND T 27	Sieve Analysis of Fine and Coarse Aggregates (Control Sieves)		
	1/2”	±6	±5
	#4 sieve	±6	±5
	#30 Sieve	±5	±4
	#200 Sieve[1]	±2.0	±1.5
SFN 50289	Percent Air Voids	2% to 6%	2.5% to 5%
ND T 113	Lightweight Pieces in Aggregate	Not more than the maximum specified	
NDDOT 4	Percentage of Fracture Particles in Coarse Aggregate	Not less than the minimum specified	
ND T 304	Fine Aggregate Angularity	Not less than the minimum specified	
ND D 4791	Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate	Not more than the maximum specified	
ND T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	Not less than the minimum specified	
[1]Not to exceed the maximum specified in Table 430-01.			

a. **Single Test Target Values.**
If an individual test falls outside the single test target value control limits, take immediate corrective action. After implementation of the corrective action, collect a sample and conduct the test that fell outside the control limits. If the test following the corrective action falls outside of the control limits discontinue paving operations until the cause is found and corrected. Resume paving operations only after obtaining approval from the Engineer.

The test following the corrective action is used to determine the effectiveness of the corrective action. It is not used for acceptance of material and will not be factored into the moving average.

If in an individual gradation test a single control sieve falls outside the single test target value control limits, continued production is allowed only if the air voids are within the control limits and the material passing the #200 sieve does not exceed the maximum specified in Table 430-01.

Discontinue paving operations if two consecutive tests exceed the single

test target value control limit for any of the following:

- ND T 113, Lightweight Pieces in Aggregate;
- ND T 304, Fine Aggregate Angularity;
- NDDOT 4, Percentage of Fracture Particles in Coarse Aggregate; or
- ND T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.

Resume paving operations only after taking corrective action and obtaining approval from the Engineer.

b. **Moving Average Target Values.**
The moving average for each test is determined using the 4 most recent test results.

If the moving average for a test trends toward the moving average target value control limits, take corrective action. After implementation of the corrective action collect a sample and conduct the test that is trending towards the moving average control limits. The test following the corrective action is used to determine the effectiveness of the corrective action. It is not used for acceptance of material and will not be factored into the moving average. Document the corrective action.

If the moving average for a test exceeds the moving average target value control limits, continued production is allowed only if the air voids are within the control limits and the material passing the #200 sieve does not exceed the maximum specified in Table 430-01.

If the air voids are outside the control limits or the material passing the #200 sieve exceeds the maximum specified in Table 430-01, perform one of the following actions:

- Implement corrective measures to produce mix that is based on the mix design; or
- Request that new target values be set if the test results indicate that adjustments to the target values are necessary. Implement the adjusted target values only after receiving the Engineer's written approval.

If the moving average for air voids exceeds the moving average control limit, discontinue paving operations and implement corrective measures. The Engineer may allow continued paving if satisfied with the corrective measures. Resume quality control testing when the plant has started and operations are equalized.

F. **Surface Preparation.**
Remove deleterious material from the surface.

Correct local irregularities in the existing surface before placing the first lift of bituminous material. If milling is specified, correct local irregularities after milling. Apply a tack coat to the surface before correcting the irregularities. Use the same type of mix that is required for the subsequent lift. Compact and roll the mix.

The mix required for correcting local irregularities will be deducted from the total mix used for the project, meaning that the subsequent lift of pavement will be thinner than originally planned.

Apply a tack coat to the surface and to the exposed edges of longitudinal and transverse joints before placing bituminous pavement. Apply a double application of tack coat to longitudinal joints and a minimum of one inch on either side of the joint. Apply a tack coat on a previously placed layer or surface of pavement before placing the next lift.

G. **Patching.**
Remove existing broken or unstable surface material and replace that material with the same mixture specified for the next course.

Remove existing surfacing, base, and subgrade material to the depth required to obtain a stable subgrade.

If required, place and compact approved aggregate from the bottom of existing bituminous pavement to a minimum depth of 3 inches below the existing surface.

Place the bituminous material in lifts not to exceed 3 inches and compact the material. Allow the patch material to cool to 130°F before placing additional material. If the breakup occurs during the paving operation allow the patch material to cool to 185°F before placing additional material.

H. **Spreading and Finishing.**

1. **General.**
Do not place bituminous mixture on a damp pavement surface, on a frozen roadbed, or when weather conditions prevent the proper handling and finishing of the bituminous mixtures.

Use bituminous pavers to spread and finish mixtures to the required section leaving the mixture uniformly dense, smooth, and free from irregularities. In locations where it is impractical to use normal laydown equipment the Engineer will allow other methods.

The surface thickness shown on the plans is for estimating purposes only. Place pavement to use the estimated tonnage uniformly throughout the roadway.

Supply mix that is uniform and homogeneous. The Engineer will reject loads of mix or sections of pavement containing uncoated batches of aggregate or segregated materials.

Remove and replace material that is visibly segregated. If a paver placed the material, remove the segregated material to the full width of the paver. If the material was placed by hand, remove the full area of segregated material, plus an additional 6 inches around the entire segregated area.

Place material in lifts between 1.5 and 2.5 inches of compacted bituminous material. Leveling courses may be placed with thickness less than 1.5 inches.

Place bituminous mixture so a single lane is not more than one day's run in advance of any adjacent lane. Leveling courses are excluded from this requirement.

Do not place bituminous pavement on bridge decks.

Place and follow markings to guide the paver. Construct longitudinal joints in a uniform line. Correct pavement edges that deviate from the uniform line and correct areas of the longitudinal joint that vary from the intended location of the joint by more than 2 inches. Construct longitudinal joints with tight seems and no visible segregation.

2. **Air and Surface Temperature Requirements.**
Place a subsequent lift after the previous lift has cooled to 130°F.

Place bituminous mix without supplementary admixture when the temperatures are at or above the requirements in Table 430-08. Include a supplementary admixture such as Evotherm, AD-here LOF 65-00 EU, or an approved equal in the bituminous mixture when placing bituminous mix when temperatures are within the ranges shown in Table 430-09. Do not place bituminous mix when temperatures are below those shown in Table 430-09.

Table 430-08
Standard Paving Temperatures

Compacted Thickness	Air Temp for Surface Course	Air Temp for Subsurface Course and Approaches	Existing Mat
1-1/2 inches or less	45°F	40°F	40°F
More than 1-1/2" inches	40°F	35°F	40°F

If placing bituminous mix according to Table 430-09, submit the supplementary admixture manufacturer's dosage rate and any changes to the mix design. The supplementary admixture may be added to the asphalt binder by the supplier or refiner, or by the Contractor at the asphalt plant. Add the admixture to the binder according to the supplementary admixture manufacturer's recommendations. If the admixture is added at the plant, equip the plant with a metering device that records the rate of admixture. Tie the metering device into the same system that measures the other components of the mix.

Table 430-09
Paving Temperatures Using Supplementary Admixtures

Compacted Thickness	Air Temp for Surface Course	Air Temp for Subsurface Course and Approaches	Existing Mat
1-1/2 inches or less	40°F - 45°F	35°F - 40°F	35°F - 40°F
More than 1-1/2" inches	35°F - 40°F	35°F or above	35°F - 40°F

Measure the existing mat temperature using one of the following methods:

– Using an infrared sensing thermometer; or

– Insert a conventional thermometer into a 1 inch deep hole in the pavement. Fill the hole with water, oil, or grease.

3. **Mix Temperature Requirements.**
Discharge mix from the mixer with a temperature no higher than the bituminous material manufacturer's recommendation. If there are no recommendations on maximum mix temperature, discharge mix with a maximum temperature of 300°F.

When the ambient temperature is 60°F or higher, place mix with a minimum laydown temperature of 230°F. When the temperature is below 60°F, place mix with a minimum laydown temperature of 250°F.

I. **Compaction.**

1. **General.**
Remove all surface irregularities before beginning compaction.

Sequence rolling operations and select the type and the number of rollers to match production and to attain the required density before the mat temperatures fall below 185°F.

In areas not accessible to rollers, compact the pavement mat with hand or mechanical tampers.

2. **Calculated Density.**

a. **General.**
Use calculated density on mainline pavement, interstate crossroads, ramps, turn lanes, rest area approaches, and parking lots.

b. **Coring.**

(1) **General.**
The recorded average density of each sublot will be determined using the density of pavement cores.

The Engineer will designate locations for obtaining pavement cores. Under the observation of the Engineer, obtain two cores in each sublot. Obtain cores adjacent to each other. The recorded average density of the sublot will be the average of the density of the two cores.

Use a machine that cuts a cylindrical core sample without disturbing the density of the sample. Complete coring on or before the working day following the placement of the lift. Obtain a core with a smooth outer surface, no distortion of the cylindrical shape, and no displacement of the aggregate particles. Obtain a core that is 4 to 6 inches in diameter and the full depth of the in place asphalt. Use a masonry saw to cut the core so that only the layer to be tested is removed.

Label each core, using a system approved by the Engineer, to identify the location from which the core was obtained.

Fill core holes before placing the subsequent lift of pavement. If there is no subsequent lift of pavement, fill the core hole within 24 hours of obtaining the core. Remove free standing water before filling core holes. Fill core holes in 2-inch lifts using material from the same mix design used on the roadway. Compact each lift using a hand tamper.

(2) **Pavement Thickness Determination Cores.**
After the placement of the final lift of pavement, at locations designated by the Engineer and under the observation of the Engineer, obtain one full depth core per mile. Label the cores The Engineer will take possession of these cores immediately upon extraction. Do not cut these cores.

3. **Ordinary Compaction.**

a. **General.**
Use ordinary compaction on shoulders, driveways, section line approaches, bike paths, leveling courses, and patches.

Ordinary compaction consists of breakdown rolling, intermediate rolling, and finish rolling. Compact the bituminous material until the surface is tightly bound and shows no displacement under operation of the roller.

For patching, immediately after spreading perform initial rolling with pneumatic-tired rollers or combination rollers.

b. **Breakdown Rolling.**
Breakdown rolling consists of one or more complete coverage with a roller meeting the requirements of one of the following sections:

– 151.01 A.3, “Self-Propelled Pneumatic-Tired Rollers;”

– 151.01 B.2, “Smooth-Faced Steel-Wheel Roller: Tandem – Type A;”

– 151.01 C, “Vibratory Rollers;” or

– 151.01 D, “Combination Rollers.”

c. **Intermediate Rolling.**
Follow breakdown rolling with intermediate rolling with a roller conforming to Section 151.01 A.3, “Self-Propelled Pneumatic-Tired Rollers,” or 151.01 D, “Combination Rollers” until the surface is tightly bound and shows no displacement under the roller.

If roller tires pick up the bituminous material or there are excessive roller marks in the mat and it appears to the Engineer that compaction is being achieved, the Engineer may allow the removal of the intermediate rolling operation.

d. **Finish Rolling.**
Perform the finish rolling with a roller conforming to Section 151.01 B.3, “Smooth-Faced Steel-Wheel Roller: Tandem – Type B,” or 151.01 C, “Vibratory Rollers” in the static mode, and continue until roller marks are eliminated.

J. **Joints.**

1. **General.**
   Place pavement against the surface of curbing, gutters, manholes, and similar structures uniformly near the contact surfaces so the pavement is slightly higher than the edge of the structure after compaction. Do not construct a joint on top of a joint from a previous lift.

2. **Longitudinal Joints.**
   Construct longitudinal joints on successive lifts between 6 and 12 inches from the previous longitudinal joint.

3. **Transverse Joints.**
   Construct transverse joints on successive lifts a minimum of 12 feet from the previous transverse joint.

K. **Tolerances.**
Correct surface irregularities that exceed 3/16 inch measured with a 16-foot straightedge

L. **Pavement Sloughs.**
Compact pavement sloughs with rollers capable of providing a smooth finished compacted slough that is free of tire marks and unevenness and drop-offs. The Engineer will not require density tests.

M. **Acceptance.**
The Engineer will accept bituminous mix based on the following criteria:

1. **Aggregate.**
   The Engineer will accept aggregate used in the mix based QC tests that are verified by QA testing and the control limits specified in Section 430.04 E.5, "Control Limits."

   If the results for two consecutive aggregate gradation tests in a single day fall outside the single test target value control limits, the Engineer will apply a contract price adjustment as specified in Section 430.06 C, "Contract Price Adjustments."

2. **Asphalt Content.**
   The Engineer will base the acceptance of the asphalt content of bituminous mix on the totalizer readings obtained as specified in Section 430.04 E, "QC Testing" and the *Mix Bitumen Cut-Off Report (SFN 9988)* and will apply a contract price adjustment as specified in Section 430.06 C, "Contract Price Adjustments."

   If the average asphalt content, as determined by the Engineer according to the *Mix Bitumen Cut-off Report, (SFN 9988)* deviates from the target value by 0.40 percentage points or more, the Engineer may reject the material. If the material is accepted, the Engineer will apply a contract price adjustment as specified in Section 430.06 C, "Contract Price Adjustments."

3. **Field Density.**
   This section will apply when the pavement is constructed as specified in Section 430.04 I.2, "Calculated Density."

   The Engineer will base acceptance of the density of hot mix asphalt on the average density of the pavement compared to the daily average maximum

theoretical density. The comparison will be made using *Density Pay Factor (SFN 59132)*.

The Engineer will determine the density of pavement based on lots. A lot is equal to the amount of material, in tons, placed each production day. If a shoulder, or part of a shoulder, is placed monolithically with the mainline, the shoulder area will be excluded from the quantity of material represented by the lot.

A sublot is defined as a single lift, one paver width wide, and 2,000 feet long. If a partial sublot is less than 1,000 feet, it will be included in the previous sublot. A partial sublot greater than 1,000 feet in length will be considered a separate sublot.

The density of a lot will be determined using the recorded average densities of the sublots contained within the lot. The recorded average densities of the sublots will be totaled and divided by the number of sublots within the lot to obtain the average density of the pavement.

If the average density of the pavement compared to the daily average maximum theoretical density is above the values in Table 430-10, the Engineer will apply a contract price adjustment as specified in Section 430.06 C, "Contract Price Adjustments."

If the average density of the pavement compared to the daily average maximum theoretical density is at or below the values specified in Table 430-10, remove and replace the pavement.

Table 430-10

Superpave FAA 40, 41, 42, and 43	Superpave FAA 44 and 45
88.0%	89.0% [1]

[1] When the lift of pavement is placed on aggregate base, reclaimed material, or cold in place recycle material this number is reduced to 88.0%

430.05 METHOD OF MEASUREMENT

The Engineer will measure, completed and in place, as specified in Section 109.01, "Measurement of Quantities" and the following:

A. **Bituminous Pavement.**
The Engineer will pay for the tonnage of bituminous mix used in the accepted pavement and will make no deduction for the weight of asphalt cement used in the mixture.

B. **Asphalt Cement.**
The Engineer will determine the quantity of asphalt cement used each day by completing the *Mix Bitumen Cutoff Report (SFN 9988)*.

C. **Cored Sample.**
The Engineer will measure each individual cored sample that is removed in the required condition.

D. **Tack.**

Tack will be measured as specified in Section 401.05, “Method of Measurement.”

430.06 BASIS OF PAYMENT

A. **General.**

Pay Item	Pay Unit
__Asphalt Cement	Ton or Gallon
Superpave, FAA 40	Ton
Superpave, FAA 41	Ton
Superpave, FAA 42	Ton
Superpave, FAA 43	Ton
Superpave, FAA 44	Ton
Superpave, FAA 45	Ton
Commercial Grade Asphalt	Ton
Patching	Ton
Cored Sample	Each

Such payment is full compensation for furnishing all materials, equipment, labor, and incidentals to complete the work as specified.

B. **Tack.**
Tack will be paid for as specified in Section 401.06, “Basis of Payment.”

C. **Contract Price Adjustments.**

1. **General.**
The Engineer will calculate the Combined Adjustment Factor by multiplying the individual adjustment factors for:

– Aggregate gradation;

– Asphalt content; and

– Compaction.

The Combined Adjustment Factor will be subtracted from 1.0 to determine the Contract Price Adjustment Factor.

The contract price adjustment will be determined by multiplying the Contract Price Adjustment Factor by the total tons of hot mix asphalt placed during a single day and the contract unit price for “Superpave, FAA __.”

2. **Aggregate Gradation Adjustment Factor.**
The aggregate gradation adjustment factor will only be applied if two consecutive aggregate gradation tests in a single day contain a sieve that is outside the Single Test Target Value Control limits specified in Table 430-07. If different sieves fall outside the limits on consecutive tests, the adjustment factor will be applied.

If more than one sieve exceeds the Single Test Value Control Limits, the Engineer will use the largest uniformity deviation (U) when determining the adjustment factor.

When the aggregate gradation factor is applied, the Engineer will calculate

the adjustment factor using the largest deviation (U) to calculate the adjustment factor.

$$\text{Adjustment Factor} = \frac{(100-U)}{100}$$

3. **Asphalt Content Adjustment Factor.**
For each day's production, the Engineer will apply the lowest adjustment factor determined from the average or uniformity methods.

   a. **Average.**
   The Engineer will determine average asphalt content using the *Mix Bitumen Cut-off Report (SFN 9988)* and apply the appropriate adjustment factor specified in Table 430-11.

   If the average asphalt content deviates from the mix design by 0.40 percentage points or more, the Engineer will determine the adjustment factor in accordance with Section 105.07, "Conformance with the Contract Requirements," or may reject the material.

Table 430-11
Average Asphalt Content

Deviation from Target (percentage points)	Adjustment Factor
0.00-0.24	1.00
0.25-0.29	0.98
0.30-0.34	0.95
0.35-0.39	0.92
≥ 0.40	Section 105.07

   b. **Uniformity.**
   The Engineer will determine the average asphalt cement content based on the totalizer readings specified in Section 430.04 E, "QC Testing" and the *Asphalt Content and Virgin Aggregate Determination Report (SFN 18674)*.

   If the asphalt content from any random reading varies from the daily average of the readings by more than 0.24 percentage points, the Engineer will calculate the adjustment factor according to *Daily Report – Hot Bituminous Pavement – Quality Control (SFN 18552)*.

$$\text{Adjustment Factor} = \frac{(100 - [20(\text{Deviation}-0.24)])}{100}$$

4. **Compaction Adjustment Factor.**
The adjustment factor for compaction will not be used for areas constructed according to Section 430.04 I.3, "Ordinary Compaction."

If the average density of the field cores is less than the daily average maximum theoretical density, the Engineer will apply the appropriate adjustment factor specified in Table 430-12 or Table 430-13.

Table 430-12 Adjustment Factors for FAA 40, 41, 42 and 43	
Adjustment Factor	**Avg. Pavement Density**
1.00	≥ 91.0%
0.98	90.0% - 90.9%
0.95	89.5% - 89.9%
0.91	89.0% - 89.4%
0.85	88.5% - 88.9%
0.70	88.0% - 88.4%

Table 430-13 Adjustment Factors for FAA 44 and 45	
Adjustment Factor	**Avg. Pavement Density[1]**
1.00	≥ 92.0%
0.98	91.0% - 91.9%
0.95	90.5% - 90.9%
0.91	90.0% - 90.4%
0.85	89.5% - 89.9%
0.70	89.0% - 89.4%

[1]The Engineer will apply the adjustment factors from Table 430-12 for lifts of pavement placed on aggregate base, reclaimed material, or cold in place recycle material.