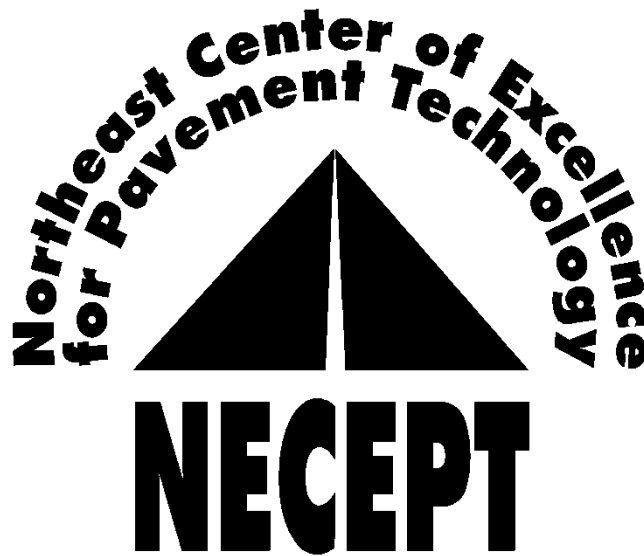


PENNDOT ASPHALT TECHNICIAN CERTIFICATION PROGRAM

FIELD TECHNICIAN PROGRAM
COURSE MATERIAL
2022



PENN STATE UNIVERSITY
NECEPT/The Thomas D. Larson Pennsylvania Transportation Institute
201 Transportation Research Building, University Park, PA 16802
Phone: 814-863-1293
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Website: www.superpave.psu.edu
Email: superpave@psu.edu



PennState

Asphalt Construction Program
Certified Asphalt
Field Technician - 2022

Module 5:
Delivery


NECEPT



1

As a CFT, your goal is to ensure that asphalt mixture delivery be a smooth, uninterrupted and continuous operation to the fullest extent possible. The haul vehicle is to transport the asphalt mixture from the plant to the paver without delay and with minimal *segregation*.

Module 5 – Objectives

To Discuss and Learn about

- Types of Trucks
- Loading the Truck
- Delivery to the Site
- Unloading at the Paving Site
- Issues and Problems



2



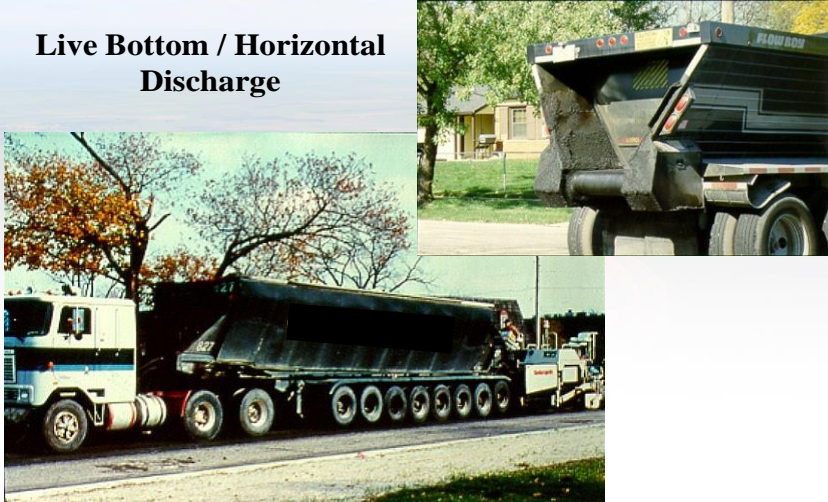
There are three primary types of trucks as shown.



The semi-circular curved shaped bed in the tri-axle dump truck stands up to impacts better than the flat floor. The force of asphalt mix at impact is deflected when it is dropped into the body as opposed to a flat floor that takes a direct impact. This design serves two purposes: 1) the minimization of segregation of the mixture due to larger particles rolling into the corners of the bed, and 2) the concentration of material into the center portion of the bed to assist guiding the material to the center of the paver and onto the slat conveyors.

Delivery Trucks

Live Bottom / Horizontal Discharge



5

This is not a PennDOT approved mix delivery vehicle.

Or, if you really need to haul a lot of mix...



6

Loading the Truck

Are we ready?





7

Trucks are here, but have they been inspected and prepared and ready to load?

Before Loading!

- Truck bed needs to be clean.
- Bed needs to be smooth and free of dents and depressions.
- The bed must be sprayed with a proper biodegradable release agent.

What about insulation?



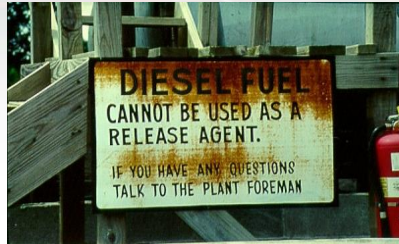


8

PennDOT Pub 408 Specs: 413 Construction, 3(d) Hauling Equipment: Provide insulation on all sides of the truck body, a double-walled truck body, or a heated truck body when the air temperature is below 10°C (50°F) from October 1 to April 30.

Truck Release Agent

- Allows mix to flow from truck bed to paver hopper
- Do not use diesel fuel – softens mix
- Use lime water mix or commercially available release agents



DIESEL SMELL FROM DELIVERY TRUCKS?

9

Apply an acceptable release agent: non-petroleum materials sprayed uniformly on the sides and bottom – just enough to coat the bed without runoff. What types of release agents have you used or witnessed??????????

Manual Application of Release Agent



10



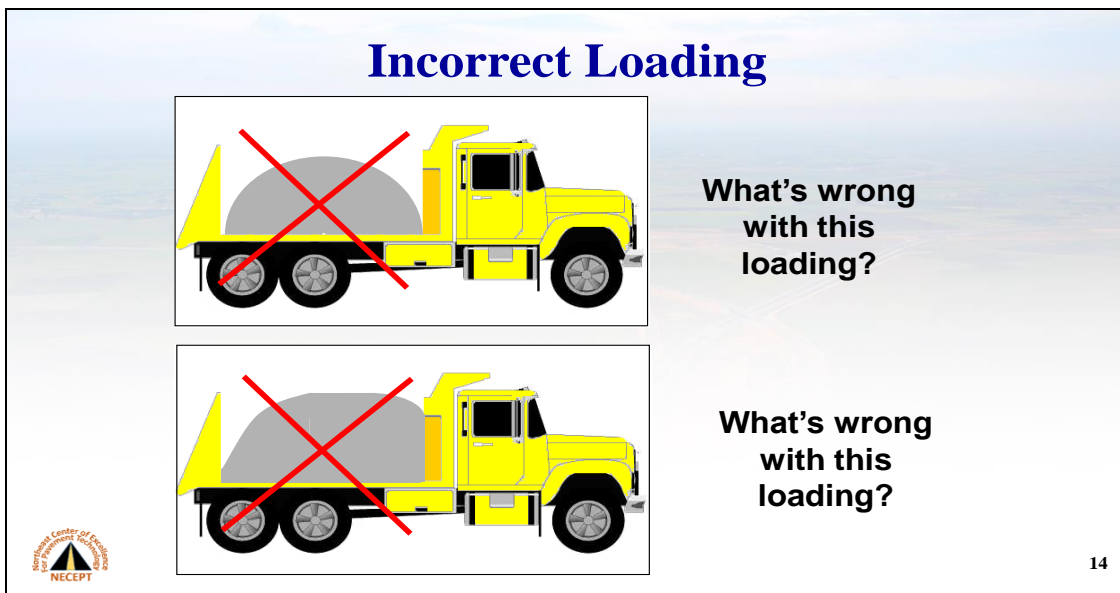
An automated system for applying the correct amount of release agent.



If excess material is applied, it **MUST** be drained. The outside of the truck should also be free of extraneous materials. Look for loose rock and dirt near the truck tail lights.

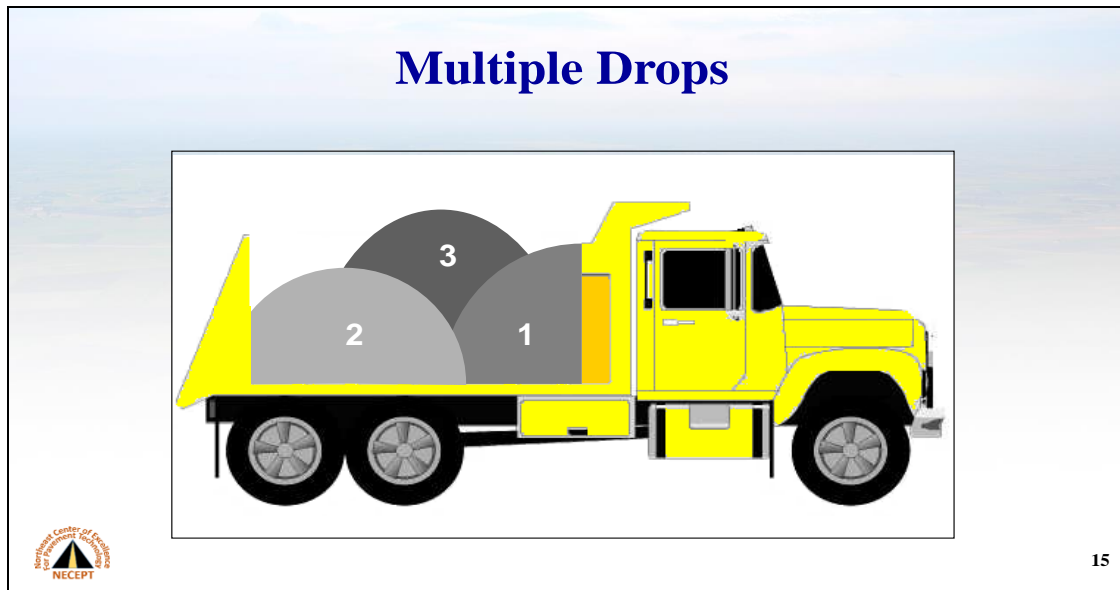


Discharging mix into the truck may seem to be fairly simple, but improper loading is a prime source for mix segregation. Correct loading procedures can help eliminate to segregation.



Single dumps to load trucks results in segregation. When the single dump is in the center of the truck bed, the material builds into a conical pile and the coarsest aggregate particles roll toward the front and the back of the truck bed. Truckload-to-truckload segregation is a combination of what comes out of one truckload last and the next truckload first.

Even a single dump to the front of the truck, although eliminating weight on the rear axles and reducing the distance that coarse aggregate can roll to the front, increases the distance that coarse aggregates can roll toward the tailgate and again results in segregation. Most of this truckload-to-truckload segregation will occur from what comes out of the truck bed first.



The objective of truck loading is to get the mix loaded into the truck as uniformly as possible. The greatest concern in uniformity is segregating the mix as it is loaded. Segregation can be minimized by moving the asphalt mix in a mass and by reducing the distance that the coarse aggregate can roll. Thus, segregation can be significantly minimized by dividing the loading of the asphalt mix into multiple drops, each delivered to a different section of the truck.

Getting the asphalt mix against the front and back is an important consideration in preventing segregation. If the mix is not crowded to the ends, the larger rocks in the mix can roll down the slopes and gather in one place. Especially for segregation-prone mixes, multiple drop procedures should be used. With multiple drops, end dump trucks are loaded at the front and rear of the bed, and then in the middle (usually 40% front, 40% rear, and then 20% center). This will be covered again under the segregation module.

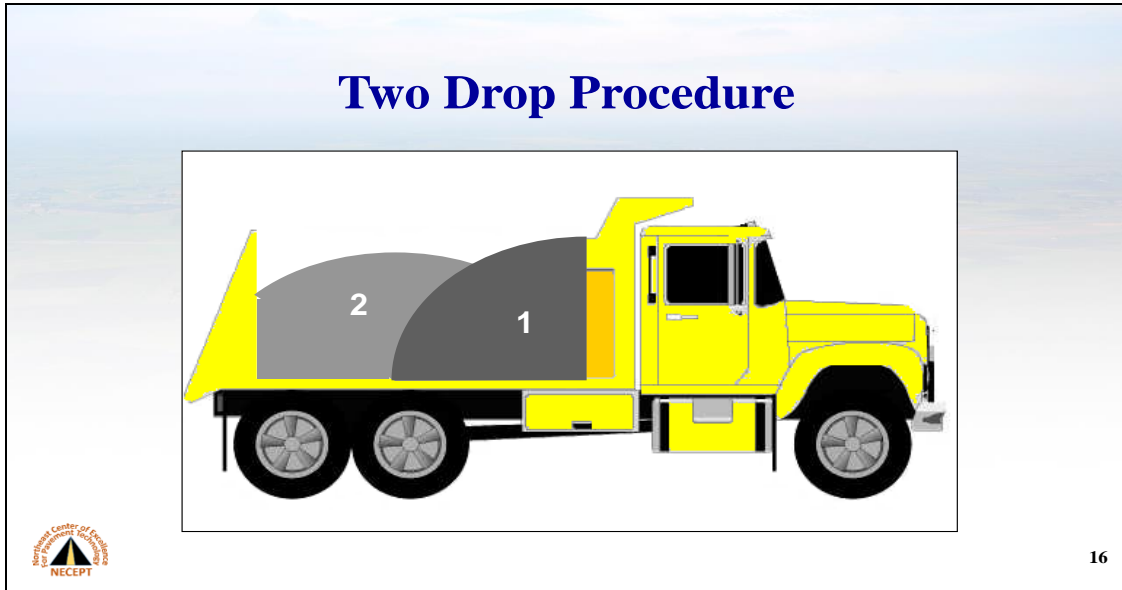
What are the normal complaints regarding multiple dumps?

Note: Semi-Trailer End Dump Trucks – 1st dump at front, 2nd dump at rear, 3rd dump in center, 4th dump between 1 & 3, 5th dump between 2 and 3.

Bottom Dump Trucks with single discharge gate – 1st dump directly over gate, 2nd dump between 1st dump and front wall of truck, 3rd dump between 1st dump and back wall of truck

Bottom dump Trucks with double discharge gate – 1st dump directly over front discharge gate, 2nd dump over rear discharge gate, 3rd dump between gate and back wall of truck, 4th dump between 1st dump and front wall of truck.

Live Bottom Trucks - 1st dump at back of bed as close to discharge gate as possible, 2nd dump at front of bed, remainder deposited as truck moves slowly forward.




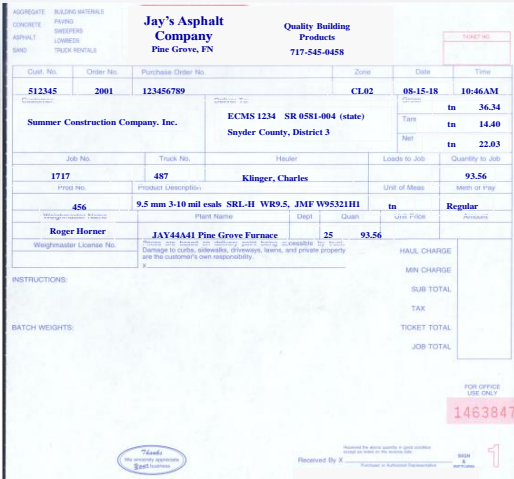
Depending on the size of the truck, a two-drop procedure may be appropriate. This might also work for pugmill loading, if two batches would fill the truck.




Documentation

Delivery Slip Pickup At Plant








18

Upon completion of the loading sequence, the driver obtains a delivery slip. The delivery slip is a very important document. It not only contains the name of the company, but also the type of mix, the loading temperature, etc.

Trucks Must Have Tarps

- Keep water/dust out of mix.
- Keep mix hot during delivery.
- Avoid thermal segregation and cold lumps.
- Keep tarped all the time.




19

Haul trucks must be equipped with tarps to protect the mix during inclement weather, maintain the heat to help prevent surface crust from forming during delivery. The tarps should be water-repellent, resist tearing, and not have any holes. Mechanically extendable tarps are preferred (to keep the driver off the side of the truck) as long as they extend over the entire load and totally cover the load. Photo depicts initial tarping of load at plant.



The tarp should cover the entire load and extend down over the sides of the truck body. Unless the tarp extends over the sides of the truck, airflow under the tarp will increase the rate of cooling of the mix, allowing water into the truck bed.

If there is water on the tarp when the truck is ready to discharge mix into the paver hopper, the water should first be removed by raising the bed of the truck and letting the water run off before the truck backs into the hopper. This should not be done on the pavement in front of the paver.



The truck slowly backs toward the paver as the paver continues to move forward. (Notice, the paver is folding its wings while continuing to move forward. This procedure need not be done every time there is a truck change.)

How often and when is your crew folding the wings?????????



The key is that the truck does not back into the paver and bump it. Bumping the paver can leave a screed mark and roughen the mat. Once the paver picks up the truck, it pushes the truck forward. A light touch on the brakes keep the truck against the paver. What should happen before the tailgate is released?



The truck brakes to a halt in front of paver, ready to be picked up on the fly. It is important that the truck be centered on the paver before contact is made to prevent damage to the mat and paver. The area between the truck and paver is off limits to personnel. Too many accidents occur in this area.




Get and check the weigh ticket before the mix is dumped into the paver. The Certified Field Technician or an individual so designated should get and check the delivery ticket to make sure it contains the right mix for the project. Several mixes may be on the jobsite, and it is important to get the right mix in the right location. It also is important to make sure the truck belongs on this project!!

Electronic Ticketing System (e-Ticketing) Active SSP (# c00062)

- Effective Date: 12/21/2020
- Report delivered material using electronic ticketing system

25



Electronic Ticketing System (e-Ticketing) Reporting Information

- ECMS Number or Purchase Order Number
- Plant Supplier Code
- Material Type/Class/Number
- JMF Number
- Date and Time Ticketed
- Unique Truck ID
- Mass (Weight), Gross, Tare, Net
- Running Daily Total in Tons of material being transported
- Name and license number of Licensed Public Weighmaster



26

Asphalt Temperature Check from Truck (POM April 2020 Edition, Change 1 (5/4/21))

- Check temperature from one of the 3/8" diameter holes drilled on each side of the truck bed before unloading.
- Use a calibrated dial or digital thermometer
- Take reading when the temperature stabilizes



27

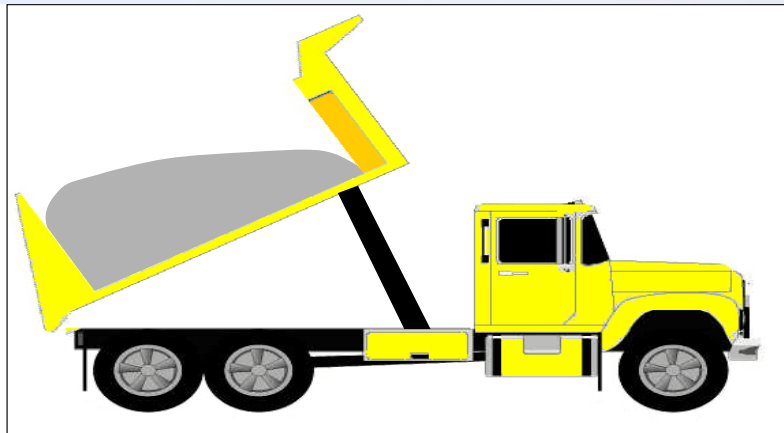
Asphalt Temperature Check from Truck

- **What if temperature cannot be taken because of truck bed liner?**
 - Do not allow the truck to unload.
 - Check the temperature of the next truck.
 - If within spec, then allow the truck with blocked truck bed holes to unload.
 - Notify the supplier's plant of the problem providing the truck number.



28

Break Load against Tailgate



29

With end dump trucks, the proper procedure for dumping the mix into the hopper is to raise the truck bed slightly and allow the mix to break and slide against the tailgate before it is released. This procedure will allow the mix to flood the hopper—not allowing mix to dribble from the truck into the hopper before the bed is raised. With live bottom trucks, try to use the same procedure to flood the hopper from the truck – on some trucks the belt or slat conveyor can be started a few seconds before the gate is open.



After the load is broken against the tailgate, the tailgate is released allowing the material to flood the hopper. After the hopper is filled, the truck bed is gradually raised, continually charging the hopper and maintaining a smooth operation.



In this photo the hopper wings are being folded as the truck leaves to help eliminate cold material build-up in the wings.

Best Hopper Use at Truck Exchange

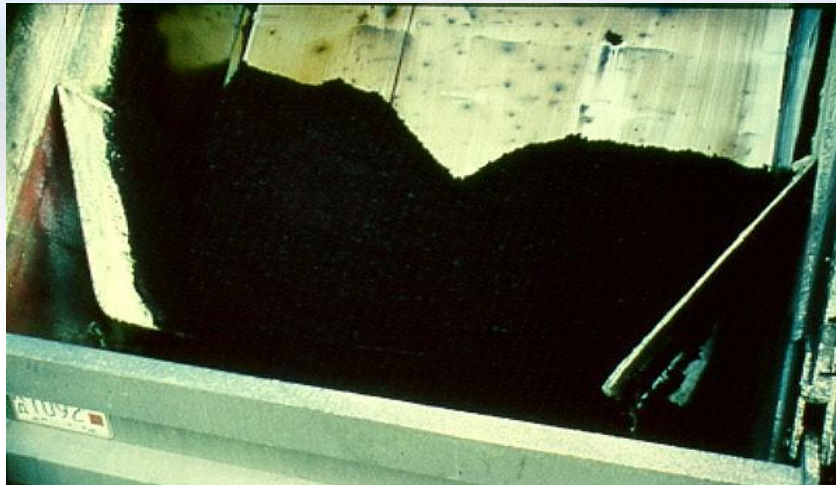
- Always keep hopper partially full.
- Never expose slat conveyors at the bottom of hopper.
- Rule of thumb - Fold wings frequently or not all until end of day clean out



32

Hopper

Baffles inside Tailgate



33

This truck has baffles just inside the tailgate in order to

- direct the mix to the middle of the hopper.
- force the mix from the truck's sides to the middle.
- ultimately, help reduce segregation.



As the truck empties the mix, the driver follows signals from the truck dumper to raise the bed and discharge all of the mix.

Once the truck is empty, the bed must be lowered before pulling away. Lowering the bed will allow the truck apron to clear the hopper guards.

Once the truck has cleared the paver, it should immediately depart from the area to a cleanup station and let the next truck back up. Cleanup locations should be designated to avoid having trucks pull from tack into dirt and back onto the tack.



This is NOT THE PLACE TO CLEAN OUT.



There should be a designated cleanup area for the drivers to clean any remaining mix from the rear of the truck, the apron, and the tailgate. The cleanup area is NOT ON THE ROADWAY. Modified asphalt can make this a more troublesome task. If the clean-out site is large enough, the trucks will not bunch up!!!!!!!!!!!!



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

Delivery to a Material Transfer Vehicle



38

Mix can also be dumped into a material transfer vehicle.

Feeding the MTV

- **Dumping procedures are critical at an MTV**
- **Segregation may occur with improper dump angle**
- **Dump apron can force hopper into roadway surface.**
- **Excessive dump rate can clog conveyor**



39

MTV Requirements

- **Covers to protect material**
- **Capable of continuous rate of transfer**
- **Equipped with remixing augers**
- **Hopper insert to provide mass flow to conveyor slats at paver.**



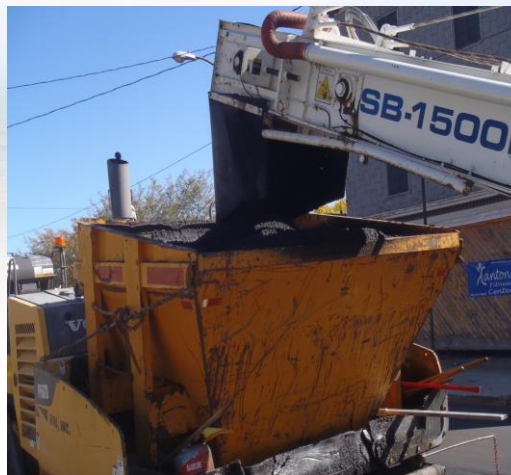
40

Some MTVs are a self-contained unit; others have the remixing chamber built into the hopper insert and the hydraulic power to operate the remixing augers is provided by the MTV unit. This operation necessitates two hoses connected from MTV to Paver and may limit maneuverability. DO NOT walk between ANY MTV unit and the paver. Operator visibility is very limited in this area.!!!!!!!

Paver Hopper Insert receives material from MTV

Drop height should be minimized

Hopper should always be at least 1/2 full

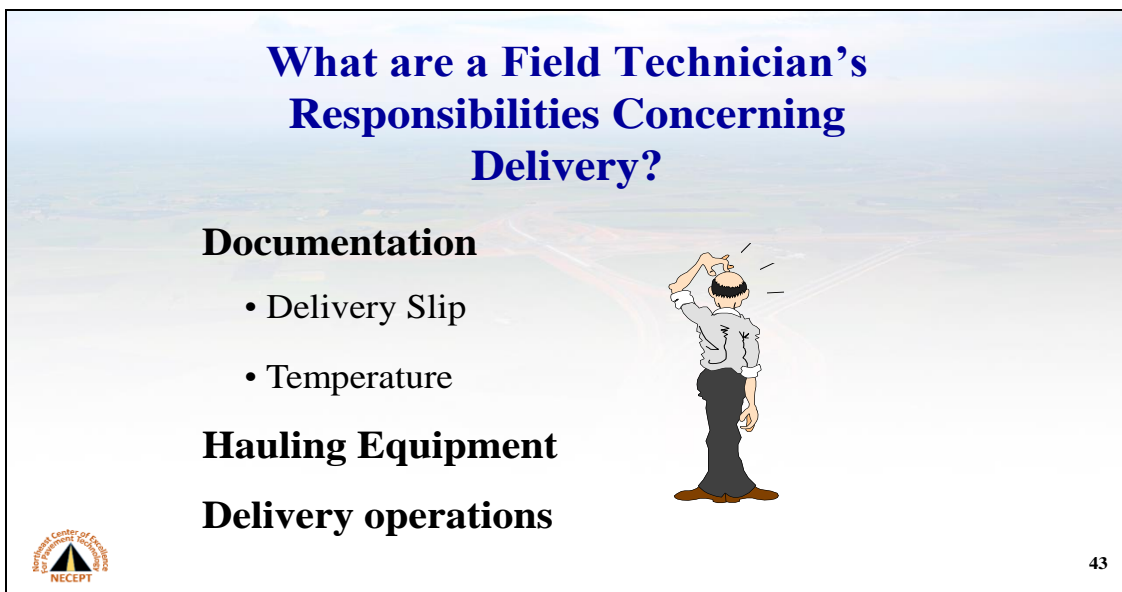


41

On the other end of the material transfer vehicle, a conveyor discharges the mix into the paver hopper, usually equipped with an oversized hopper insert to properly receive the mix. If a gap occurs in delivery, the MTV should be stopped without being completely emptied, so that a consistent minimum amount of mix is retained on the augers to mix with the new material delivered from the next haul truck. The paver should also be stopped with the hopper at least half full.



We will review responsibilities of the field technician, who may be representing the contractor or the agency, as related to delivery of the asphalt mixture. We will discuss the potential problems associated with the mix delivery and how a technician could identify those problems and what type of solutions exist as remedy to those problems. Sometimes, a technician may need to look into the delivery operation from start to finish to identify the source of the problem.





One of the first responsibilities in this area is documentation. The haul trucks also need to be examined along with the total delivery operations.

Documentation – Delivery Slip

**Watch the Video
On Delivery Tickets**

- Inspect/Collect Delivery Slips.
- Ensure that the proper mix at the proper temperature is being delivered.


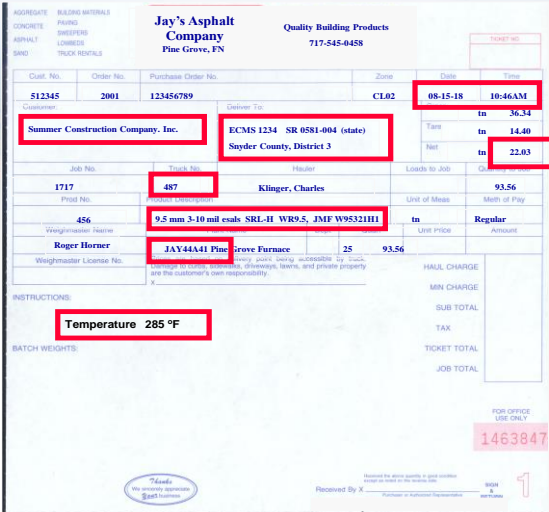
44

It is the trucker’s responsibility to make sure he receives a delivery slip before leaving the plant to ensure payment. At the job site the technician or designated individual will collect the delivery slip and check the mix type and temperature of the mix. The trucker gets an initialed copy, the Agency gets a copy and the technician gets a copy.

Documentation

Delivery Slip

- Contract No.
- SR, Section
- Supplier Code
- County/Dist.
- Material Type
- JMF No.
- Date/Time
- Tons of Matl.
- Truck No.
- Temperature (if plant temp taken)

45

The delivery slip is used to identify the contract number, the state route and section, the supplier, county and District, the type of material, the JMF, date and time, tons of mix on the truck, truck number, and the temperature of the mix when the plant technician takes a reading. Check the ticket to make sure it contains the right mix for the job, and that the truck is on the correct project. Several mixes may be on the jobsite, and it is important to get the right mix in the right location.

Documentation - Temperature

Technician's Responsibility

- Check Temperature SAFELY




46

It is the technician's or his designated representative's responsibility to check the delivery temperature. This will be performed as stated in the Quality Control Plan. Usually, it is the first three trucks and then every fifth one. The area where trucks are dumping into the MTV or Paver is VERY dangerous. Infrared (non-contact) thermometers are notoriously unreliable at the tailgate. Checking temperature through the truck body may or may not be an option.


Where do YOU check the temperature??

Documentation –Delivery Temperature

Mix Temperature shall not be outside the range given in Section 413, Table A

Temperature of Mixture (F)				
Class of Material	Type of Material	Chemical, Organic, Foaming Additives, Minimum	Mechanical Foaming Equip/Process Minimum*	Maximum*
PG 58S-28	Asphalt Binder	215	230	310
PG 64S-22	Asphalt Binder	220	240	320
PG 64E-22	Asphalt Binder	240	260	330
All other binders	Asphalt Binder	The higher of 215 or the minimum temp. specified in Bulletin 25 minus 45F	The higher of 230 or the minimum temp. specified in Bulletin 25 minus 30F	As specified in Bulletin 25

* Outline in the Producer QC Plan and follow more restrictive temperature requirements provided by the WMA technology manufacturer or Technical Representative(s) for production and placement of the mixture. Determine the SGC compaction temperature for the production QC which yields the same target air voids as the designed JMF. Include the SGC compaction temperature in the Producer QC Plan. Compact the completed mixture in the SGC for QC volumetric analysis at the SGC compaction temperature according to the guidelines provided by the Technical Representative.



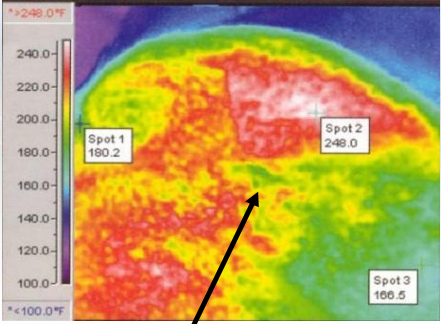
47

The mixture delivery temperatures as given in the specifications.
 Compare plant temperatures with delivery temperatures; sometimes, the mix temperature raises on the truck as it picks up more heat??


Delivery

Problems

- Crusting
- Temperature Variability
- Lumps In Mix



Temperature Difference **> 60°F**
 This is a large temperature difference with potential to cause thermally-induced mix segregation



48



If the truck is poorly tarped and the mix is hauled long distances, the hot or warm asphalt material will cool and develop a crust on the top or sides. The crust serves as an insulating layer for the rest of the mix and reduces the rate of cooling for the remaining material. Thus, within limits, crust formation can be beneficial. The crust, however, must be completely broken down before reaching the paver.

Delivery Temperature Issues

Causes

- Not Enough Trucks
- Delays At Plant
- Poor Scheduling
- Tarp which does not completely cover the load or has holes in it.

Where are the trucks?



49

Other reasons???????

Trucks

Solutions

- Use Enough Trucks
- Minimize Delays
- Use Proper Tarp

50

Asphalt mixtures in a mass on the truck will maintain a reasonable temperature for several hours depending on the efficiency of insulation in the truck. As long as chunks of asphalt mix are not generated to affect the quality of the mat behind the paver, the crust should not be detrimental to the long-term performance of the mix. If chunks of mix are seen behind the screed, remove them, DO NOT broadcast material to hide them. Changes need to be made in the mix production temperature, the amount of insulation on the truck bed, the covering of the load with the tarp, the paving schedule, or any combination of these factors to fix the problem.

Hauling Equipment

Specifications say


- Tightly sealed vehicle
- Free of petroleum oils, solvents, or other materials that affect the mix
- Adequate covers
- Deliver material at correct laydown temperature
- Insulated (or heated) if needed.




51

The hauling equipment must meet the specification requirements. The technician should be aware of the requirements and, if problems are present, necessary steps must be taken to resolve the issue.

Mechanically unsound condition and leaking hydraulic fluids or diesel or diesel fuel will lead to premature failures.



52




Trucks must be in a mechanically sound condition. Items to maintain include engine, drive train, hydraulic system, brakes, and lights. Hydraulics and brake lines must be checked **daily**. The truck’s hydraulics system raises and lowers the truck bed and problems with this system are dangerous and may impact the asphalt mix quality. The hydraulic fluid comes from the same barrel of oil as the asphalt (i.e., both originate from the crude oil), and as such will dissolve the asphalt from the aggregate and lead to a premature maintenance problem.

Hydraulic oil leak may only be visible when pressure is applied to raise the load. The effect on the mix will be evidenced two or three years later in the form of small circular failures in the top layer of the pavement. A few of them may be concentrated in a 150-200 sq. ft. area.


Trucks

Solution

Inspect Daily and Correct Any Mechanical Deficiencies



53





It is the Certified Asphalt Field Technician's responsibility to make sure that the trucks are in good condition for dumping and to be alert for hydraulic fluid leaks and any detrimental materials that may be deposited on the highway.

Truck Bed

Problems

- Dent or Damaged
- Wrong or excessive truck release agent
- Unclean Bed





54

Be SAFE when checking the bed condition of an empty truck at the paver or MTV hopper after unloading!!!

Truck Bed

Solutions

- Smooth, Clean Truck Beds
- Proper Release Agent






55

The solution is to prepare a smooth, clean truck bed with the use of proper release agents.

Trucks

Problem?



Result of
“banging”
truck body!

Solution!

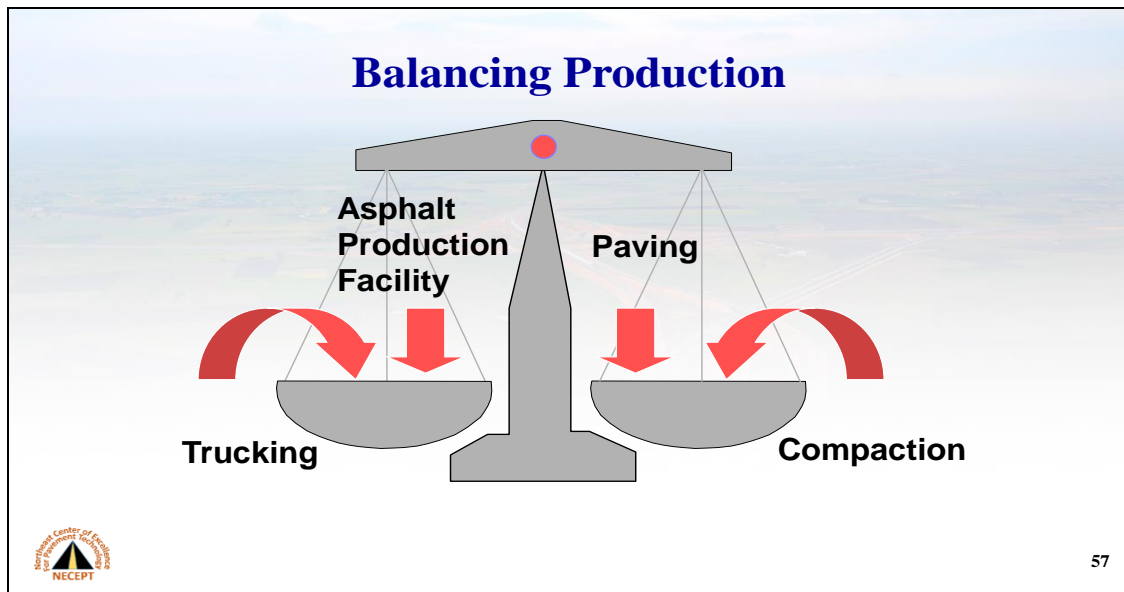


Make the trucker
shovel the mix off
the road!!!!!!!!!!



56


Dumping the asphalt mix on the mat is another problem that can occur on the project. The truck box needs to be lowered before pulling out of the hopper to avoid having the tailgate drag the asphalt mix onto the mat which will then be driven over by MTV or Paver. Trucks must clean out at designated areas, NOT on the roadway.



This may not be the technician’s responsibility; however, it is something that should be known by the technician. Paving is a constant balancing act. Mix production and delivery must be balanced with laydown and compaction to ensure a smooth operation and a high-quality mat. Remember, the purpose of the haul vehicle is to transport the asphalt mixture from the asphalt plant to the paver without delay and with minimal change in the characteristics of the mix during the delivery process and without segregation.

Scheduling Problem

How do you determine the number of trucks needed to balance production rates?



58

Average Truck Capacity (SIZE): 20 net tons

Total Truck Trips Needed (TRIPS):
 = MIX ÷ SIZE = 1800 ÷ 20 = 90 trips = TRIPS

Truck Cycle (in minutes):

Delay at Facility	: <u>8</u>
Load Time	: <u>5</u>
Ticket & Tarp	: <u>3</u>
Haul to Job	: <u>15</u>
Delay on site	: <u>7</u>
Dump/clean up	: <u>7</u>
Return Haul	: <u>15</u>


=====

Total cycle in minutes = 60 + 60 min/hr
 = **Truck Cycle (CYCLE):** 1 hours/trip

Number of Trips per Truck (LOADS):
 = TIME ÷ CYCLE
 = 10 ÷ 1 = (Round down) 10 trips/truck = LOADS

Number of Trucks Needed (TRUCKS):
 = TRIPS ÷ LOADS
 = 90 ÷ 10 = (Round up) 9 total trucks = TRUCKS

Is TRUCKS x LOADS ≥ TRIPS? (9) x (10) = (90) ≥ (90)




59


Use the Mix Delivery Production Calculation Form

Extenuating Circumstances

**What kind of situations
have you experienced?**

What about rain?




60

Can you think of any other extenuating circumstances that can cause a disruption in the delivery process thereby disrupting the continuity of the paving project? What do you do when it rains? How do you prepare for the possibility of rain ? What about the tack coat?

Will this new pavement last?




61

Judgment is required when rain occurs during paving. If the existing pavement surface contains puddles of water, placement of the asphalt should not be continued.

Paved During Rain Yesterday!



A close-up photograph showing a person's hands and feet as they inspect a large, deep crack in a newly paved asphalt surface. The crack runs horizontally across the frame, with a significant gap where the asphalt has broken apart. The surrounding pavement appears wet and dark.



62

General Safety Issues



Watch for Overhead Wires!



- Safety
- Cleanup



63

Safety is THE top priority concern. Keep the site clean and traffic controlled.

Raised Beds Can Cause Problems



They could use these guys!



Module 5 - Review of Objectives

We discussed

- Types of Trucks
- Loading the Truck
- Delivery to the Site
- Unloading at the Paving Site
- Issues and Problems



66



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Discussion



pennsylvania
DEPARTMENT OF TRANSPORTATION



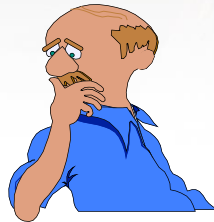
67

Quiz

Module 5

Delivery

?



1. Trucks used to haul asphalt mixes are special trucks that should not be used for any other purpose.

- a. True
- b. False

Answer:

2. An improved truck design that is now being used to haul asphalt mixes features a semi-circular shaped bed.

- a. True**
- b. False**

Answer:

3. Tarps are not required on clear sunny days.

- a. True**
- b. False**

Answer:

4. Fuel oil is an excellent truck release agent that is recommended by the Department.

- a. True
- b. False

Answer:



5. How the truck is loaded at the plant may cause segregation in the mat.

- a. True
- b. False

Answer:



6. Information included on a delivery slip includes

- a. Supplier Code
- b. SRL
- c. Design ESALs
- d. All of the above

Answer:



7. When backing into the paver, the truck driver should back in until he hits the push rollers on the paver.

- a. True
- b. False

Answer:



8. When the air temperature is below 50°F from October 1 to April 30, haul trucks should be insulated or have a double-walled body, or have a heated truck body.

- a. True
- b. False

Answer:



9. Poorly maintained trucks with hydraulic leaks can lead to pavement maintenance problems.

- a. True
- b. False

Answer:



10. Before loading, truck beds should be

- a. Clean**
- b. Smooth and free of dents and depressions**
- c. Sprayed with proper release agent and properly drained**
- d. All of the above**

Answer:

AGGREGATE BUILDING MATERIALS
 CONCRETE PAVING
 ASPHALT SWEEPERS
 SAND LOWBEDS TRUCK RENTALS

Jay's Asphalt Company

Pine Grove, EN

Quality Building Products

717-545-0458

TICKET NO.

Cust. No.	Order No.	Purchase Order No.	Zone	Date	Time
512345	2001	123456789	CL02	08-15-02	10:46
Customer:		Deliver To:		Gross	tn 36.34
Summer Construction Company, Inc.		SR 0581 (004) state		Tare	tn 14.40
				Net	tn 22.03
Job No.	Truck No.	Hauler		Loads to Job	Quantity to Job
1717	487	Klinger, Charles			93.56
Prod No.	Product Description			Unit of Meas	Moeth of Pay
456	9.5mm 3-10 million esals SRL H SP 9.5)			tn	Regular
Weighmaster Name	Plant Name	Dept	Quan	Unit Price	Amount
Roger Horner	Pine Grove Furnace				
Weighmaster License No.	Prices are based on delivery point being accessible by truck. Damage to curbs, sidewalks, driveways, lawns, and private property are the customer's own responsibility.			HAUL CHARGE	
	X _____			MIN CHARGE	

INSTRUCTIONS:

BATCH WEIGHTS:

HAUL CHARGE
 MIN CHARGE
 SUB TOTAL
 TAX
 TICKET TOTAL
 JOB TOTAL

FOR OFFICE USE ONLY

1463847



Received the above quantity in good condition except as noted on the reverse side.

Received By X _____
 Purchaser or Authorized Representative

SIGN & RETURN

1

MIX DELIVERY PRODUCTION CALCULATION FORM:**(U.S. Units)**

Date: _____ Project #: _____

Project: _____

Tons scheduled to be placed today (MIX): _____ tons

Hours of paving scheduled (TIME): _____ hours

Rate of mix needed to be delivered to jobsite (H-RATE):

$$= \text{MIX} \div \text{TIME} = \underline{\hspace{2cm}} \div \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ tph}$$

Rate of mix available from HMA facility (F-RATE): = _____ tph

STOP: Is the H-RATE slightly greater than or equal to the F-RATE?

Average Truck Capacity (SIZE): _____ net tons

Total Truck Trips Needed (TRIPS):

$$= \text{MIX} \div \text{SIZE} = \underline{\hspace{2cm}} \div \underline{\hspace{2cm}} = \underline{\hspace{2cm}} \text{ trips} = \text{TRIPS}$$

Truck Cycle (in minutes):

Delay at Facility : _____

Load Time : _____

Ticket & Tarp : _____

Haul to Job : _____

Delay on site : _____

Dump/clean up : _____

Return Haul : _____

=====

Total cycle in minutes = _____ \div 60 min/hr

= Truck Cycle (CYCLE): _____ hours/trip

Number of Trips per Truck (LOADS):

$$= \text{TIME} \div \text{CYCLE}$$

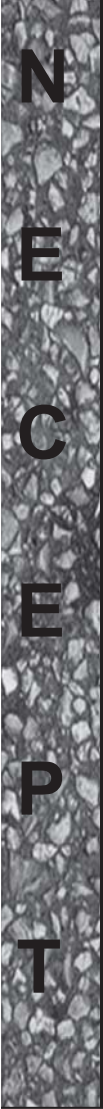
$$= \underline{\hspace{2cm}} \div \underline{\hspace{2cm}} = \text{(Round down)} \underline{\hspace{2cm}} \text{ trips/truck} = \text{LOADS}$$

Number of Trucks Needed (TRUCKS):

$$= \text{TRIPS} \div \text{LOADS}$$

$$= \underline{\hspace{2cm}} \div \underline{\hspace{2cm}} = \text{(Round up)} \underline{\hspace{2cm}} \text{ total trucks} = \text{TRUCKS}$$

Is TRUCKS x LOADS \geq TRIPS? () x () = () \geq ()



HMA Pavement Construction Program

Certified Asphalt Field Technician
Course of 2022

Module 6: Asphalt Mixture Placement



Asphalt Construction Program

Certified Asphalt Field Technician - 2022

Module 6: Asphalt Mixture Placement






1

In this module, we will discuss the placement of the Asphalt Mixture on the prepared base using an asphalt paver.

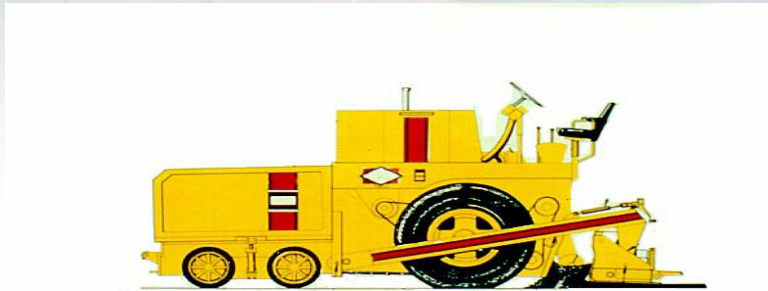
Module 6 – Objectives

- **Asphalt Paver**
 - Components & Function
 - Grade & Slope Control Systems
- **Operating Techniques**
 - Initial Paver Preparation
 - Operational Principles of
Screed
 - Paver Operation
- **Paving Issues &
Problems**




2

- **Two Components:**
 - Tractor Unit: supplies all power
 - Screed Unit: simply pulled behind paver

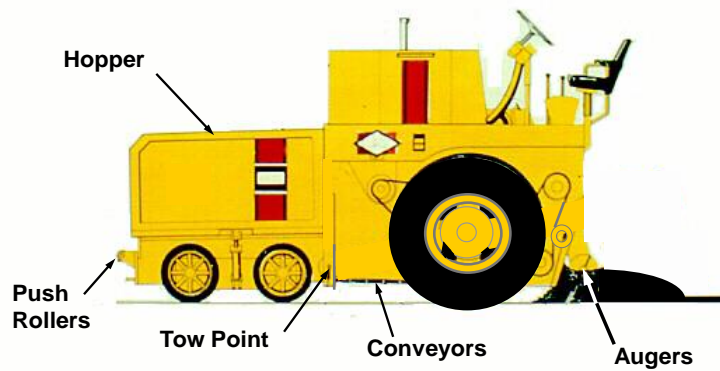


3

The Paver is the primary piece of equipment on any paving project and its main function is to transfer the material from the truck to the pavement surface and place the asphalt material at the required width, thickness, and cross-slope, while producing a satisfactory mat texture.

Tractor

- **Provides power**
- **Carries mix from hopper to screed.**




4

The tractor unit provides all of the power for the paver and delivers the mix to the screed unit.

Tractor Unit Components

- **Paver Controls**
- **Drive Systems**
- **Push Rollers and Truck Hitches**
- **Material Feed System**
 - Hopper
 - Slat Conveyer
 - Conveyer Flow Gates
 - Augers
- **Tow Points**



5

Paver Operation Controls






Electronic system PLC (Programmable Logic Control)

The PLC system regulates and monitors operational functions of the tracked paver. Besides that other features are:

- Easy to read instrument panel
- User friendly controls
- Display indicating electrical faults together with the type and location of fault.
- Monitoring of cooling liquids and grease oil
- Collection of paving distance
- Reading of operation- and paving hours.

Courtesy of Dynapac USA, Inc.



6

Many new pavers are equipped with programmable control systems to regulate and monitor all operational functions of the unit, and record paving data (operation hours, paving hours, paving distance, etc.)

Paver Drive Systems



Rubber Tired Paver



Track Paver

- **Rubber tired pavers**
 - moved more readily
 - faster paving speeds
- **Track pavers**
 - spread weight over larger area, better on soft base
 - more effective on paving grades.
 - More maneuverability


7

The tractor engine provides hydraulic and mobile power to the tires or tracks. Tires may be ballasted with a calcium chloride solution to increase traction. The tracks can be all steel, steel with rubber pads, or flexible bands with steel shoes and rubber pads.

Front Wheel Assist Increases tractive power




8

Many rubber tire pavers also include a front wheel assist option, WOW--- 6-wheel Drive.

Push Rollers & Truck Hitches



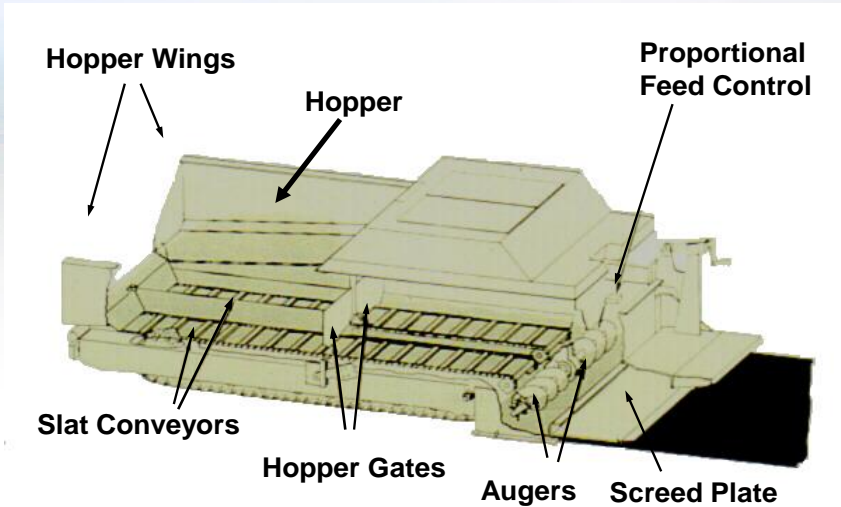

- Truck rests against push rollers, paver pushes truck
- Kept clean and free to rotate while pushing
- Truck hitches maintain contact with paver



9

On the front of the paver are the rollers for pushing the truck, and the hitches to prevent the truck from drifting out of the hopper. Hitches are to be released before allowing truck to leave the area!!!!!!!!!!


Material Feed System Components


10

The goal of the material feed system is to get a constant head of material in front of the screed. If the material feed system is operating properly, the slat conveyors and augers will rarely shut off. This is accomplished by setting the proper position on the hopper flow gates and using the correct speed on the slat conveyors and augers. If the conveyors and augers are at constant speed (only on or off), the flow gate settings control the flow. For variable speed augers and conveyors, material flow is controlled by all three.


Hopper



Hopper receives mix from truck to feed conveyors



Flashing Or Overflow Guards



11

The hopper must be wide enough to allow the bed of the truck to fit inside and low enough to allow the truck bed to be raised without placing weight on the front of the hopper. Flashing or overflow guards on the front of the hopper keep mix from spilling onto the pavement. The flaps are a thick, flexible rubber or polymer and must be replaced when damaged or worn. Folding the hopper wings of the paver should be avoided when the hopper is nearly empty, and the slat conveyors are exposed.

This needs to be cleaned up!!!



12

This should clean easily, NO TACK!!!!!!!

Hopper Options



Courtesy of Dynapac USA, Inc.

Independently operated
hopper wings

Hydraulically operated
hopper front flaps



Courtesy of Dynapac USA, Inc.



13

Options available include independently operated hopper wings and hydraulically operated front hopper flaps.

Slat Conveyers

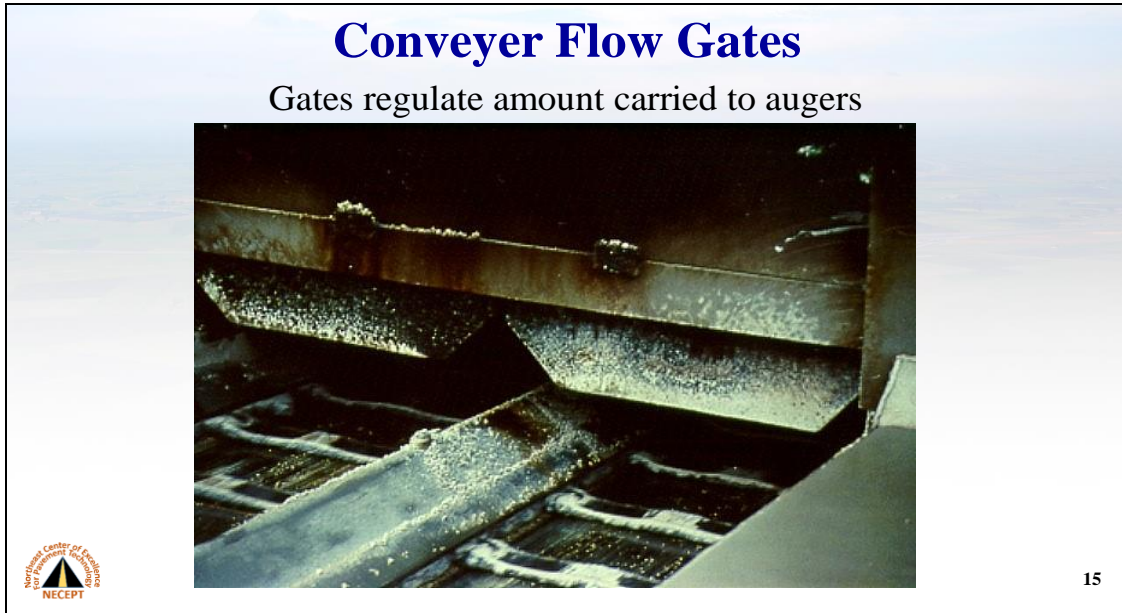
Conveyors move independently



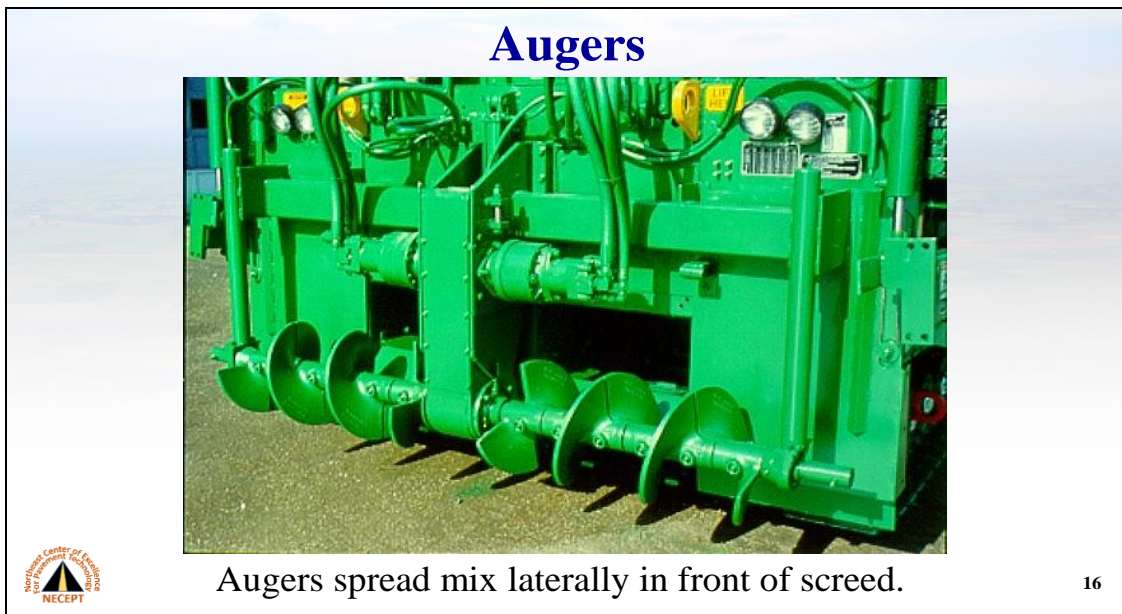


14

At the bottom of the hopper are slat conveyors. They transport the mix from the hopper back through the tunnel in the tractor unit to the augers, each of them feeding one side of the screed.



Above the slat conveyors at the back wall of the hopper are the adjustable flow gates which regulate the amount of mix carried to the augers. The goal is to have the flow gates set during the paving operation so that the slat conveyors keep running continuously. On some pavers, a sensor is located behind the flow gates to monitor the amount of mix passing into the tunnel and alert the operator of a low material flow or no flow condition. One paver manufacturer has replaced the slat conveyors with auger screws running from the hopper back to the screw augers.



The augers operate independently of each other, and the optimum depth of material is best controlled by a sensor at each end plate. Note that there are no kickback paddles installed on these augers.

Kick Back Auger Paddles



17

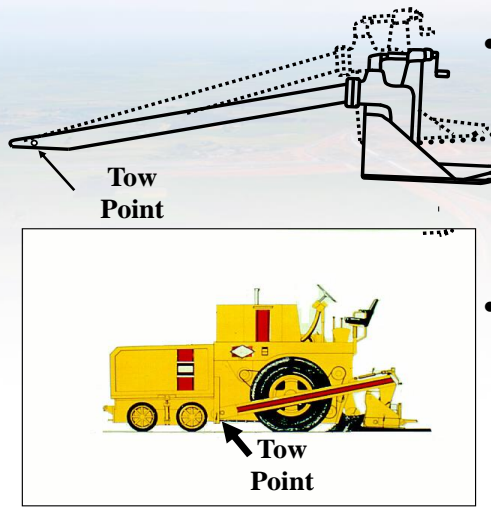
Material Feed System

- **Goal:**
 - Provide constant head of uniform and unsegregated material in front of screed
- **Approach:**
 - Provide sufficient supply of material with proper position on flow gates and correct conveyor and auger speed
- **Controlling Factors:**
 - Speed of the paver
 - Depth and width of mat




18

Tow Points



- Pin connection where screed is attached to tractor unit.
- Screed pivots around tow point.



19

The screed is merely towed behind the tractor, “free floating”

Hydraulically Operated Tow Point

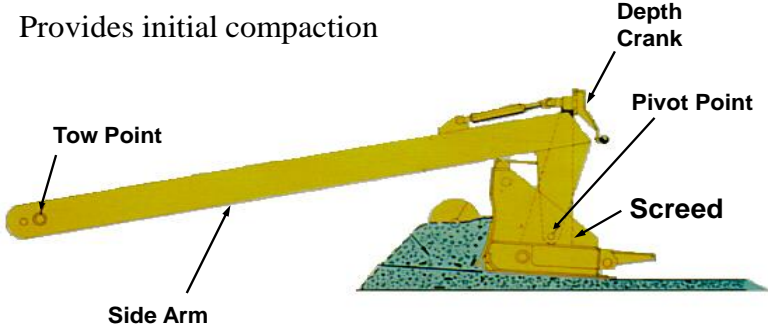



20

The tow points can be hydraulically raised or lowered as necessary and are usually connected to an automatic grade and slope control system. The position of the tow point can affect screed performance, mat appearance, and pavement life.

Screed

- Establishes thickness
- Provides initial texture
- Provides initial compaction



The diagram shows a yellow screed unit. A long horizontal bar, labeled 'Side Arm', is attached to a vertical assembly. The vertical assembly includes a 'Depth Crank' at the top, a 'Pivot Point' below it, and the 'Screed' plate at the bottom. A 'Tow Point' is located at the left end of the side arm. The entire unit is shown resting on a textured surface representing asphalt.


21

The second component of the paver is the screed unit which is towed by the tractor and controls the thickness, initial density, and smoothness of the mat.

Screed Unit

- Screed plate
- Strike-off
- Crown control
- Screed Vibrator
- Screed Heater
- Thickness Control Screws

- Screed Arm
- Extensions & end plates
- Electronic Controls

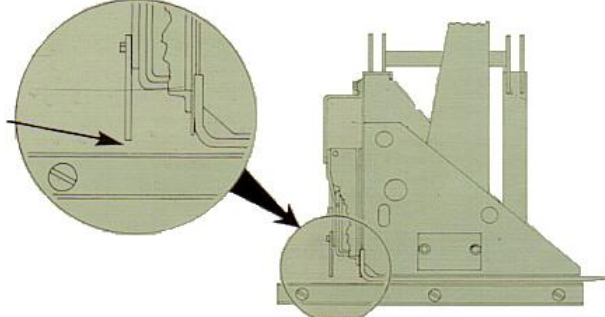


The photograph shows a yellow screed unit mounted on a paver. It features a long horizontal arm with various mechanical components, including what appears to be a strike-off bar and control mechanisms. The unit is positioned over a dark surface, likely the asphalt mat being laid.

22

Strike-off

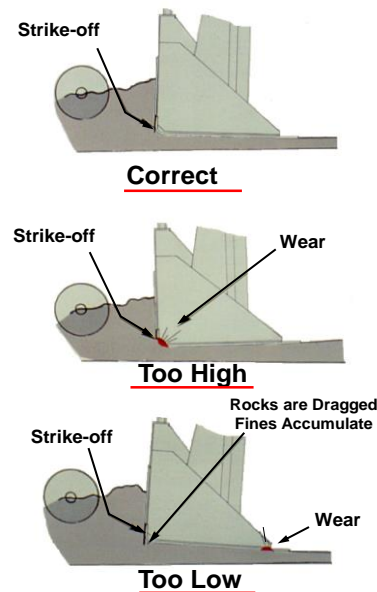
- Strike-off should be set at the proper height as per manufacturers recommendation.



23

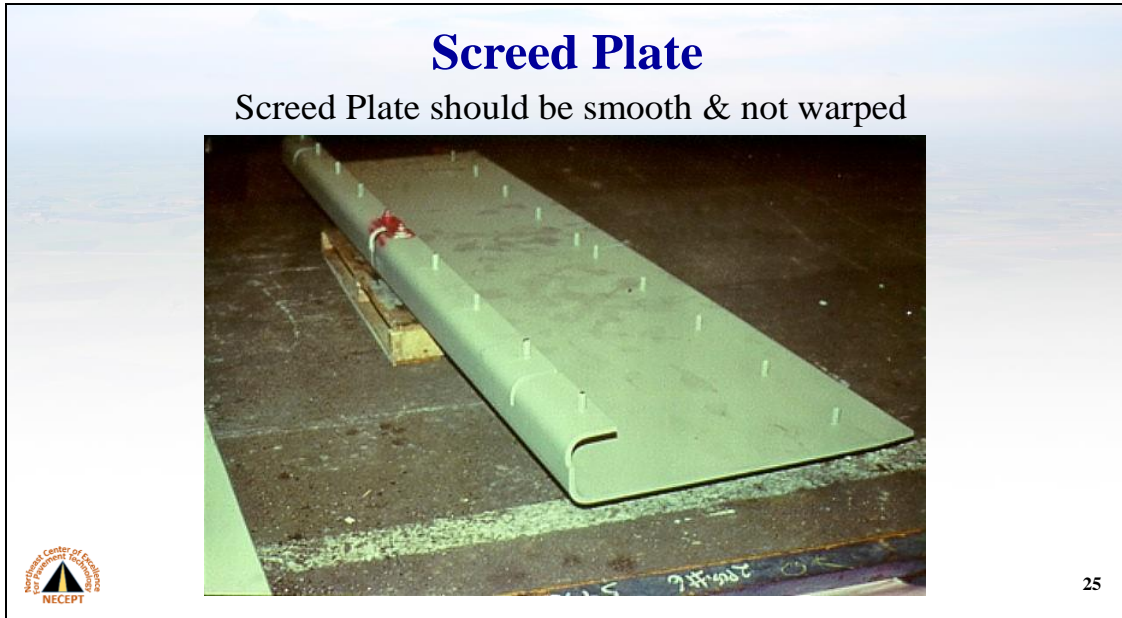
Typically, a strike-off (or pre-strike-off) plate is mounted in front of the leading edge of the screed to regulate the amount of mix fed under the screed. This plate also reduces wear to the leading edge of the screed.

Strike-off Set Incorrectly Affects Screed Performance

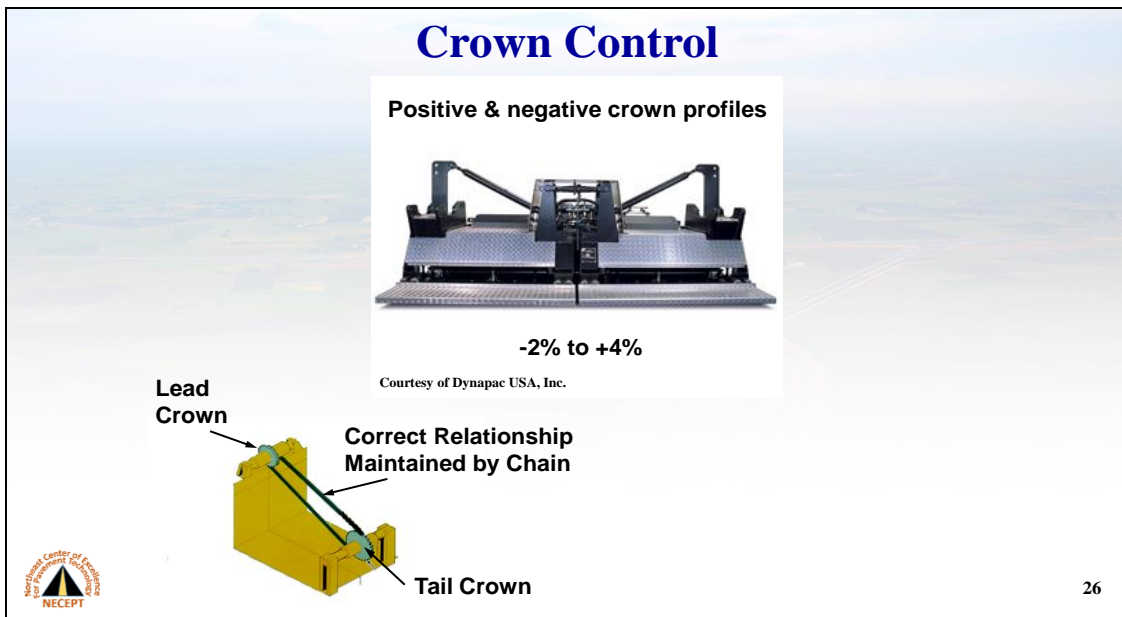


24

If the strike-off is too high, too much material is fed under the screed, causing it to rise. The screed would have to be pivoted forward around the tow point to compensate, causing high nose plate wear. If the strike-off is too low, too little material goes under the screed. The screed would have to be pivoted backward, causing high tail wear. Correct setting is needed for a quality mat appearance and maximum density.

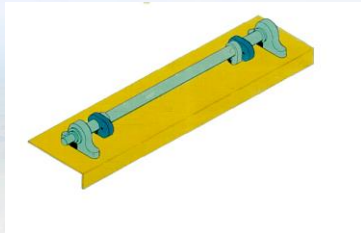


The screed plate is bolted to the bottom of the screed and works much like a hot iron to smooth out the surface of the mat and creates the initial texture and density of the mat. The cut at the center of the nose of the screed allows the plate to be flexed to form a crown in the mat.




The screed plate can be flexed at its center to provide a variable amount of positive or negative crown to the mat. A turnbuckle device is used to obtain the desired profile. *Lead crown* is the relationship between the front and rear edge of the screed and should be adjusted according to the manufacturer’s specifications.

Screed Vibrators




Vibratory Shaft with Weights



Controls to adjust tamper and vibration frequencies

- Initial compaction
- Vibration created with rotating shaft that contains eccentric weights.
- Compaction controlled by speed of rotation and position of weights.
- Frequency usually set at maximum.


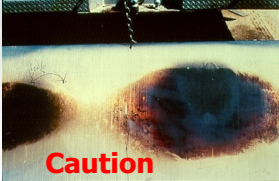


Courtesy of Dynapac USA, Inc.

27


Screed vibrators provide initial compaction of the mix as it passes under the screed. The position of the weight (if changeable) is more eccentricity for thicker lifts. Typically, initial compaction = 70 to 85% of maximum density. Some new screeds are now being outfitted with both vibrators and vibrating tamper bars with controls to adjust frequencies for both.

Screed Heaters





Caution
Overheating can damage screed plate

- Heat cold screed to about 300 °F prior to paving.
- Provides a more uniform surface texture.
- Prevents mix from sticking to screed plate.



Courtesy of Dynapac USA, Inc.



Propane or electric heating with automatic temperature controls available


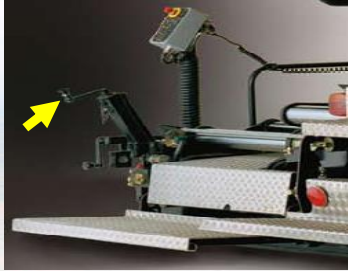
28

Screed heaters cannot be used to raise the heat of the mix. (The mix is not under the screed long enough.)

Don't overheat or let the heaters on too long, you can damage the screed plate.

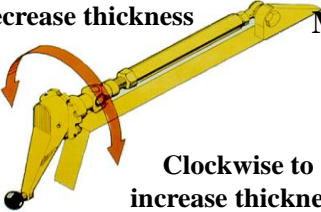
Newer pavers have automatic controls which maintain a constant screed temperature throughout the paving operation.

Thickness Control Screw


Courtesy of Dynapac USA, Inc.

Counter clockwise to
decrease thickness



MAYBE

Clockwise to
increase thickness


29

The thickness control screws rotate the screed about its pivot point. The rotation changes the screed's *angle of attack*; as the *angle of attack* changes, the screed rises or falls to balance the forces acting on the screed, thereby changing the mat thickness

Lower picture may not hold true for all manufacturers. Many paving teams use the hydraulic controls on the toe-point to control depth, which may result in a smoother ride. The correct usage of either system is--- NO MORE THAN NECESSARY!!!!!!!!!!!!

Fixed Screed Extension Manual- bolt on




30

The basic width of the screed (8 to 10 ft.) can be increased with rigid screed extensions. It is important that the extensions be set at the same elevation and angle of attack as the main screed and should be added to both sides equally to keep the dynamic load balanced. Auger and auger tunnel extensions should also be added when using rigid extensions, along with a strike-off extension assembly.

Screed Extension - Hydraulic



Extensions are to be fed and activated with the same method as main screed



31

Hydraulic extensions can be used to create changes in slope (shoulders). Hydraulic extensions may be in front of or behind the main screed. It is important that the extendable portion of the screed is set at the same angle of attack and aligned with the main screed to prevent a longitudinal line or a difference in mat surface texture between the main screed and extension may occur. Strike-off assemblies and auger and tunnel extensions should also be utilized with any screed extension.

Hydraulic Screed Extensions with remote control units



Courtesy of Dynapac USA, Inc.



32

In this model, both the left and right extension parts of the screed are equipped with remote control units for control functions like extending, screed leveling and auger-turning direction. In addition, to produce an even homogeneous surface, grade and slope controllers are being used to check the position of the screed to a default reference.

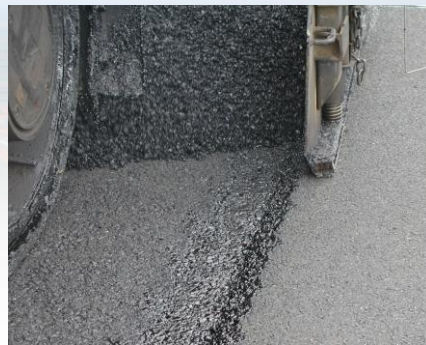
Remote Control for Visibility and Safety



33

Screed End Plates

Attached to end of screed to keep mix contained.





- Held tightly to existing surface to retain mix and control width of spread.



34

Some end plates are spring loaded to exert down pressure, others merely drag, and some are controlled by screw type height adjustment and are virtually rigid.

FHWA Safety Edge Device



35



End Plate for Safety Wedge

**Is this a
Notched Wedge
Joint?**



Notched Wedge Joint



36


Various shaped edge plates are also available to form a required edge profile. One example is *Notched Wedge Joints (NWJ)* which will be covered in Module 7.



Safety Edge

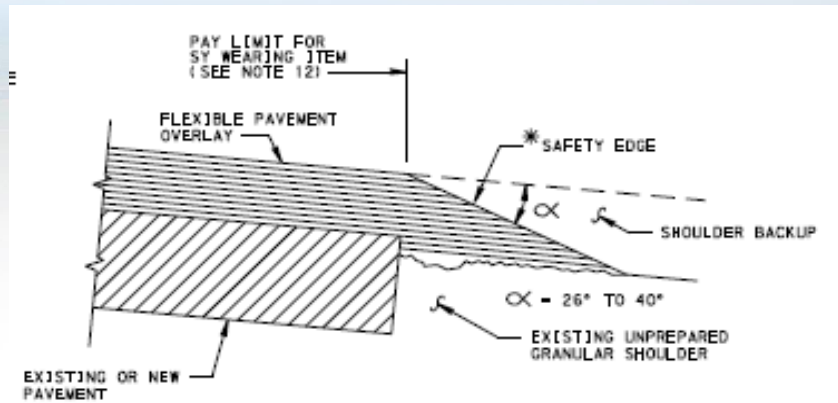
Pavement Design Manual (Pub 13M, Chap. 12.13)

- Safety Edge formed during paving
- 30° taper at the edge of the pavement (with 26° to 40° construction tolerance)
- Device to constrain material and increase density
- Single plate strike-off is not allowed.
- Applied to both wearing and binder courses with depth of 1.5 inches or greater.
- Total depth of safety edge \leq 5 inches
- Asphalt material incidental to the paving item

 NECEPT

38

Safety Edge Pub 72M – RC-25M



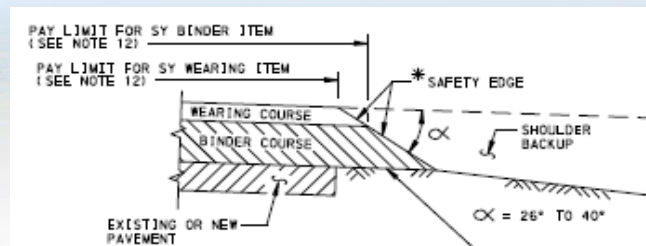
SAFETY EDGE-WEARING COURSE

* NOTE: DO NOT USE SAFETY EDGE ON COURSES LESS THAN 1½" DEPTH.



39

Safety Edge Pub 72M – RC-25M



REMOVE VEGETATION, GRADE AND COMPACT EXISTING OR NEW GRANULAR SHOULDER UNDER SAFETY EDGE LEVEL WITH EXISTING OR NEW PAVEMENT TO A WIDTH OF 12". SURFACE PREPARATION IS INCIDENTAL TO THE BINDER COURSE.

SAFETY EDGE-WITH BINDER AND WEARING COURSE

* NOTE: DO NOT USE SAFETY EDGE ON COURSES LESS THAN 1½" DEPTH.



40

Paver Maintenance

- Owner's Manual
- Routine Checks
- Routine lubrication



Courtesy of Dynapac USA, Inc.



Courtesy of Dynapac USA, Inc.

Automatic Central Lubrication

- Spray all parts in contact with asphalt mixtures with approved release agent before & after paving



41

Paver maintenance is critical to maintain optimum operations. The owner's manual should be read and followed. Routine checks and lubrication are essential, along with proper cleaning of all parts of the paver.

Grade & Slope Controls



Courtesy of Dynapac USA, Inc.

- **Sensors**
 - Mechanical
 - Ultrasonic
 - Laser
- **Grade References**
 - Stringline
 - Mobile reference
 - Joint matching shoe





42

Automatic grade and slope controls produce a smoother asphalt pavement by using a reference point to maintain the tow point elevation. Differences in pavement elevation are averaged out over longer distances by use of a stringline, ski, or sensor for reference. Grade references can be used alone on either side of the paver, or on both sides. One type can be used on one side (e.g., stringline) and another type on the other side (e.g., ski). Ultrasonic and laser technology is widely applied for grade and slope control.

Stringline


- **Longest grade control reference**
 - Can be very accurate
- **Drawbacks**
 - Survey crew needed to set elevation
 - Difficult to use on horizontal curves
 - Easily disturbed on job site

43


Stringlines are no longer typically used. Laser and sonic controls are the norm and the use of GPS technology is rapidly becoming commonplace on larger projects.

Mobile Reference (Ski)




- Various styles
- Up to 50' length
- Non-contact styles also available

Tube with wire stretched between ends

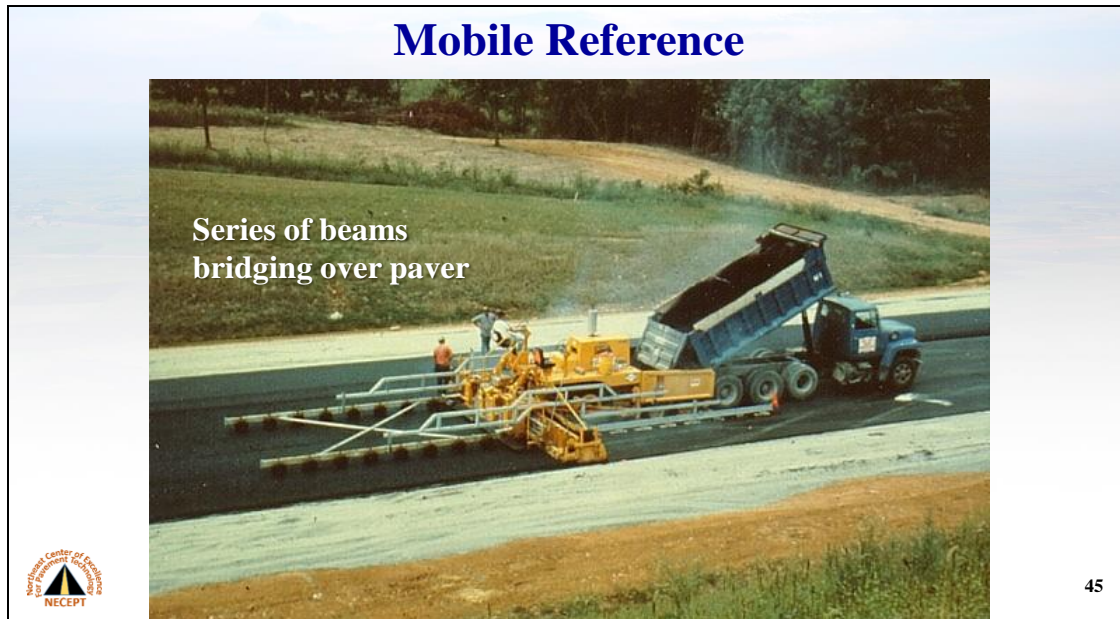


Floating beam with series of shoes



44

A mobile reference (ski) can come in various styles, although they function in the same manner. The tube rides directly on the surface, and the grade sensor rides on the wire to detect changes in elevation. A floating beam shown in the lower photo with shoes or skis are attached to the bottom with grade sensor riding directly on the beam. Lengths up to 50 ft. are often used resulting in a smoother pavement.



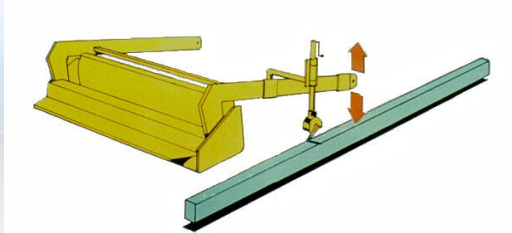
One manufacturer developed a mobile reference that bridges over the paver. One beam references the grade of the existing surface, and one references the wheels behind the screed. Intermediate beams connect the two reference beams, and the grade sensors ride on them. This type of mobile reference was used on I-80 in District 3-0. The contractor received a maximum smoothness bonus on this project. Care must be exercised so that the wheels behind the paver are hot, otherwise the mixture will stick to them.



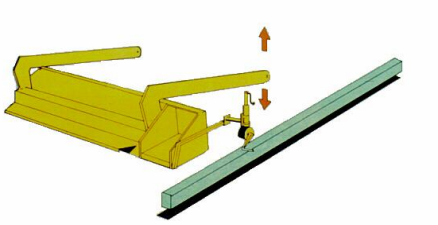
This reference is a short (1 ft.) ski that rides directly on the adjacent surface or curb. The joint shoe will provide a matching elevation across the longitudinal joint and can be teamed with an automatic slope sensor on the other side of the screed.

NOTE: All type of mobile reference points work on a “hunt” mode which creates a mild wave (sinusoidal) which undulates from plus to minus 1/8 inch and is visible in 30 to 50-foot repetitions

Grade Sensor Position




Grade Sensor - Side Arm Mount



Grade Sensor - Screed End Mount

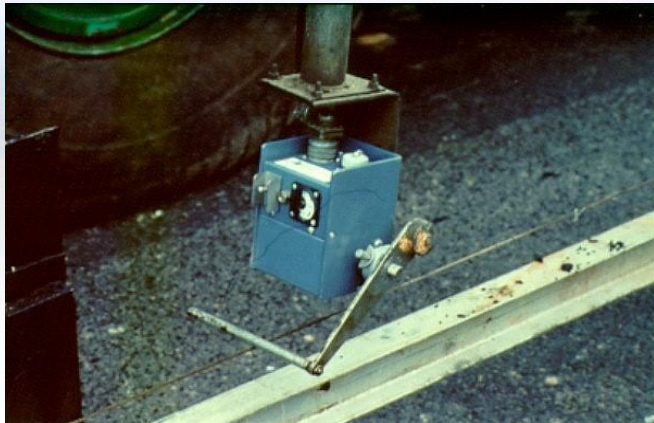
Generally, located between the third points of the leveling arm




47

Rely on the manufacturer’s paver or technology recommendations for the location of the grade control sensor. In all cases, the sensor should be in front of the screed’s pivot point.

Grade Sensor



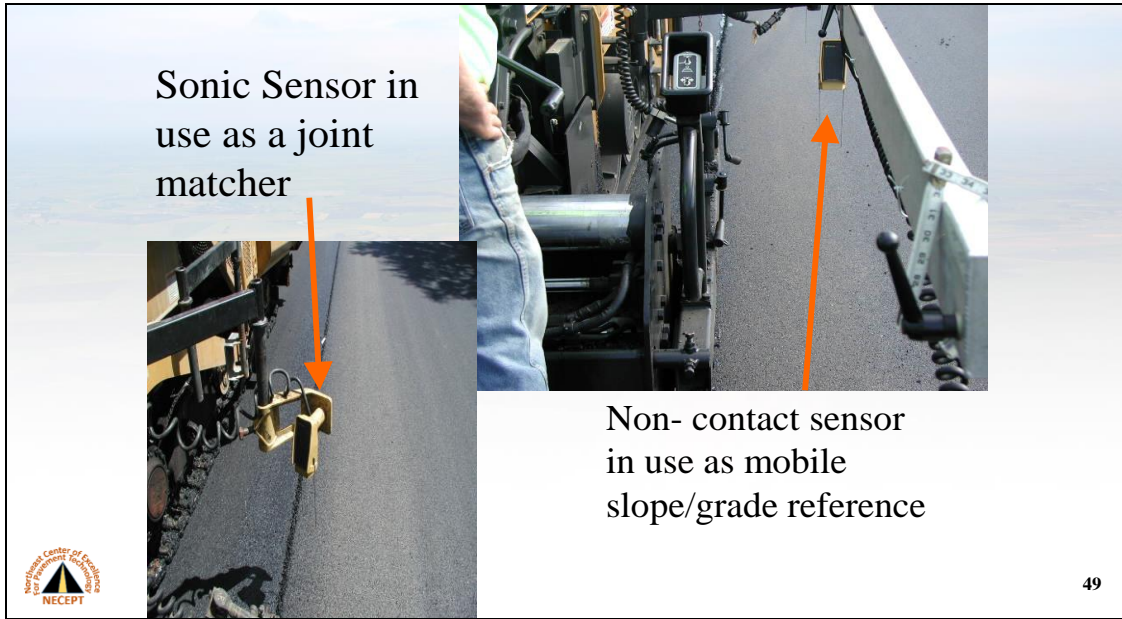
Sensor indicator lights should flash as tow point cylinder activates



48

The operation of the sensor should be checked regularly. When the paver is placing a mix, the sensor indicator (either lights or a meter) should indicate movement. The tow point should also be moving in response to changes in elevation.

NOTE: A black ring will form and will be visible on the cylinder ram which controls the tow point. This ring will usually be just below the seal on the hydraulic cylinder and will vary in distance from the seal depending on action of the controls.



The use of sonic grade sensors continues to grow rapidly.



NOTE: A small amount of spilled material (or the toe of a shoe) can cause unwanted adjustments.




Because of their weight, these units can start to bounce!!!!!!! What caused the white line?

Slope Control Sensor

- Used with automatic screed controls
- Grade control on one side with slope control on other side

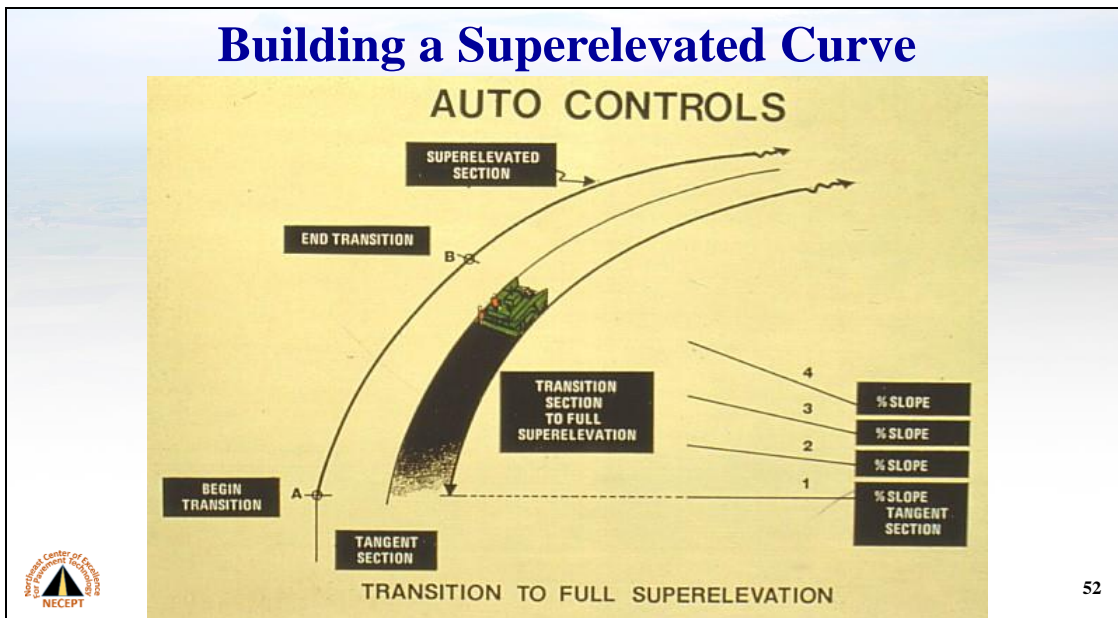



Inclinometer


51

Slope control is determined by a sensor attached to the cross beam between the two side arms of the screed. Typically, the grade control sensor and its mobile reference is placed along the pavement centerline, and the slope sensor controls the slope at the outside edge.

NOTE: If used, this system should be employed on all layers, scratch/leveling is not a layer.



For building a transition into a superelevated curve, it is good practice to supply the screed operator with a list of the station numbers and cross slopes or have them visibly marked on the grade stakes. In superelevations, the grade (or depth) sensor is operated automatically on one side of the machine, and the slope sensor is operated manually on the other.

NOTE: Be aware that the percent of cross slope needs to be attained at the appropriate grade stake, It must NOT be dialed in at the stake to avoid moving the transition longitudinally.



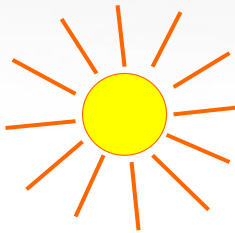
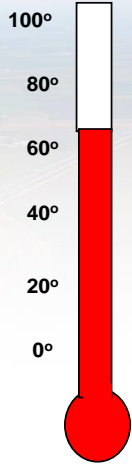

Operating Techniques

- | | |
|--|--|
| <ul style="list-style-type: none"> • Weather conditions • Warming up Machine • Positioning on Joint • Nulling the Screed • Initial Settings • Charging Hopper, Tunnels, Screed • Pulling off Joint • Checking Mat • Truck Exchanges | <ul style="list-style-type: none"> • Mainline Paving • Transitions • Temporary Paving • Echelon Paving • Night Paving • Checking Yield • Speed of Paver • Screed Density |
|--|--|



Weather Conditions

- **Temperature above 40°F**
 - Air temperature
 - Surface temperature
- **No rain**







55

Weather condition must be considered. Reference Module 2 for temperature ranges for different paving courses.

Warming up Machine

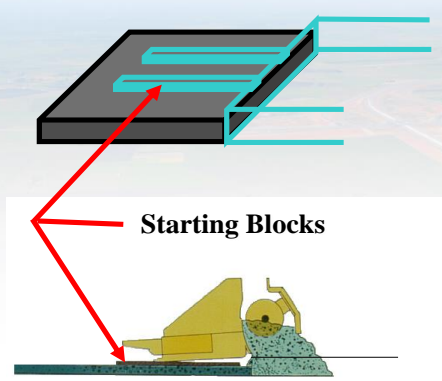
- **Warm up tractor**
- **Heat the screed**
 - Screed should not be in contact with the mat during heating
 - Screed heaters are not to be used to heat the mix!

56


This is a good time to give all of the equipment a thorough inspection to make sure everything is ready. **NOTE:** Use a stringline to check screed and extensions for alignment, (both front and rear), as well as strike-off and extension height.

Positioning Paver



- Temporary joint is removed, cleaned, and tacked
- Straightedge cold joint
- Strike-off a little behind the cold joint ~1”.
- Starting blocks placed under the screed.
- Rule of thumb - raise screed 20 to 25% more than compacted thickness.

Starting Blocks





57

After the temporary joint is removed, cleaned, and tacked, the paver is ready to be positioned. Remember to raise screed 1/4 inch for every inch of compacted mat thickness.

Longitudinal Positioning

Steering guides must be visible

58

The first pass will determine the layout of all subsequent passes as well as the joint construction so it must be effectively and visibly referenced. The steering guide (painted orange here) must be positioned so that the operator can see the guide, any reference on the pavement, and some distance down the mat. The closer the guide is to the paver, the easier it is for the operator to utilize.

Nulling The Screed



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The screed must be properly nulled after setting down on the starting blocks, prior to paving. Nulling the screed removes all the tension in the screed and makes it “free-floating” on the mix. This is done by turning the thickness control screws in both directions until the screw shows some free play. Nulling is done on one side of the screed, then the other, and then the first side is checked again. Freeing up one side often induces some force on the other side.

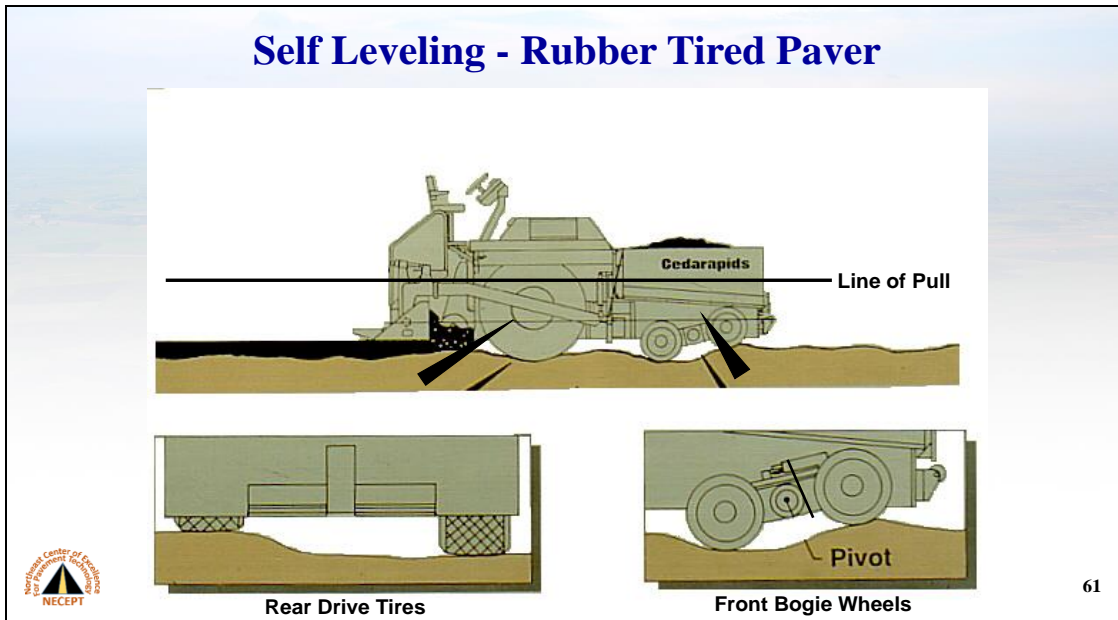
NOTE: After being hauled, and some times when constructing a transverse joint on superelevated curves, it may be beneficial to lift the screed and set it down again and check for need to re-null. Slack take-up will vary from unit to unit as the screed contacts the resistance of the material.

Operational Principles of the Screed

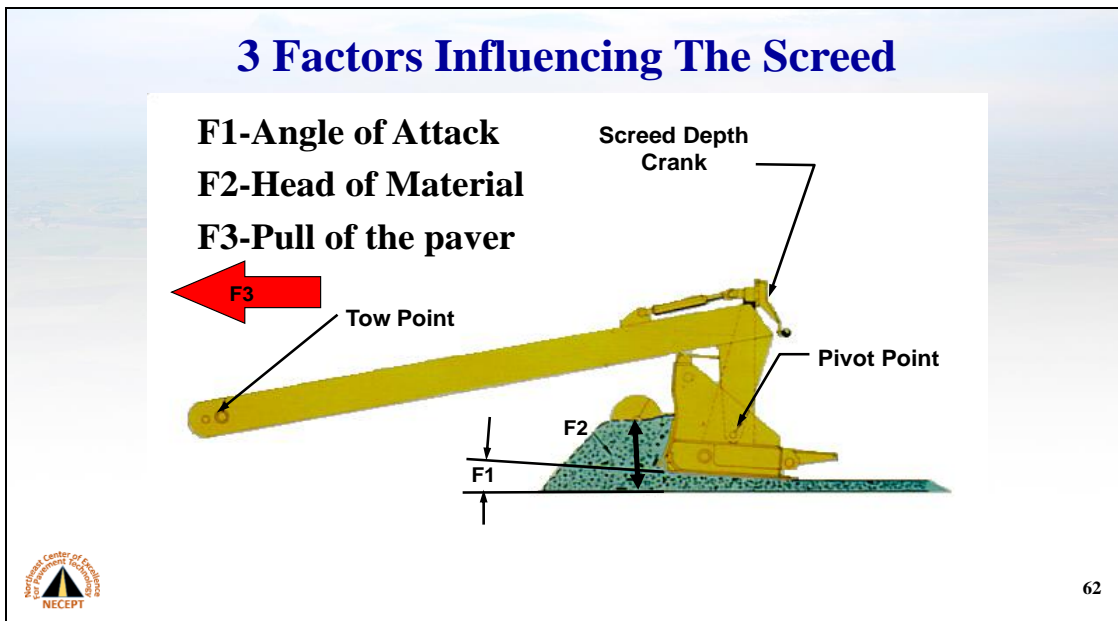
- Self-leveling Concepts
- Screed Response versus Distance
- Forces Acting on a Screed



60



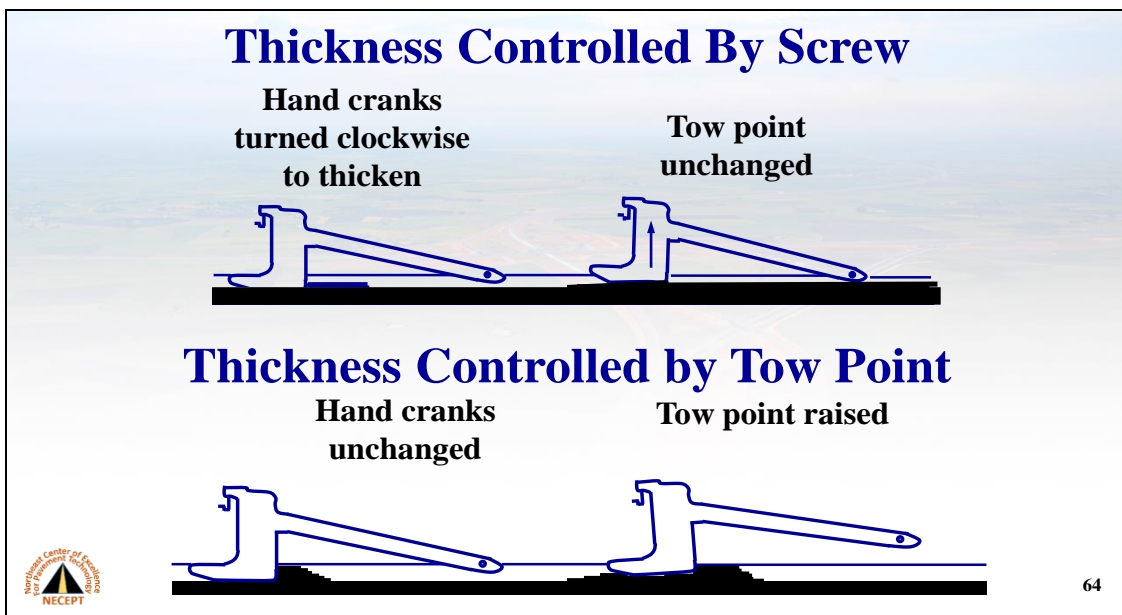
As the paver moves along the road, the tractor unit follows the ups and downs of the existing surface. While the tow point moves with the tractor, the screed reacts slowly to this and follows along relatively unchanged. In effect, the screed averages out and levels itself over these changes. Hence the term, “self-leveling screed.” One further step toward producing a level surface is setting up a reference unattached to the paver. The tow point is guided by the reference, instead of the motion of the tractor unit, to keep the screed level. Use of the reference is guided by automatic grade controls, as discussed earlier.



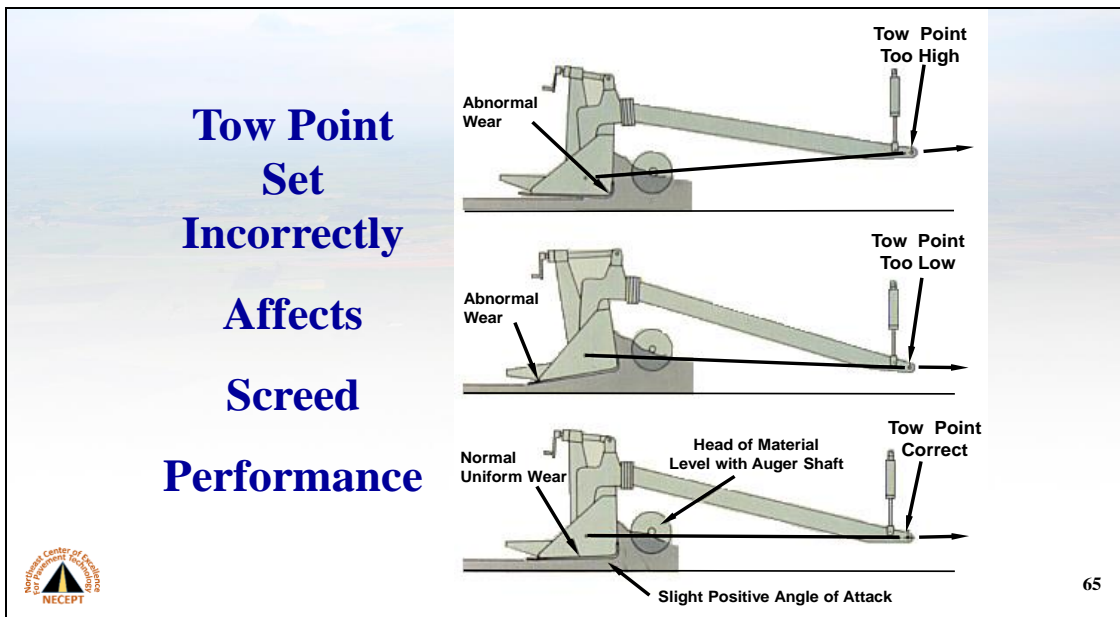
The self-leveling action of the screed means it will respond to the various factors acting on it to find its balance or equilibrium. Other factors are pre-compaction and screed weight, both of which will be influenced by the speed of the paver. The Angle of Attack is part of the initial setup, the Head of Material and Speed of Paver will be covered later.



The thickness of the mat can be controlled one of two ways: with the thickness control screws, or with the tow points.



To increase depth, the hand cranks are turned clockwise (on some units) and the front of the screed is pivoted up, and the screed rises. The change in thickness is not instantaneous and happens over a length of paving. The thickness of the mat can also be controlled with the tow points. To increase thickness, raise the tow point. The screed arm (or tow arm) attaches the screed to the tow point.



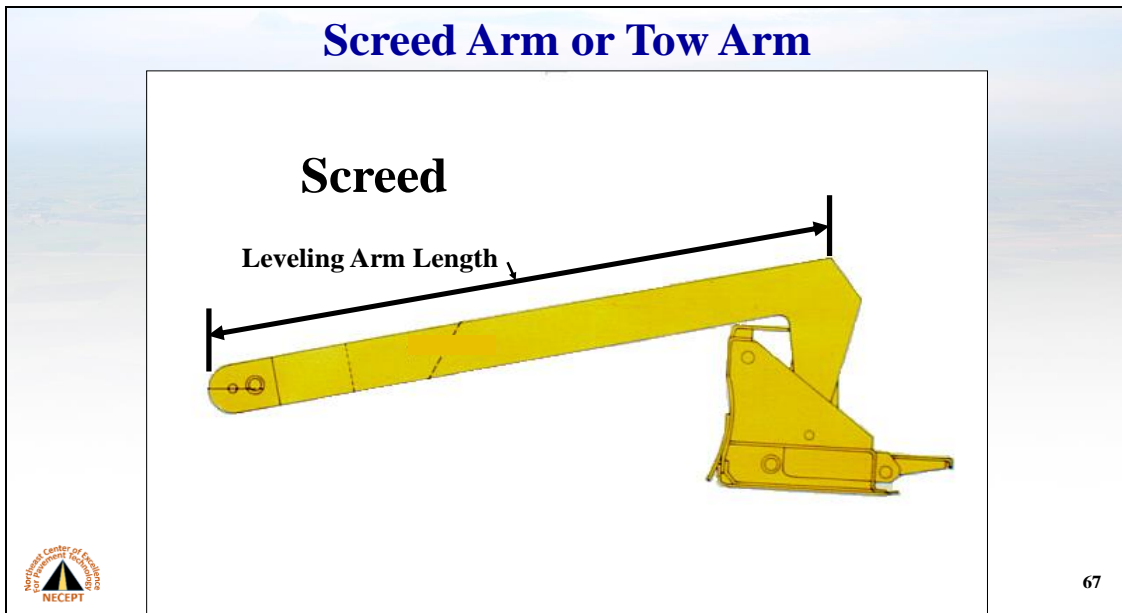
The tow point location will affect screed performance. The proper angle of attack with the screed is where the nose is slightly above the tail. The wear on the screed will be uniform if the angle of attack is adjusted properly.

NOTE: Usually after nulling, satisfactory performance can be accomplished by using the tow point technique

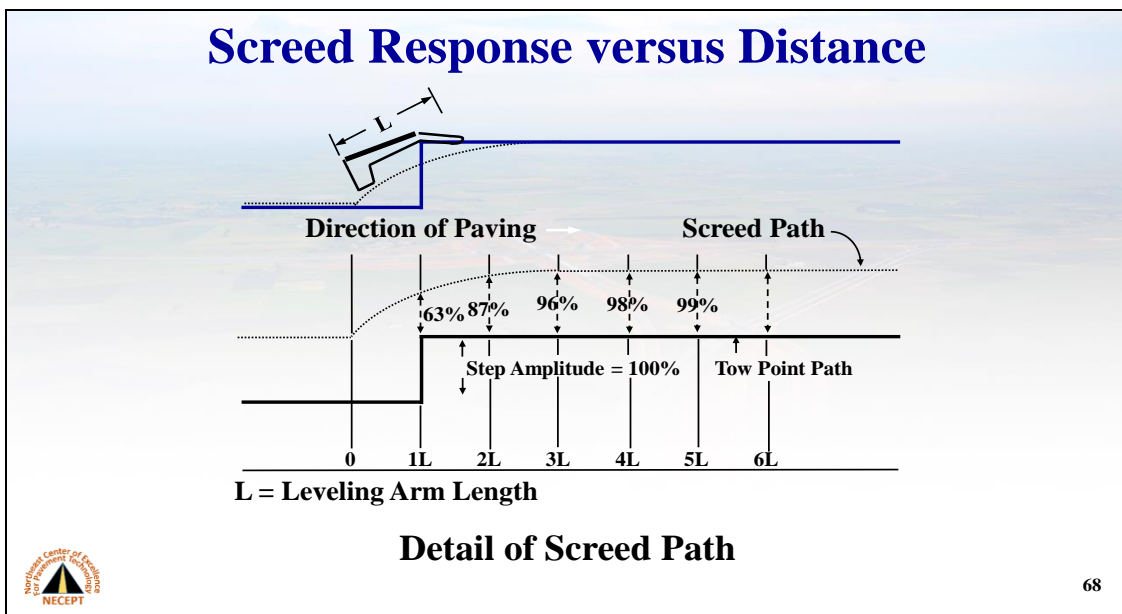


The biggest maintenance item with the screed is uneven wear on the screed plate. Heavy wear on the nose of the screed plate will result if the screed is too “nose down” in the mat.

NOTE: this condition is evident in the mat as a more open appearance as the weight of the tail of screed is not smoothing the mat, occasionally there will be in streaks also caused by extensions and main screed not being in proper adjustment.

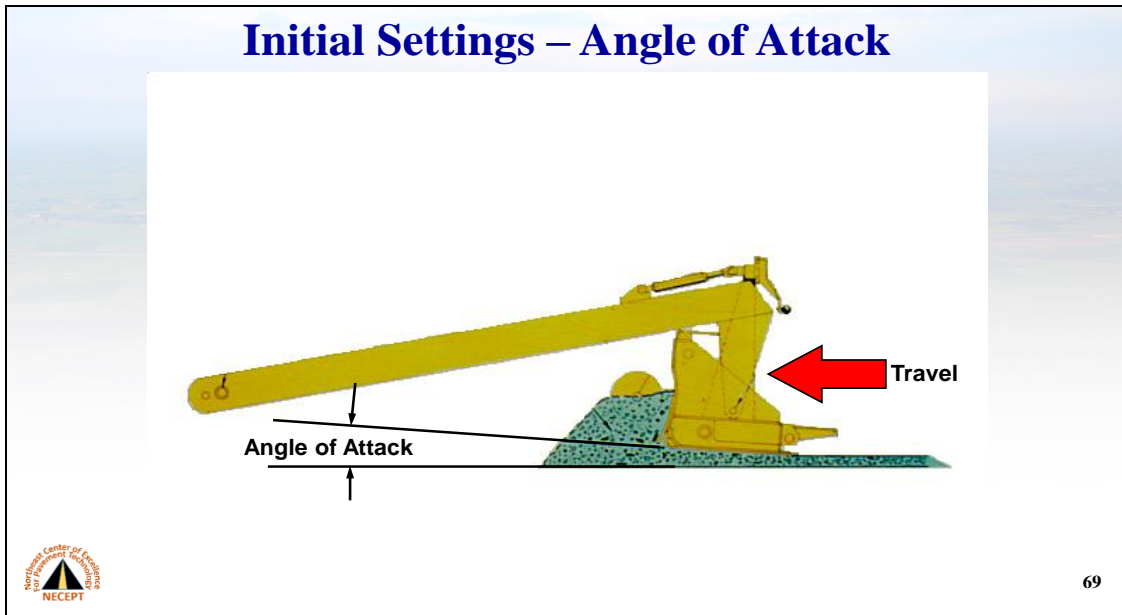


Even without automatic paver controls, the leveling or averaging effect places more mix in the low spots and less mix in the high spots. The screed levels the surface due to the fact that the screed must travel about **FIVE** lengths of the tow arm before fully reacting to any adjustments of the control screws or the tow point. After initial set-up, all adjustments should be minor and infrequent.

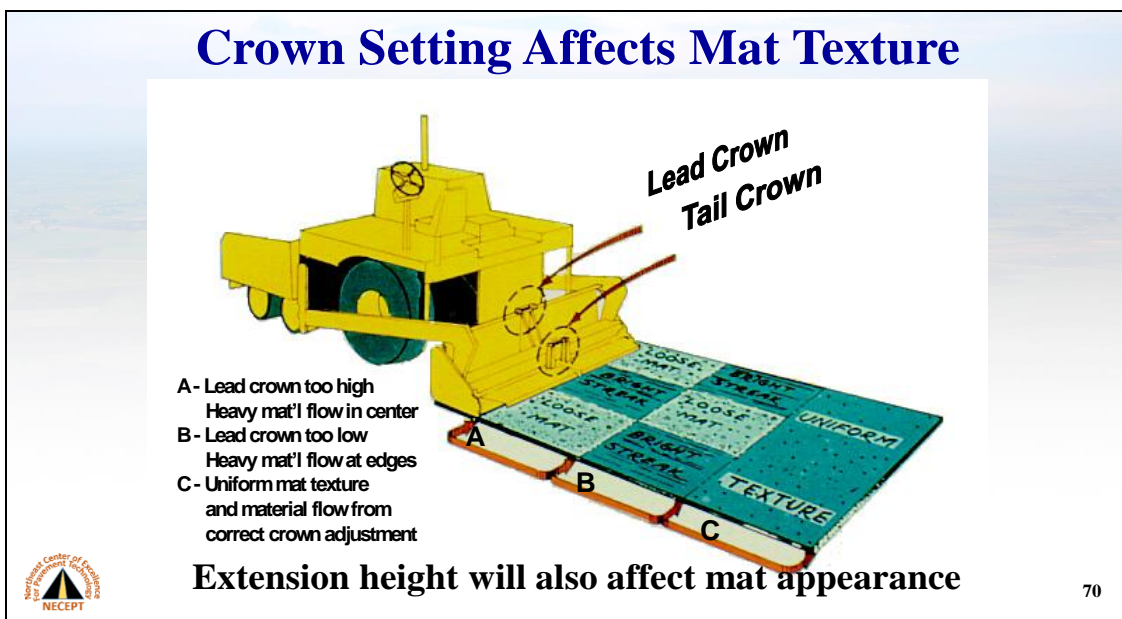


For example, if the tow arm is 8 feet long, the paver would have to move about 40 feet before the screed fully reacts to a change in thickness input into the system. From initial set-up, all adjustments should be minor and infrequent.

Note: that 96% effect is attained in 3 lengths

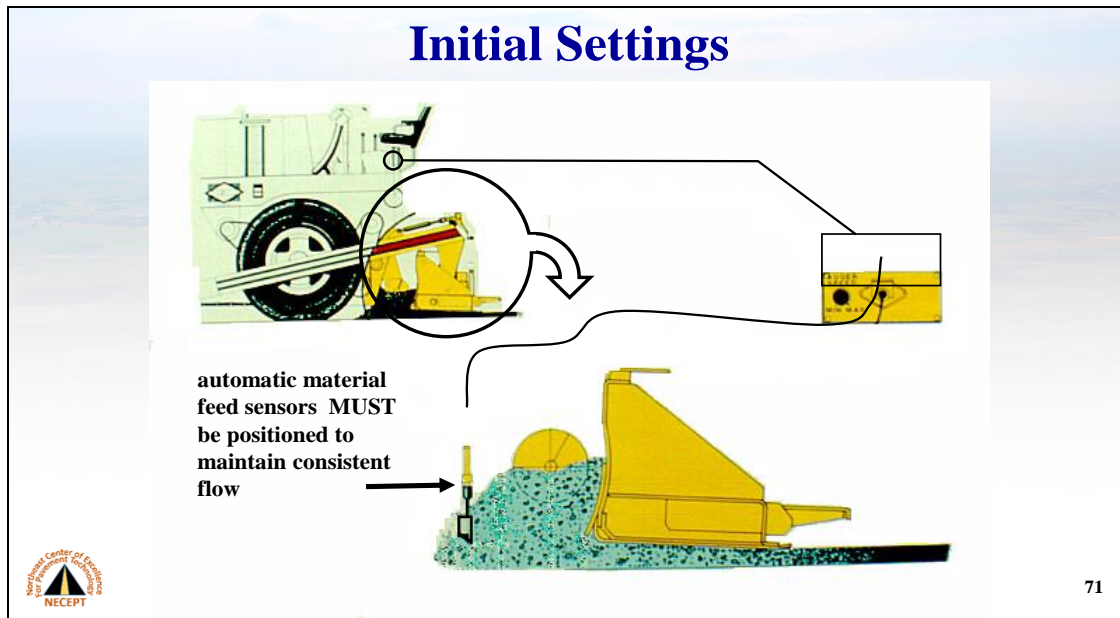


Increasing the angle of attack will increase the thickness. Decreasing the angle of attack will decrease the thickness. The initial angle of attack is induced into the screed on both sides. Extensions may also have to be adjusted, whether they are extended or kept at the main screed. If the pavement is to be crowned, the amount of crown must be induced into the screed. If hydraulic extensions are being used, any change in slope must also be made prior to starting. When paving one lane, the rear of the screed should always be straight (no crown).



If the lead crown is too high, more material will be forced under the center of the screed, and the mat will be shinier there. If the lead crown is too low, more mix will be forced under the screed at the edges. A difference in texture will result from either—the loose mat texture is caused by the lower amount of material in that location. This difference in texture may also be caused by strike-off or

extension height adjustment. These open or loose areas will also affect density readings. *Lead Crown* is always set as per individual manufacturer's specifications and the mat texture produced.



If automatic material feed sensors are being used, they must be in place and operating properly. The proper location is as close to the end of the augers as possible, just inside the end plate. The primary key to a smooth pavement layer is maintaining a head of material level with the auger shaft in front of the screed. The need to ***eliminate rolldown at the endplate*** cannot be over emphasized.

Truck Exchanges Without an MTV

- Exchanges are important to uniform operations
- Once one truck is empty, the next is ready to back up to paver.
- The paver “picks up” the truck and pushes it forward as the box is being raised
- The truck **DOES NOT** back into the paver or bump it.
- Keep paver moving, no stopping



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As we discussed earlier, the truck exchanges are important to uniform production. Once the truck is empty, another should be ready to immediately back up to the paver.



Don't forget truck rule #1... **“DON'T BACK INTO PAVER”**. When initially charging the paver, sometimes the second or third truckload is used because it may be hotter. Flood the hopper and begin pulling the mix to the augers with the slat conveyors.

Out of Trucks?

- Wait with a nearly full hopper.
- When truck arrives, get the paver to paving speed as quickly as possible.
- Why start out with only one truck?


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This keeps the mix and paver warm, and the screed charged with a full head of material. When the truck arrives, have the bed raised and ready to flood the hopper. When the truck is picked up by the

paver, release the gate and flood the hopper. If the paver stops frequently, a speed adjustment may be necessary.

NOTE: It is **NOT** recommended to start when only one truck is in front of the paver!!!!!!!!!!!!!!!!!!!!!!

Charging the Screed

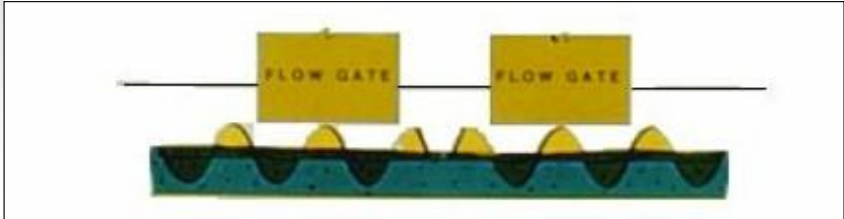
- Need a uniform head of material
- The ideal head of material covers the center of the screw augers


75

The second and maybe most important factor affecting the screed is the *head of material*. As the amount of asphalt material in the auger chamber against the screed changes the net force acting on the screed also changes. Some paving experts maintain that 90 to 95 % of the mat problems can be solved by maintaining a **uniform head of material during operations**.

Charging The Screed: Head of Material

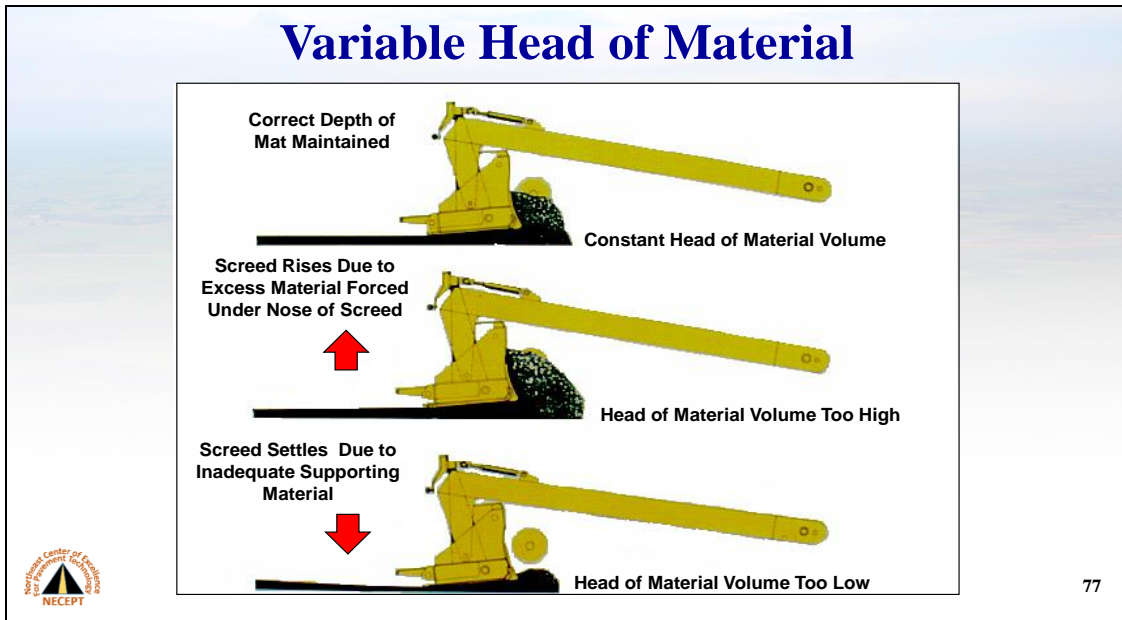


Uniform Material Volume Flow



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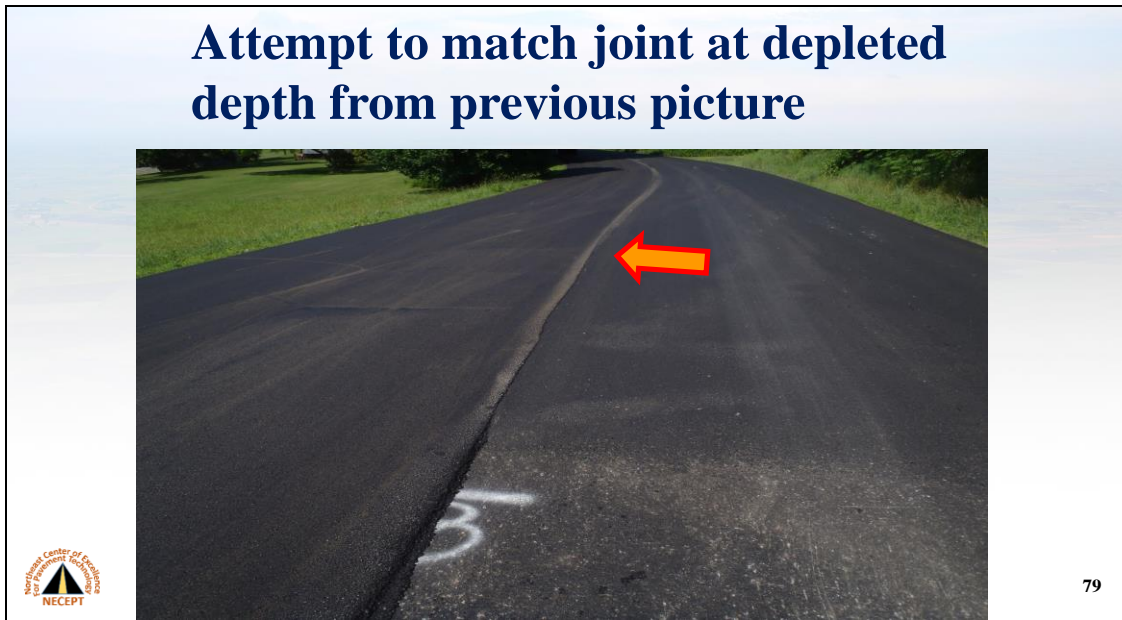
Enough mix must be run back to provide a uniform head of material across the screed and **just cover the center of the auger shafts**. When enough material has reached the end plate to ensure a uniform head of material across the entire width of the screed, the automatic screed control can be adjusted.



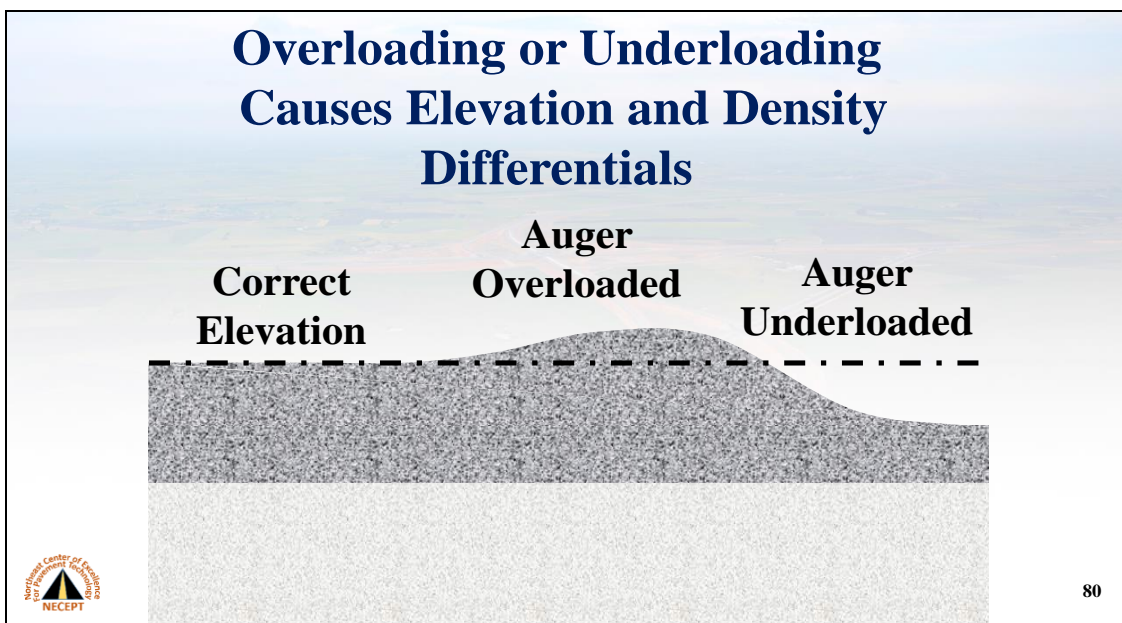
As discussed, the ideal head of material covers the center of the screw augers. If head of material is too high, then the force on the front of the screed increases, and the screed compensates by moving upward. If head of material is too low, then the force on the screed decreases, and the screed compensates by moving downward. **The bottom picture shows a case that occurs all too frequently at the end of the day!!!!!!!**



Insufficient thickness at the end of the day can be seen. This issue is due to depleted head of material. Matching depth in the second pull will be impossible.



Note crushed white line is no longer on the first pass. To correct the issue the right-hand lane will need to be milled back to where material is at specified depth. This also creates a very poor centerline joint as well as a rough ride.





A typical location for underloading is at the end of the day, The head of material is allowed to drop, thickness suffers and the take off for the next day will be under depth, causing a lot of cranking and a

very noticeable dip in the roadway. Proper use of a straightedge to determine the location for the transverse joint will eliminate the removal of a lot of cold, hard material.

Pulling off Joint

- Once all the settings are in place, the paver moves forward
- Start fairly rapidly, then move quickly up to paving speed





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Once the screed is charged, the sensors are switched from standby to on. Transverse joint construction will be covered in module 7.


Note: typical operation would have more blocks.

Verifying the Settings



- Is the slope correct?
- How is the mat texture?
- Is the thickness correct?
- Some screed adjustments may be needed.

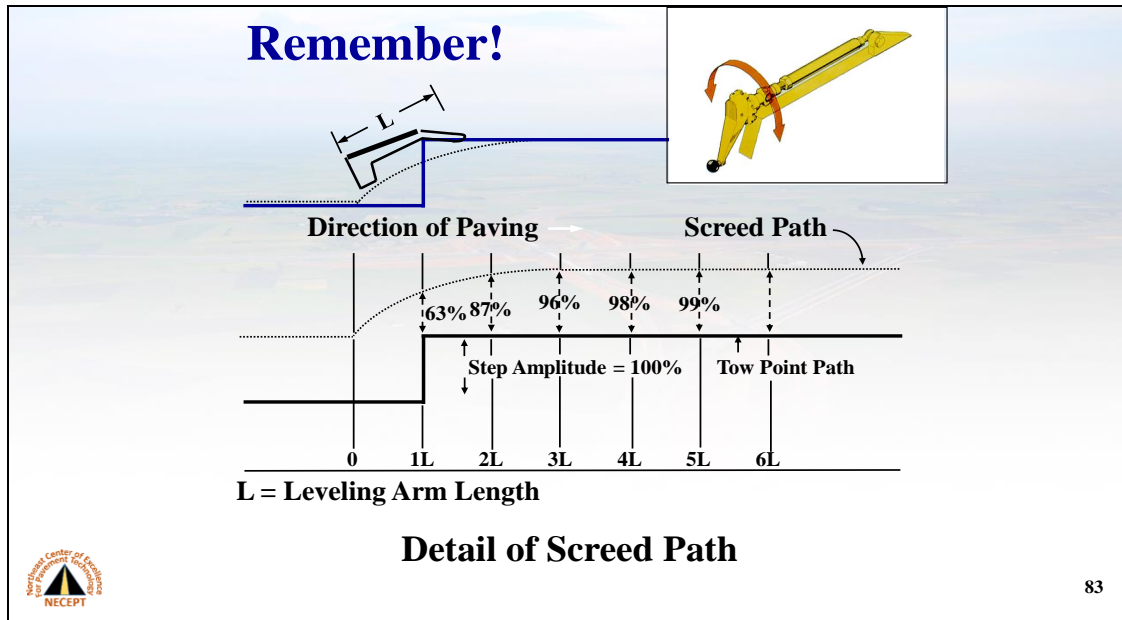
Checking Cross Slope



82

Recheck settings as the paving begins. Is there a crown before or after rolling?

Required adjustments should be minor and infrequent. Mat texture with SMA and Superpave mixes will look much more open than conventional mixes. However, still look for a uniform appearance.



Remember, the thickness of the mat can be controlled one of two ways: with the thickness control screws, or with the tow points. The screed must travel about five lengths of the tow arm before fully reacting to the thickness adjustment.

Types of Paving Operations

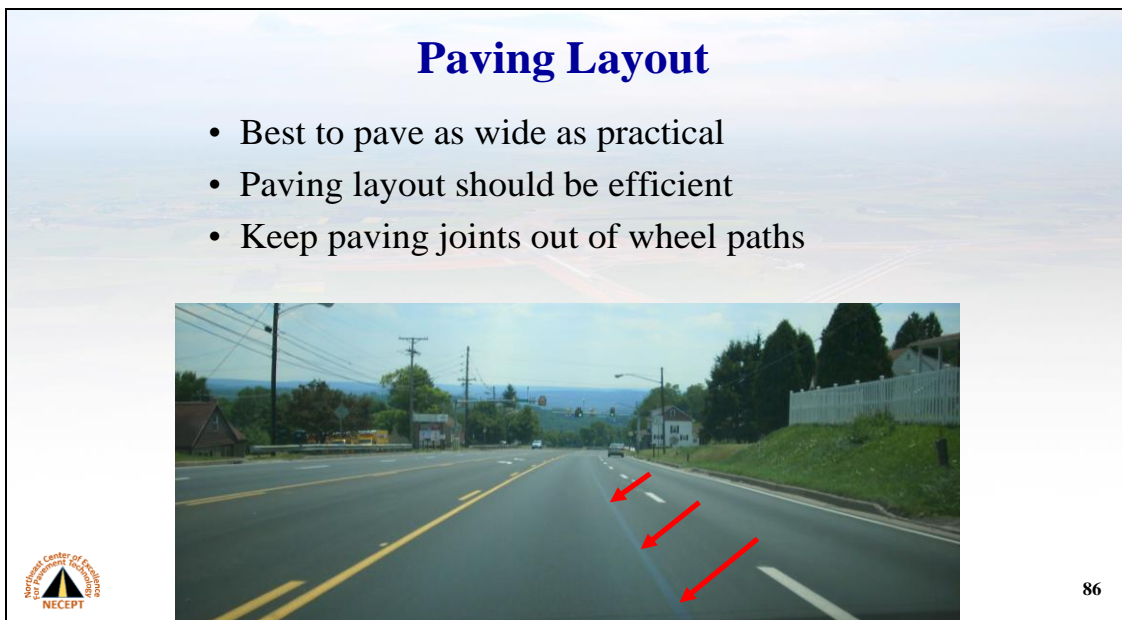
- **Mainline Paving**
 - Planning Pulls
 - Variable Width Paving
 - Transitions
- **Temporary Paving**
- **Echelon Paving**
- **Night Paving**

NECEPT

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Mainline paving is typically 12 feet wide, although greater widths are used to minimize paving joints. The first pull is critical in that the next lane needs to be placed tight against the first lane to form a tight dense joint.



The paving layout should be both practical and as wide as possible. Excessive extension on one side may cause ripples in the mat. Optimal joint spacing will place the surface course joint along the lane stripes. For placement of multiple lifts, the longitudinal joints should be staggered, or offset from one another. In this photo of new paving, the joint layout was not done correctly.

Hydraulic Screed Extensions allow variable width paving & eliminates joints



Shoulder paving using extension – steeper slope, no joint



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It is common to see a narrow shoulder paved with the driving lane, especially with hydraulically extendable screeds. One extension is used to pave the shoulder, and it can be set at a different cross slope than the main screed. This is good practice as it eliminates one longitudinal joint and an additional pass of the paver. Auger extensions should be added with screed extensions. One caution: If this combination is being used, careful attention must be given to the layout of the temporary and permanent striping. Splits or tears in the mat may result from rollers crossing the break at shoulder joint

Transitions

How do we handle the slope change?

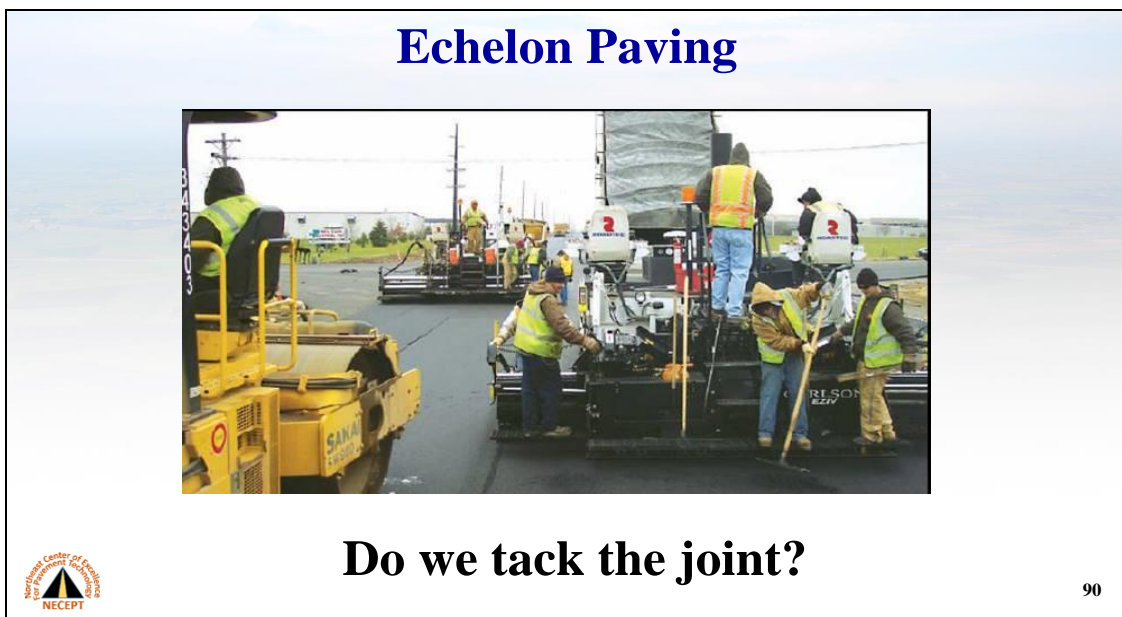



88

With hydraulically extendable screeds, it is tempting to construct variable width sections “on-the-fly.” Be wary—these changes affect the forces on the screed. The hydraulic extension may be used if texture and smoothness are matched and if it would replace handwork, it should be considered. For wide turnouts and tapers, do the mainline first to keep density and smoothness uniform. Then come back to do the tapers and turnouts.



As mentioned earlier, transitions into superelevated curves need to be carefully planned. Temporary ramps and crossovers need even more attention to grade and slope. Traffic usually goes too fast in construction zones, and these pavements often have sharper curves and stronger slopes than normal.



Echelon paving is when two pavers are running next to one another. The cold joint between the two paving lanes is eliminated. Properly lapped and compacted, the longitudinal joint is usually difficult to see. Normally, the density in this joint will be similar to the density of the adjacent mat.

MTV in Echelon Paving



Night Paving



Safety Issues

Traffic
Visibility



Night paving happens frequently, and for urban area highways it is often the standard practice. At night, everything typically needs more attention due to limited visibility, cooler weather, different paving, and trucking crews plus many other variables. Sufficient supplemental lighting for all equipment is a big need, especially pavers and rollers. **Safety is probably the biggest issue in night**

paving. Traffic and motorists' driving habits are always a concern. Add to that the additional drunk drivers that may be on the road especially after the bars close and the safety risks may increase significantly.

Night Paving



**What
experiences
have you had?**

**How Did Your
Mat look
At Night?**



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Equipment operators must be aware of all personnel moving around them. Equipment maintenance is particularly important since parts and replacement equipment may not be available. Testing personnel need to be extra careful at night. A new mat looks quite different at night. Personnel must be aware what a quality pavement looks like under different lighting. All personnel must wear safety vests and be clearly visible. What about leggings??

Technician's Responsibilities & Problem Identification

What are a Field Technician's Responsibilities Concerning Placement?



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Everything, you must constantly be checking to see who is checking!!!!!!!!!!

Technician's Responsibilities

- Understanding the equipment and its operation.
- Different types of paving and the problems associated with it.
- Determining speed and yield of the paver.
- Determine location and monitor material sampling.
- Monitor those operations that can cause segregation.



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You should keep accurate records of mix design, ambient temperature, roller pattern, successes and failures for reference needs for your own sanity.



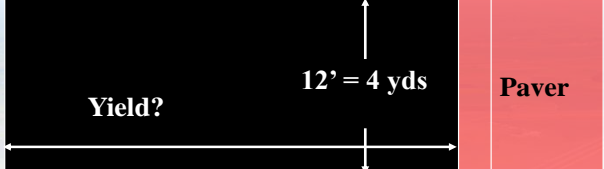
Check Yield Occasionally How often?

96



If you are paving with a yield specification, periodically check how far each truckload is going. Every truckload is typically too often; it may result in too many thickness changes. A longer distance (say, 1000 feet) may be more appropriate for checking yield.

Truckload Yield Determination




Yield? $12' = 4 \text{ yds}$ Paver

Assume:

- lane width = 12 feet
- lift thickness = 2 inches
- truck load = 20 tons = 40,000 lbs.
- coverage rate = 110 lbs./in/sq. yd.

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How do we check yield per truckload? Let's assume you are paving a 12-foot lane with 2 inches of Asphalt mixture. Each truck holds 20 tons and the coverage rate is 110 pounds per inch per square yard.

Truckload Yield Determination

Coverage rate for 2-inch lift =

$$2 \text{ in.} \times 110 \text{ lbs./in./sq. yd.} = 220 \text{ lbs./sq. yd.}$$

$$1 \text{ Truck at 20 tons} \times 2000 \text{ lbs./ton} = 40,000 \text{ lbs.}$$

$$\text{Coverage Area} = 40,000 \text{ lbs./}220 = 181.8 \text{ sq. yd.}$$

$$\text{YIELD} = \frac{(181.8 \text{ sq. yd.}) \times (9 \text{ sq. ft./sq. yd.})}{(12 \text{ feet width})} = 136 \text{ feet}$$



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Depending on the specific gravity of your mix, 110 lbs./in./S.Y. may need to be adjusted up or down slightly (the heavier the stone in the mix, the higher the number). 110/lbs./in./S.Y. is a good rule of thumb as a starting point.

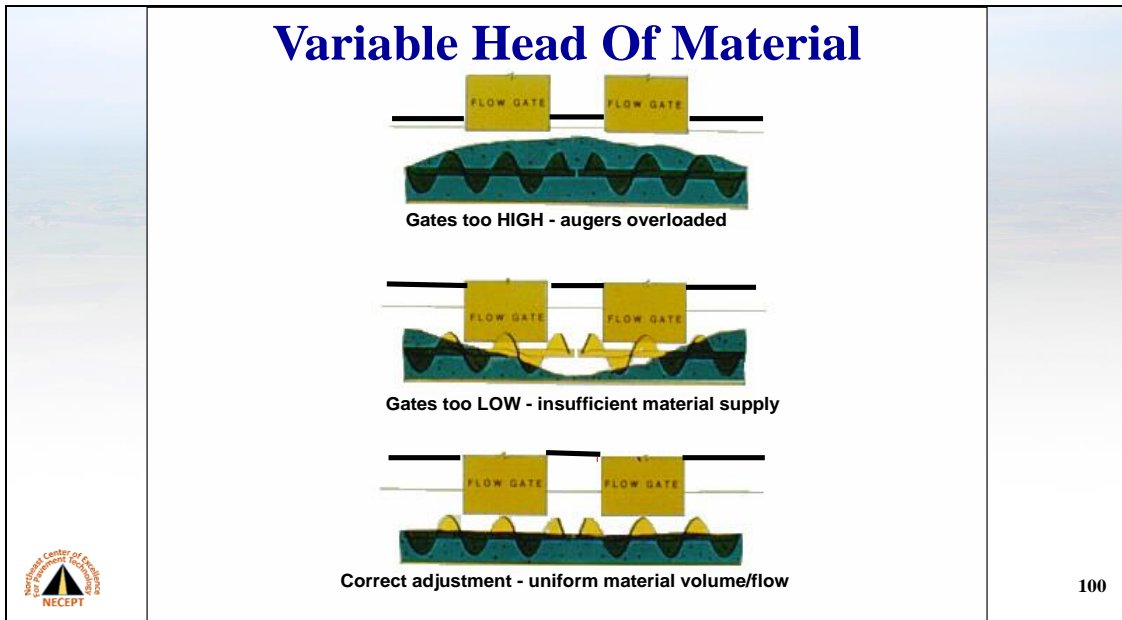
Issues and Problems

- **Goal:** A uniform mat with proper cross slope and thickness with a uniform surface of proper texture.
- **Main Issue:** Maintaining a continuously moving operation with a constant head of material ahead of the screed

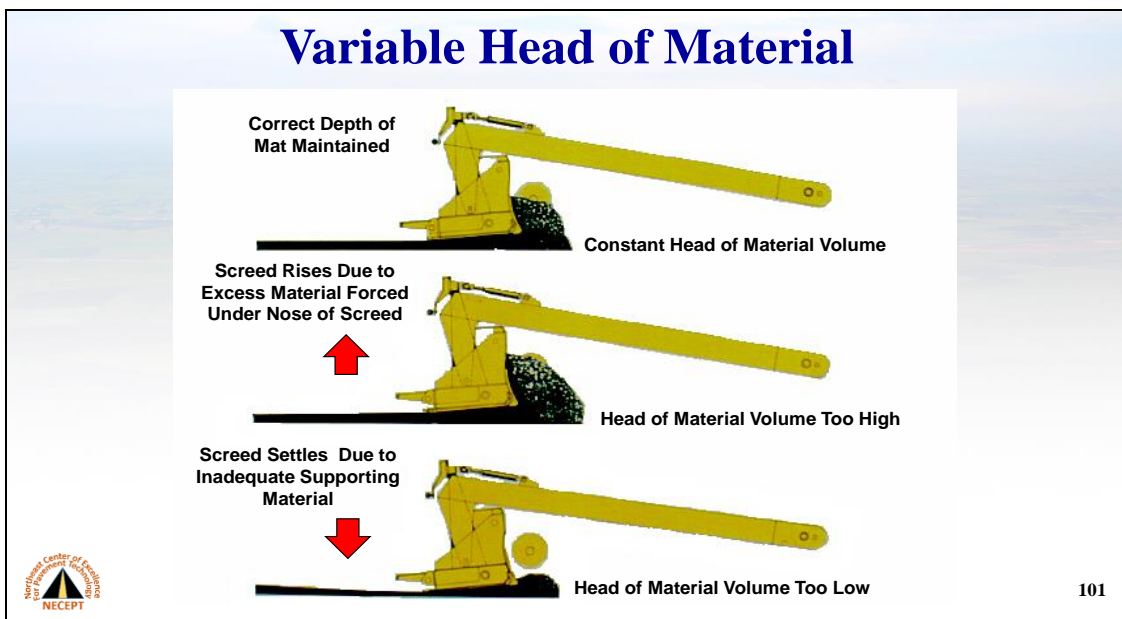


99

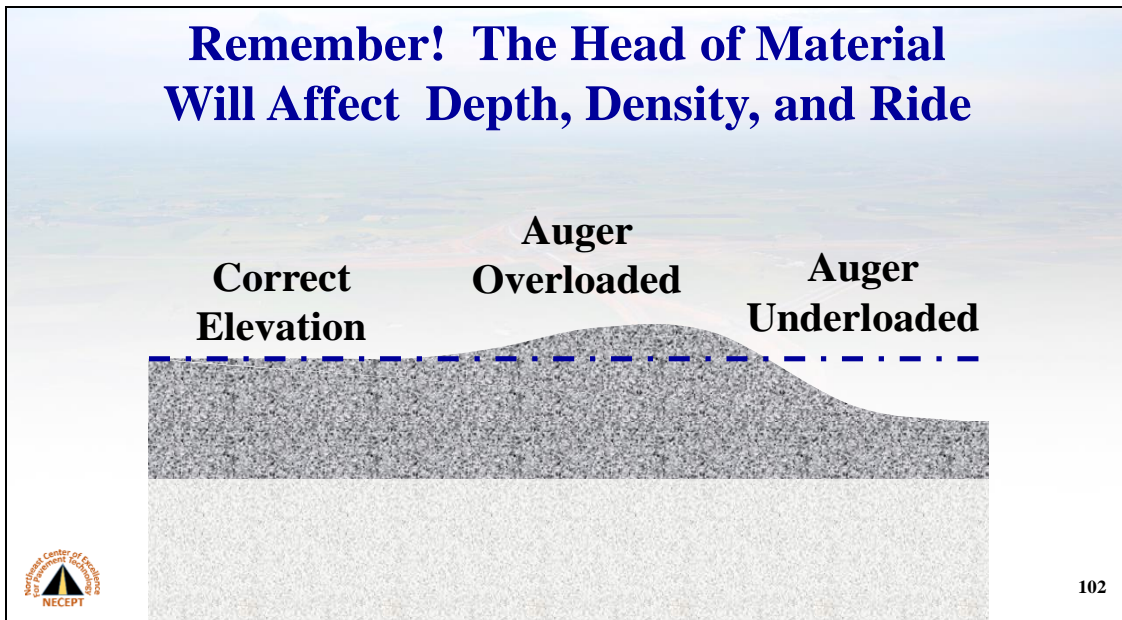
Some of the main problems involving paving deal with the constant supply of material and maintaining a constant head of material ahead of the screed. Other issues deal with excessive wear to the paver.



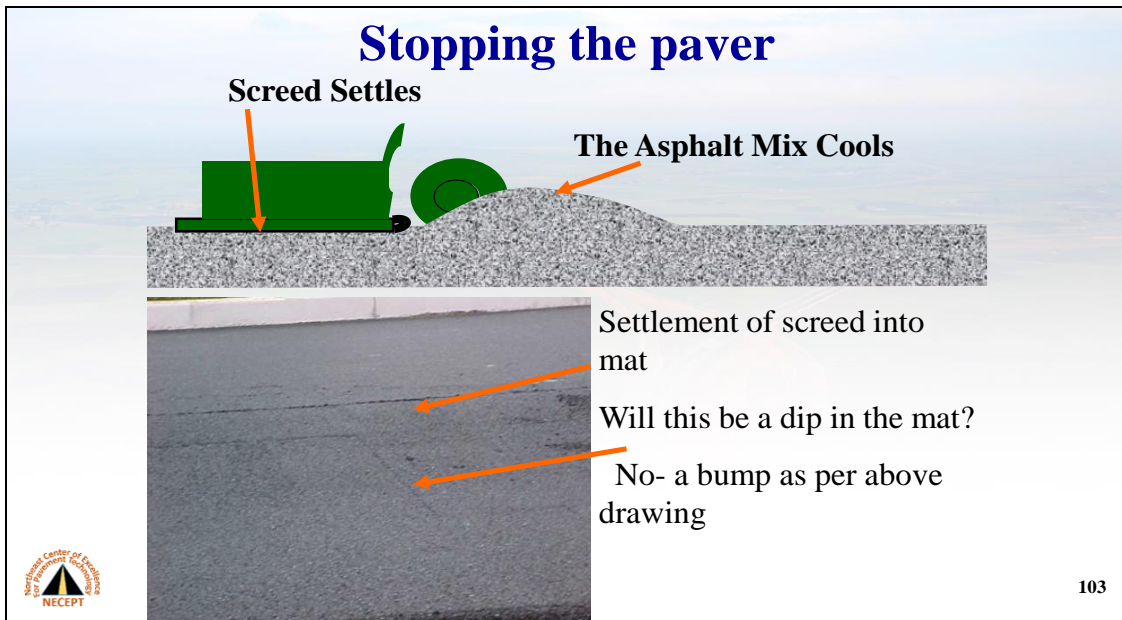
Not getting the head of material set properly in the beginning will only lead to problems later on. Problems with flow gate height are highlighted here. The ideal head of material just covers the center of the augers. If extensions are being used improperly, some mix may need to be shoveled to the corners of the end plates. Again, the key (and it cannot be overemphasized) is to **create a uniform head of material and keep it constant**.



As discussed earlier, the ideal head of material covers the center of the screw augers. If head of material is more than ideal, then the force on the front of the screed increases, and the screed compensates by moving upward. If head of material is less than ideal, then the force on the screed decreases, and the screed compensates by moving downward.

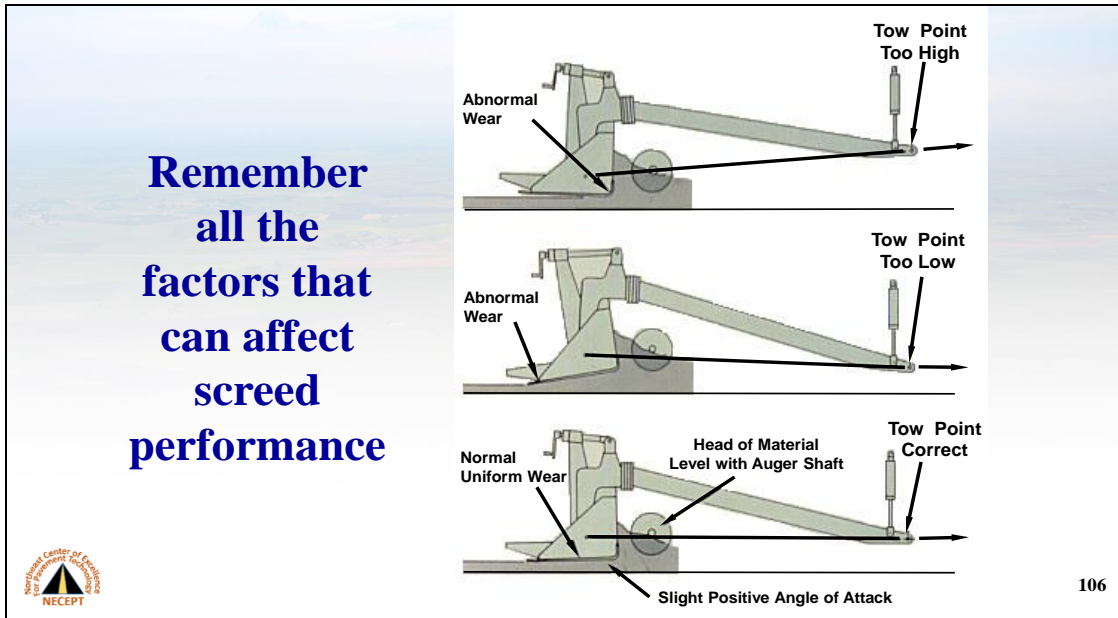


If the augers are underloaded, the thickness placed is too thin. If the augers are overloaded, the thickness placed is too thick.

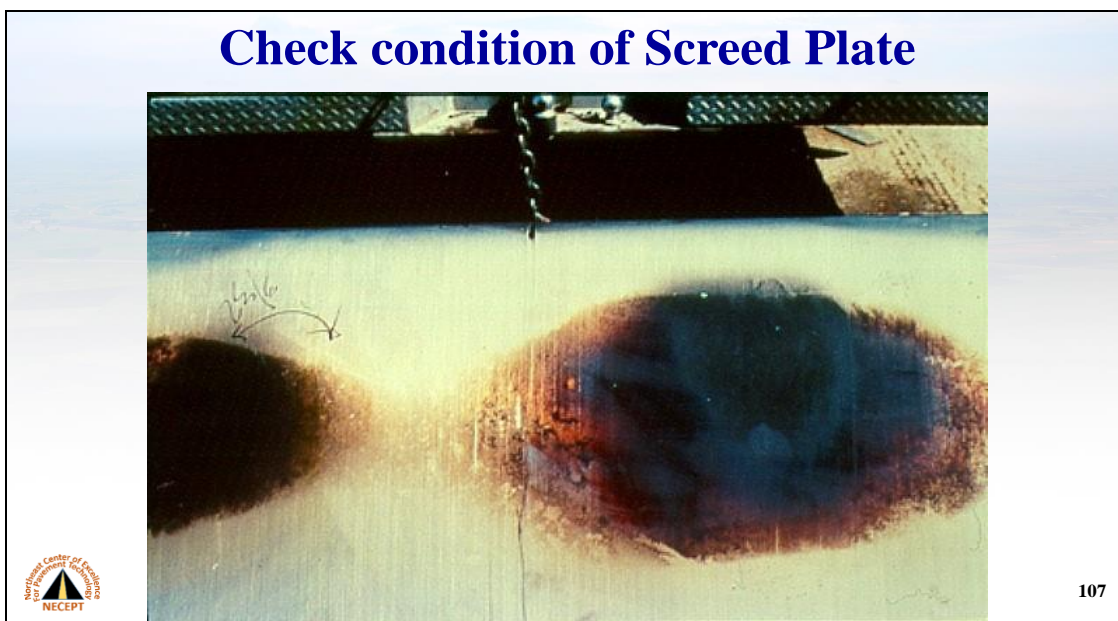


If the paver stops for an extended length of time, any mix in the paver (head of material, conveyors, hopper) can cool, requiring more force to move the paver. In addition, screed can settle, causing bump in the mat.

concept is even more important to understand. If a second change is made before the first one is accomplished, the first change will never be completed.



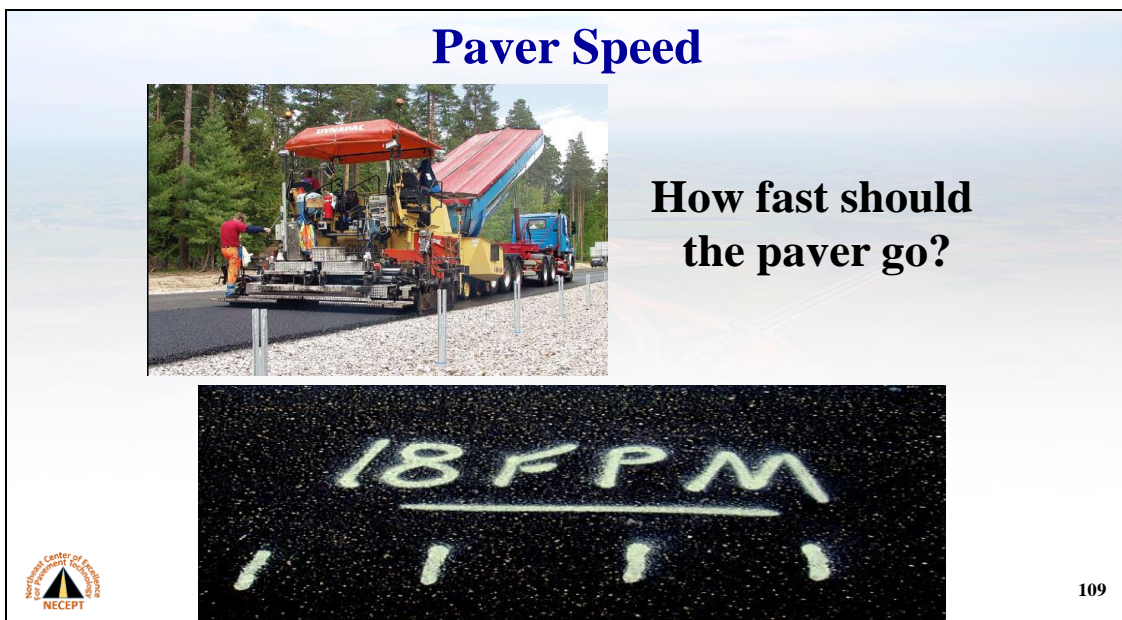
Remember, the proper angle of attack with the screed is where the nose is slightly above the tail. The wear on the screed will be uniform if the angle of attack is adjusted properly.



Screed should be smooth, not warped or dented. Over-heating the screed can lead to the screed plate warping. Again, check screed for straightness regularly. Also check extension height before pulling off joint, preferably before setting the screed on the starting blocks.



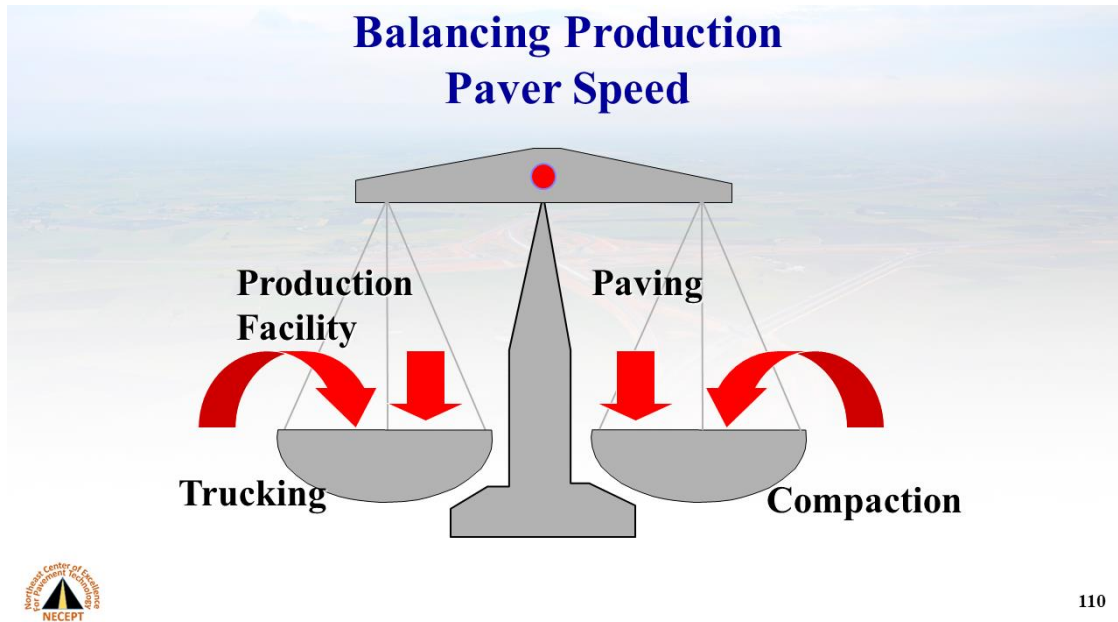
How is the mat texture? This crew failed to heat the screed uniformly prior to pulling off the joint and produced a ragged open mat. Screed extensions were not properly adjusted as evidenced by open streaks. Rolling, raking, or broadcasting material will NOT correct this situation.



When we pull off the joint or start from a stopped position, we need to bring the paver up to speed as rapidly as possible to initiate the smooth paving operation. But what about the paver speed? How fast should the paver go?

Before you began paving, you should calculate an ideal paver speed. This speed should be checked and maintained.

NOTE: check the total tonnage delivered on the ticket from **the fifth truck of the second round** and calculate tons per hour delivered. With some exceptions, this will allow you to determine best case scenario of paver speed, as you will already know yield per square yard.



As was discussed in the previous modules, the entire paving operation is a balancing act. It starts at the Asphalt facility with how much can the producer supply to the project and how many trucks will be available to transport the asphalt to the paver. Now we have to determine the speed of the paver to ensure a constant flow of material with a minimal number of stops. Schedule ahead of time to balance all of these rates. Understanding the variables that can affect each rate is the key to adjusting the others when changes occur—and be assured, changes will occur. Keeping the rates in balance will lead to a better pavement, and more production. If you have a number of trucks waiting, should you speed up the paver to empty them? Not necessarily -- the roller operator may not be able to achieve compaction if the paver speeds ahead. Also, if you change the speed of the paver, you may need to change the amount of mix delivered to the augers to compensate for the change. Automatic material flow control will adjust for these changes. Speeding up the paver will change the *pre-compactive* effort by the screed, requiring more compactive effort from the rollers. All of these things come into play and all need to be considered as the paving operations continue down the road.

Scheduling Problem

How do you determine the speed of the paver to ensure a continuous operation with a minimal number of stops?



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Let's look at a paving production rate problem.

Paver Production Calculation Form (An Example Scenario)

Date: _____ Project # (ECMS) _____

Project Location _____

Tons Scheduled for today: **1800** Paving Hours scheduled: **10**

Delivery Rate TONS divided by Hours $\frac{1800}{10} = 180$ tons per hour.

Paving Width **12** feet Paving Depth **1½** inch



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Density CalculationsTarget Density **94 %**Gmm = **2.500** $2.500 \times 62.4 = 156.0$ lbs. per cu.ft.**156** $\times .75 = 117$ lbs/sq.yd/inch at 100% compaction**117** $\times .94$ % (target density) = **109.98** (**110**) lbs per inch per sq.yd**110** $\times 1.5$ inches thick = **165** lbs. per sq. yd @ at 94% density

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**Paver Production Rate at 85 % efficiency
(waiting for trucks, etc)****180** Tons per hour $\times 2000$ lbs. per ton = **360,000** lbs. per hour**360,000** divided by **165** lbs per sq. yd. = **2,181.8** (**2182**) sq.yds per hour**2182** sq.yds $\times 9$ = **19,638** sq ft. per hour**19,638** divided by **12** feet (width) = **1636.5** lineal feet per hour**1636.5** divided by **60** (min. per hour) = **27.275** (**27.28**) lineal ft. per minuteAverage speed of **27.28** fpm divided by efficiency rate of **.85** = **32.09** fpm

If we increase average speed by only 1.0 fpm. We would require an additional 6.6 tons per hour or 66 tons per day, that is 3 truckloads, and is why we run out of trucks. Computations below.

1 fpm $\times 60$ min/hr $\times 12$ ft / **9** sq. ft./sq. yd. = **80** sq.yds per hour,**80** $\times 165 / 2000 = 6.6$ tons per hour

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FIRST AID for Hot Asphalt Burns

KEEP COOL

ON-SCENE FIRST AID FOR ASPHALT BURNS

- Immediately address any Airway, Breathing or Circulation concerns and
- START COOLING**
- Do NOT remove asphalt from skin
- Leave burn uncovered
- Quickly place affected area under running/flowing water
- **Notify others**
- **Call for help # _____**

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ON-SCENE FIRST AID FOR ASPHALT BURNS

- Skin** (Do NOT delay)
- Immediately place the affected skin under running/flowing water for at least 20 minutes
 - Prolonged flushing/cooling is necessary
- Eyes** (Do NOT delay)
- Lay the person on their back
 - Flush with running water for at least 20 minutes by allowing the water to flow over the bridge of the nose to the eyes
- Urgent medical attention is required for burns to the face, eyes, hands, feet, genitalia and for circumferential or large burn areas.*

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Source: Asphalt Institute

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Last note: **Safety always comes first.** Here is recommended approach in case of asphalt burns. If policies disagree with the above information, check with medical personnel and get policy changed.

Module 6 – Review

- **Asphalt Paver**
 - Components and Function
 - Tractor and Screed Unit
 - Operational Principles of Screed
 - Grade and Slope Control Systems
- **Operating Techniques**
 - Initial Preparation
 - Operation
- **Paving Issues & Problems**

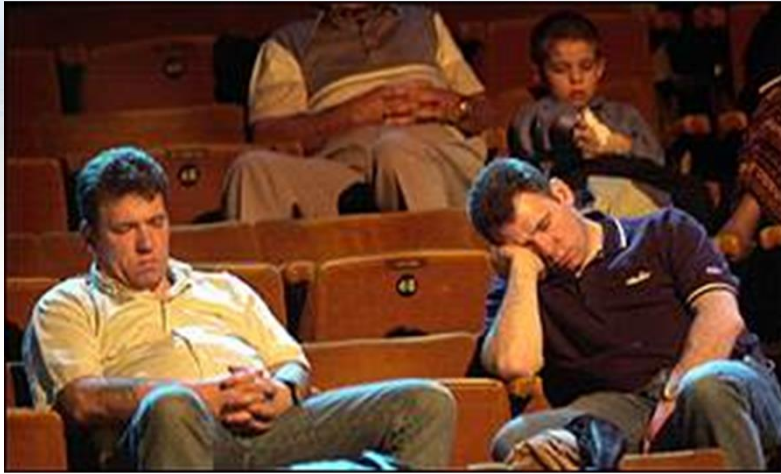


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Module recap!

Do we need another yield or production rate problem?

Are You Still With Me?



117



PennState

Discussion



pennsylvania
DEPARTMENT OF TRANSPORTATION



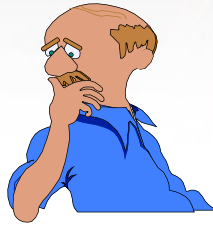
118

Quiz

Module 6

Placement

?



1. A paver consists of two units, a screed unit that supplies the power and a tractor unit to carry the mix.

- a. True
- b. False

Answer:

2. A tractor contains the following.

- a. Hopper**
- b. Conveyor**
- c. Auger**
- d. All of the above**

Answer:



3. The goal of the material feed system is to supply a constant head of unsegregated material in front of the screed through proper position of the gates and correct conveyor and auger speed

- a. True**
- b. False**

Answer:



4. The head of the material in front of the screed should be level endplate to endplate and just above the center of the auger shaft.

- a. True
- b. False

Answer:

5. Production of the mix by the plant, delivery of the mix by haul trucks, placement of the mix by the paver and compaction of the mix by the compaction equipment all need to be balanced in achieving the goal of a continuous operation.

- a. True
- b. False

Answer:

6. PENNDOT allows the use of both rigid screed extensions and hydraulic screed extensions.

- a. True**
- b. False**

Answer:



7. The hopper should be emptied and wings folded after each truck load of material.

- a. True**
- b. False**

Answer:



8. When changing the tow point or turning the thickness control crank, the paver has to move how far before the change is successful.

- a. two tow arm lengths
- b. four tow arm lengths
- c. five tow arm lengths
- d. none of the above

Answer:



9. Temporary paving needs at least the same level of attention to proper placement as mainline paving.

- a. True
- b. False

Answer:



10. Traffic control and safety is everyone's concern.

- a. True**
- b. False**

Answer:

Paver Production Calculation Form (An Example Scenario)

Date: _____ Project # (ECMS) _____

Project Location _____

Tons Scheduled for today: _____ Paving Hours scheduled: _____

Delivery Rate TONS divided by Hours _____ = _____ tons per hour.

Paving Width _____ feet Paving Depth _____ inch

Density Calculations

Target Density _____ %

Gmm _____ X _____ = _____ lbs. per cu.ft.

_____ X _____ = _____ lbs/sq.yd/inch at 100% compaction

_____ X _____ % (target density) = _____ (_____) lbs per inch per sq.yd

_____ X _____ inches thick = _____ lbs. per sq. yd @ at 94% density

Paver Production Rate at 85 % efficiency

(waiting for trucks, etc)

_____ Tons per hour X _____ lbs. per ton = _____ lbs. per hour

_____ divided by _____ lbs per sq. yd. = _____ (_____) sq.yds per hour

_____ sq.yds X _____ = _____ sq ft. per hour

_____ divided by _____ feet (width) = _____ lineal feet per hour

_____ divided by _____ (min. per hour) = _____ (_____) lineal ft. per minute

Average speed of _____ fpm divided by efficiency rate of _____ = _____ fpm

If we increase average speed by only 1.0 fpm. We would require an additional 6.6 tons per hour or 66 tons per day, that is 3 truckloads, and is why we run out of trucks. Computations below.

_____ fpm X _____ min/hr X _____ ft / _____ sq. ft./sq. yd. = _____ sq.yds per hour,

_____ X _____ / _____ = _____ tons per hour

TABLE A

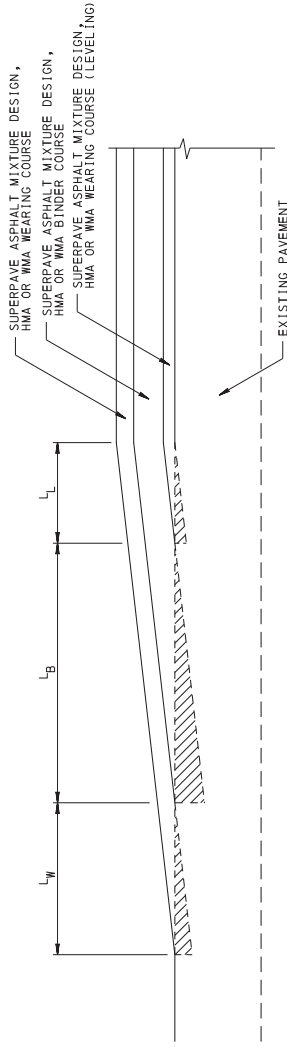
REGULATORY POSTED SPEED LIMIT (mph)	MINIMUM LENGTH OF MILLING		
	L_L	L_B	L_W
> 65	35'	80'	80'
≥ 55 TO < 65	35'	80'	60'
≥ 45 TO < 55	25'	35'	30'
< 45	15'	25'	20'

TABLE B

MIX	ENGLISH
SP9.5	$\frac{3}{8}$ "
SP12.5	$\frac{1}{2}$ "
SP19	$\frac{3}{4}$ "

NOTES

1. PLACE EDGE FINISH WITH EXISTING PAVEMENT AND SEAL AS SPECIFIED IN PUBLICATION 408, SECTION 408.31(K).3.
2. CONSTRUCT FLEXIBLE BASE REPLACEMENT IN ACCORDANCE WITH THE REQUIREMENTS OF PUBLICATION 408, SECTION 316.
3. PREPARE EXPOSED VERTICAL AND HORIZONTAL SURFACES AS PER PUBLICATION 408, SECTION 408.31(K).
4. FOR NON-OVERLAY APPLICATIONS, THE TOP $\frac{1}{2}$ " OF BASE REPLACEMENT WILL BE SUPERPAVE WEARING COURSE.
5. FOR RESTORATION OF RIGID PAVEMENT, REFER TO PUBLICATION 408, SECTION 516 AND RC-28M.
6. FOR SUPERPAVE BASE REPLACEMENT, SAW CUTTING, EXCAVATION, HAULING AND DISPOSAL, BITUMINOUS TACK COAT APPLICATION, CURING, SEALING AND SEALING OF THE JOINTS ARE CONSIDERED AS INCIDENTAL.

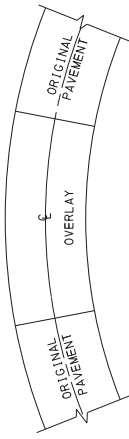


TYPICAL PAVING NOTCH DETAIL

LEGEND

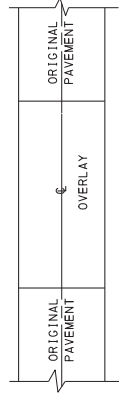
REMOVES AN AREA OF THE EXISTING PAVEMENT TO BE MILLED TO PROVIDE PROPER TRANSITION FOR THE NEW PAVEMENT COURSE. THE DEPTH SHOULD EQUAL THE NOMINAL DEPTH OF THE NEW PAVEMENT COURSE. THE LENGTH (L_L OR L_B) SHOWN FOR A LENGTH (L_L OR L_B) SHOWN IN TABLE A. THE VARIABLE DEPTH MILLING IS INCIDENTAL TO THE PAVING ITEM.

L_W = THE MINIMUM LENGTH OF EXISTING PAVEMENT TO BE MILLED FOR THE WEARING COURSE.
 L_B = THE MINIMUM LENGTH OF EXISTING PAVEMENT TO BE MILLED FOR THE BINDER COURSE.
 L_L = THE MINIMUM LENGTH OF EXISTING PAVEMENT TO BE MILLED FOR THE LEVELING COURSE.



PLAN VIEW

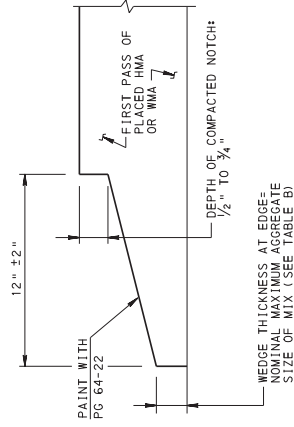
SUPERELEVATION SECTION



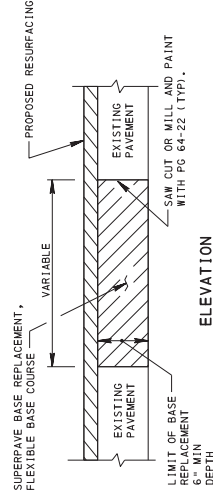
PLAN VIEW

TANGENT SECTION TWO-LANE TWO-WAY TRAFFIC AND TWO-LANE DIRECTIONAL

OVERLAY TRANSITIONS



LONGITUDINAL NOTCHED WEDGE JOINT



ELEVATION

SUPERPAVE BASE REPLACEMENT

SEE NOTES 3, 4, 5 AND 6.

**COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION
BUREAU OF PROJECT DELIVERY**

**OVERLAY TRANSITIONS
AND
PAVING NOTCHES**

RECOMMENDED SEPT. 15, 2016
Matthew P. Sedick
 CHIEF, INT. DELIVERY DIVISION

RECOMMENDED SEPT. 15, 2016
Robert J. ...
 DIRECTOR, BUREAU OF PROJECT DELIVERY

SHT. 1 OF 2
RC-28M



Asphalt Pavement Construction Program

Certified Asphalt Field Technician
Course of 2022

Module 7: Asphalt Paving Joint Construction



Asphalt Construction Program
Certified Asphalt
Field Technician - 2022

Module 7:
Asphalt Paving Joint Construction



Northern Center of Excellence
for Pavement Technology
NECEPT

 1

All pavements have one internal weakness – joints. It is difficult, however, if not impossible, to construct a pavement without any joints. Thus, the goal should be to make as few joints as possible and to construct them carefully and properly.

Module 7 - Objectives

- **Transverse Joints**
- **Longitudinal Joints**
- **Issues and Problems**
- **Relevant Specifications**

 2

Joint Construction

- **Transverse Joint**
 - Beginning & End of Project & end of day
- **Longitudinal Joint**





3

Longitudinal joints are between the lanes and are the weakest parts of the placed mats.

Poor Joint Construction

- **Premature Joint Cracking**
- **Raveling**
 - Crushed Aggregate
 - Lower Density
 - Segregation
- **Potholes**

*What is your biggest problem with constructing joints?
Have you experienced joint related failures in your projects?*


4

Improperly constructed joints will allow for the intrusion of water which will lead to moisture induced damage, fatigue cracking, and potholes. If not fixed, the joint failure may consequently result in total failure of the pavement.

Excessive overlap can lead to crushed aggregate which in turn will lead to loss of bond and raveling. Unnecessary luting, incorrect overlap, and improper rolling techniques can all lead to lower densities, raveling, and eventual failure.

Transverse Joint Preparation



- Milled Notch MUST be correct (RC 28)
- Requires skill.
- Some handwork necessary.
- “Leave the mix high” **WHY?**
- Compact immediately.



5

A transverse joint must be constructed across the pavement whenever paving starts or stops (at the beginning or end of the job) or suspended for the day. This joint must match the depth and cross slope of the existing pavement.

Tying into the existing pavement requires skill to ensure a smooth transition. There will be some handwork necessary to complete the joint, “leave the mix high” to allow for compaction. Hand-worked mix is looser than paver-laid mix and more difficult to compact. Compact this mix immediately. The longer time it takes to do hand work results in a cooler mix.

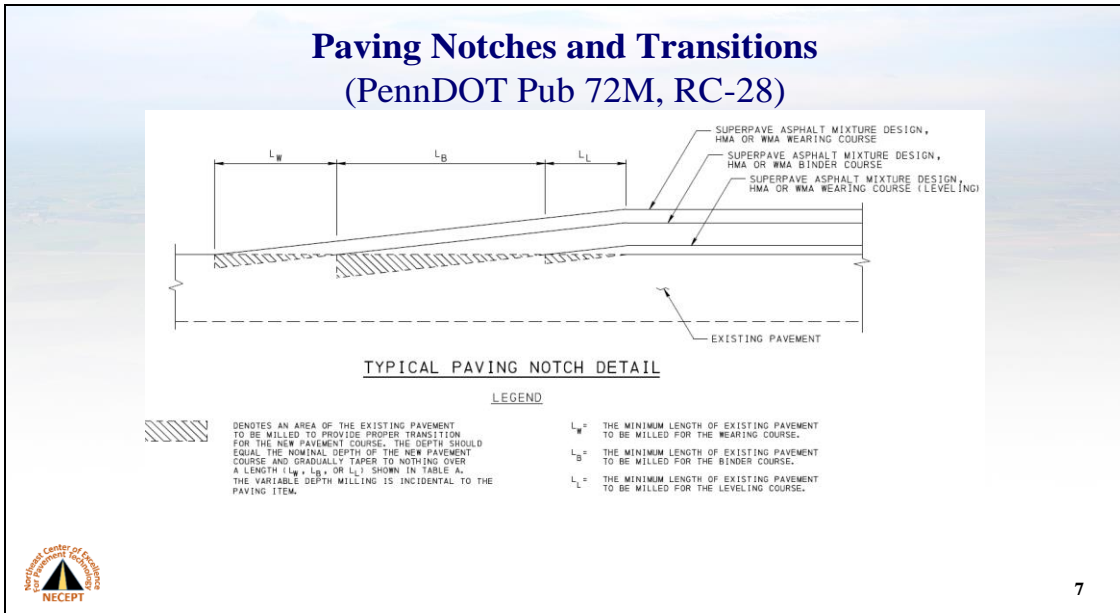
Transverse Joint

Section 413.3(g)3. Paving Notches. Mill the existing pavement surface at tie-in locations of the wearing course in accordance with the Standard Drawing RC-28M, or as otherwise indicated. Perform milling as specified in Section 491.



6

A properly milled **tie-in** will result in a smoother joint that is easier to construct and will be longer lasting.



Standards for Roadway Construction (RC) are provided in PennDOT Publication 72M. This publication must be consulted for details of any roadway related construction. Make sure paving notches are milled and material is placed at proper depths. Ensure that tapers (transitions) are long enough.

Paving Notches and Transitions (PennDOT Pub 72M, RC-28)

TABLE A

REGULATORY POSTED SPEED LIMIT (mph)	MINIMUM LENGTH OF MILLING		
	L_L	L_B	L_W
> 65	35'	80'	80'
≥ 55 TO < 65	35'	80'	60'
≥ 45 TO < 55	25'	35'	30'
< 45	15'	25'	20'

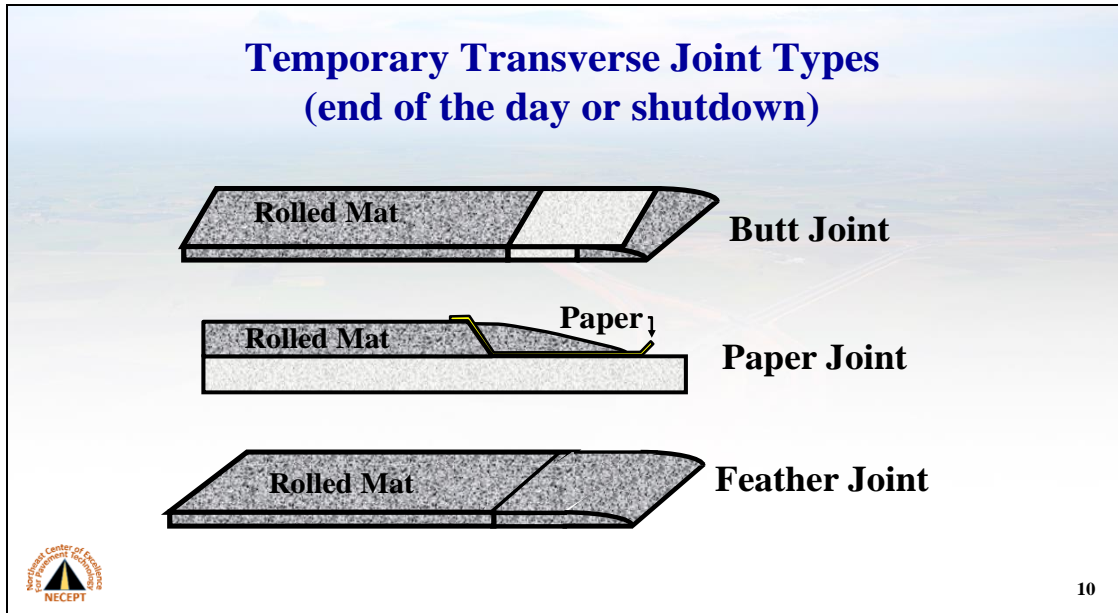
L_W = THE MINIMUM LENGTH OF EXISTING PAVEMENT TO BE MILLED FOR THE WEARING COURSE.
 L_B = THE MINIMUM LENGTH OF EXISTING PAVEMENT TO BE MILLED FOR THE BINDER COURSE.
 L_L = THE MINIMUM LENGTH OF EXISTING PAVEMENT TO BE MILLED FOR THE LEVELING COURSE.

8

Note that leveling, binder, and wearing notches may be of different length. This issue must be discussed at the pre-placement meeting as this milling is incidental to the material being placed.



One pass of mini-mill was certainly insufficient; note depth at arrow. An attempt to improve the ride was later made by installing a longer wedge, and later still, more material was placed at the edge of the structure. Three strikes!



Temporary transverse joints are needed whenever the paving operation is interrupted. This interruption and shutdown could be because of work stoppage at the end of the day or delay for reasons such as equipment breakdown or whether impact. If traffic will be allowed, the joint could be in the form of a vertical butt joint. If traffic will be allowed, a tapered joint with ramp must be built to allow safe transition.

In the first style shown in the schematics above, a board is placed at the end of the mat and next to the joint, followed by an end ramp to allow the equipment to get off the mat. Treated paper can be used instead of boards as shown in the second sketch. At a point where the mat is still uniform in thickness, the screed is lifted, and the paver pulls off. The mix is shoveled away from the joint location, and the paper or board is placed downstream of the joint. The mix is shoveled to form a ramp and the transition is compacted. The tapered (feather) joint typically requires a milling machine for removal of the taper and is the most common type in use today.

The length of a tapered joint depends on the thickness of the mat. The thicker the mat, the long the taper. Many agencies use a minimum ration of 12:1 for the length of the taper. For example, a compacted thickness of 2 inches would require at least a length of 2 ft. for the taper

Transverse Joint Location

**Use straightedge to determine where pavement thickness begins decreasing...
... and mark location of joint**



... and mark location of joint




11

If a tapered transverse joint has been constructed, the mix in the taper must be removed and discarded before paving can be restarted. Whether using a tapered transition for a butt or papered joint, a straight-edge must be used to ensure that the joint will be in full-depth material and have the proper profile. If the straightedge indicates that the previously placed mat is not level at the pre-formed transition, the location of the transverse joint must be moved back upstream to a point where the pavement layer is of the proper thickness and smoothness. A 30 to 50-ft string line will ensure a smoother joint. Maintaining a proper head of material yesterday will result in removal of less cold hard material today.

Where will these joints get cut tomorrow?



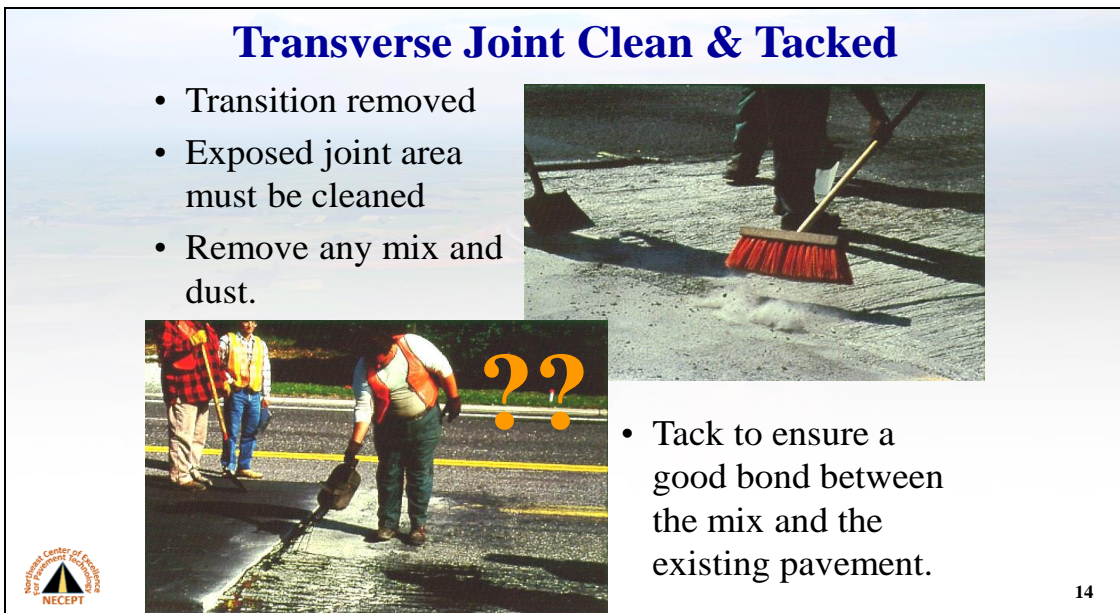


12

Notice the marks on the mat from screed and extensions. What could have caused them? How long did the paver sit with augers running while the hopper was cleaned? Where the screed vibrators still on?



Before construction of the new mat resumes, a cold milling machine can be used both to form the vertical edge of the transverse joint and to remove the unwanted mix. This contractor is using a small milling machine to create a vertical edge where the larger milling machine left a ramp at the structure. Note the high strip left at bottom right. Care must be taken to create a clean, vertical transition, **AT THE PROPER DEPTH**, for starting the paving operation.



After the transition has been removed, the exposed joint area must be thoroughly cleaned and properly tack coated to ensure a good bond between the new mat and the existing pavement. Is the bottom photo depicting good practice?

QUESTION: How many distributors have a working hand hose?


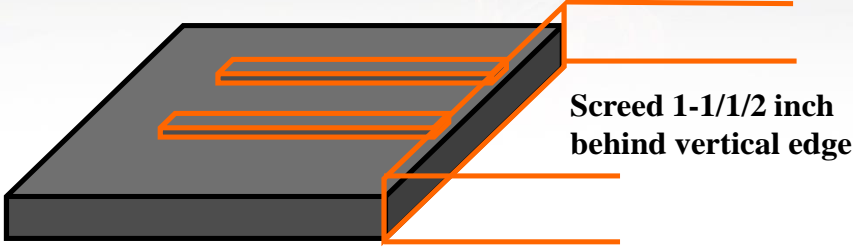
Excessive tack at joint with dry streak and none on vertical edge




Backing up to a joint with a distributor or turning the bar on, and then taking off leaves excessive tack with none on the vertical edge. This is the proper place for a hand hose.

Transverse Joint Positioning Paver Screed

Raise the screed **1/4 in. per 1 in. of depth** (compacted mat thickness) to allow for rolldown

**Screed 1-1/2 inch
behind vertical edge**



16

As a rule of thumb, for every one-inch compacted thickness, the loose mix must be roughly 1 1/4" thick. In other words, once the mix is rolled and compacted, is expected to densify for roughly 20 percent (20 percent of 1 1/4" inches is 1/4" inches). Therefore, the paver screed must be placed on a set of starting blocks or strips of woods on the upstream side of the transverse joints. These blocks should be 1/4" thick for every inch of compacted mat (For example, 1/2" thickness is needed to have a compacted mat of 2 inches. Rolldown may differ for some mixes. After the screed is set on the blocks, check the initial paver settings and start-up procedures. **Pull off the blocks and bring the paver up to the laydown speed as quickly as possible.** For a screed with extensions, you will need more blocks.

The screed should be properly nulled (twice, if necessary), and placed 1 1/2 inches on the upstream side of the transverse joint, which should have been cut perpendicular to the lane being paved. The head of material should be equal across the auger centerline before pulling off from the joint. If the paver starts out on the correct blocks and the screed begins with a full head of material, the thickness of the downstream mat will be correct.

Luting the Joint

If the paver screed is properly positioned, only the material on the old mat will need removed with no material required to be added to hot matminimize luting.



Transverse Joint Luting



- Minimize luting
- Never a reason to lute joint excessively.
- Remove any excess coarse material
- DO NOT broadcast material back onto the mat.

Notice material in front of lute and already on the mat.



Transverse Joint Initial Smoothness



- Ride quality should be checked **BEFORE** compaction.
- Straightedge rests on uncompact mat, extends over the compacted mat by the thickness of boards



19

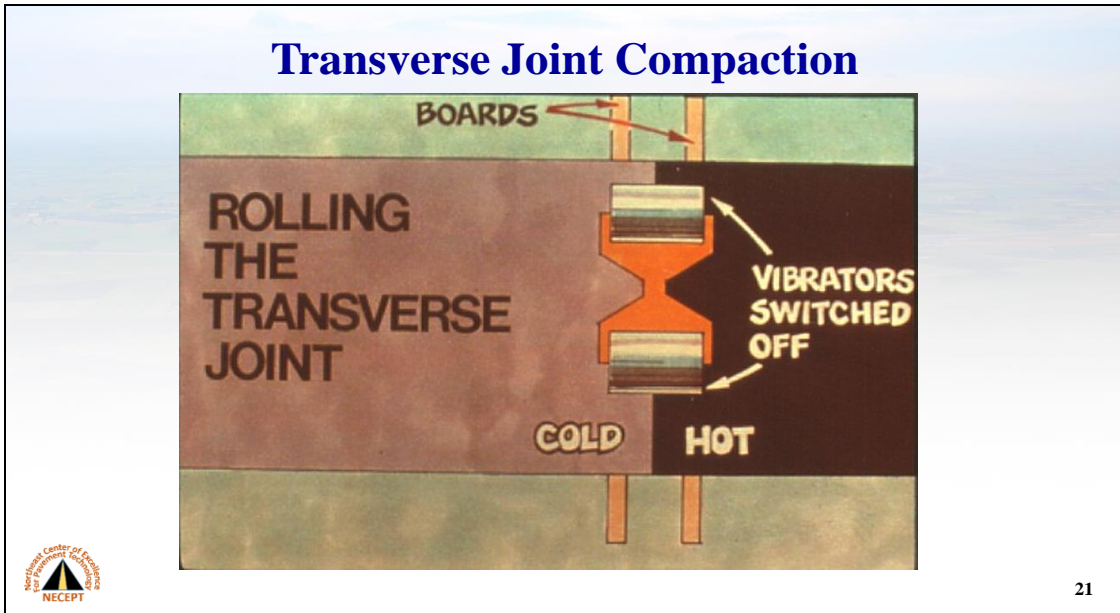
As the straightedge rests on the uncompact mat, it should be *parallel* to the existing mat and rest completely on the starting shims or boards which should be of an equal thickness to the amount of rolldown, 1/4" per one inch of depth (compacted thickness).

Profile Check at Transverse Joint



20

Poor positioning/nulling of the screed will result in a LOT of handwork, cooling of the mat, a rough riding transition and reduced pavement life at the joint.



Ideally a transverse joint should be compacted in the transverse direction. If traffic and conditions allow, use runoff boards to support the roller as it moves beyond the longitudinal edge of the pavement, and to allow the roller to make the first pass in the transverse direction.

Although this may be the ideal condition, it may not be possible because of shoulders, curbs, guide rail, geometrics, and maintaining traffic.



This photo shows a roller at a transverse joint at a bridge approach rolling across the lane transversely.



If required to roll longitudinally, get the breakdown roller on the mat **as soon as possible**. Have the roller pass slowly and completely onto the mat with the driven drum leading, before reversing direction. If the joint is constructed properly, the compactive effort needed will be no different than that needed for the rest of the mat. Single drum vibratory rolling onto the mat for the first pass and NOT vibrating back into the joint will help maintain the profile as placed. At the end of project, you may need to match wheel ruts. Transverse rolling is about the only effective method to achieve a ride.



Field conditions may prohibit transverse rolling with full sized roller, but many contractors have a small roller on site to pinch the joint and “pinch and “half-lap” roll to improve joint construction and enhance the ride.



After the first compaction coverage is complete and before the mix has cooled, use a straightedge again to check the level of the joint.



A joint that is laid to the proper depth can be ruined by vibrating back into the joint or structure. Vibrating slowly and pounding the mat into submission will NOT correct a poorly placed joint and may well ruin one that is properly placed!!!!!!!

Longitudinal Joint




- **Various types**
 - Vertical (Butt) Joint
 - Notched Wedge Joint
 - Cut Vertical Joint (which creates a vertical butt joint)


27

A longitudinal joint is formed when a new mat is placed against an existing mat. The most common types of joints are the vertical joint, the notched wedge joint, and the cut vertical joint.

Vertical or Butt Joint


Hot Lane



Cold Lane



- Commonly used joint
- Good performance

“PennDOT Approved”

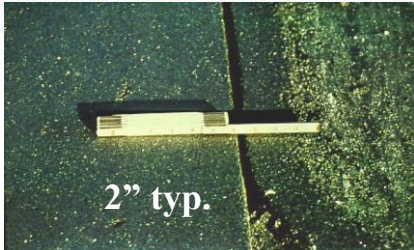

28

The vertical joint, or butt joint, has been used for many years and continues to perform well if care is taken during construction.

Cut Vertical Joint

- Joint “cut back”
- Good performance
- Most costly
- Need to remove & recycle excess



2” typ.

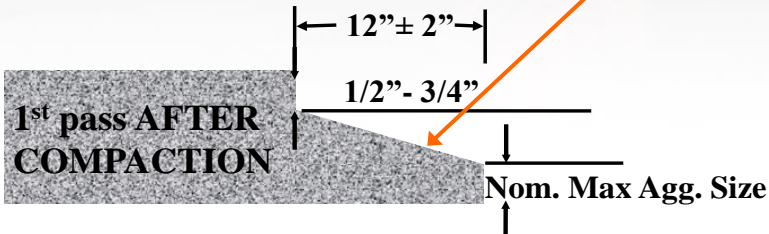
29

One of the better longitudinal joints is the cut vertical joint, but cut joints cost more. Over the years the best way to get the required density in an airport joint was to use the cut joint. When used on highways, safety becomes a concern in removing the material from the cut joint. Some specs require the joint to be “cut back” 1 to 2 inches before the next mat is placed. This can be done with a saw, or a cutting wheel attached to a grader, roller, or loader. The purpose of this work is to remove the part of the mat that may have less density than the rest of the mat due to lack of confinement during compaction. If traffic will not be passing over the mat, cutting back the joint while the mix is still warm requires less effort. The successful use of the cutting wheel depends upon the skill of the operator.

PA’s Notched Wedge Joint


For asphalt mixes with nominal max aggregate size of 19.0 mm or less

Pub 72M, Standard RC-28



1st pass AFTER COMPACTION

Paint total joint face with PG 64 -22



30

This profile of first pass is after rolling, not “as laid”.



Joint looks good, but tack coat should be visible beyond the edge and in front of the paver.



Longitudinal Joints



**New
Interlocking
Joint
or
“Zipper
Joint”**

What happened here?



33

One of the worst Longitudinal Joints ever constructed. “It’s only base”??????????

Why New Procedures?

Common sight on Pennsylvania Highways



34

The evidence of longitudinal joint premature failure can be found everywhere throughout our transportation system. These conditions demand our attention to improve our construction procedures for longer lasting pavements and lower maintenance costs.

First Winter Results of Poorly Constructed NWJ



35

Temperature segregation from the varying depth of material at the NWJ can cause problems. A consistent tack application that is wider than the paving panel INCLUDING THE NWJ is critical for success!!!

Longitudinal Joint Construction PennDOT/PAPA Training Video

Watch the Video



36

Recap of Video

- Plan ahead to avoid joints whenever possible
- Offset joints 6" from previous layer
- TACK must be 6" wider than pavement
- First Pass MUST be straight
- Overhang Roller 3-6" on unsupported edge



37

Recap of Video –Second Pass

- Lightly coat entire surface of NWJ or vertical joint with 64S-22 or Asphalt in mix
- Paver should overlap previous lane by 1-1/2 inches
- Depth of overlap should match rolldown
- NO LUTING or RAKING



38

Recap of Video –Second Pass Compaction

- Compact from edge toward joint.
- Leave about 18 inches of uncompacted material at NWJ.
- Last pass overlaps Longitudinal joint by 2-6 inches.
- Joint must receive as many passes as the rest of the mat.



39

Longitudinal Joint Construction

1) Plan work to minimize longitudinal joints

- No joint always superior
- Utilize paver extensions when practical & cost effective
- Pave in echelon (two pavers) creating a hot joint for superior performance
- Does this joint need TACK?

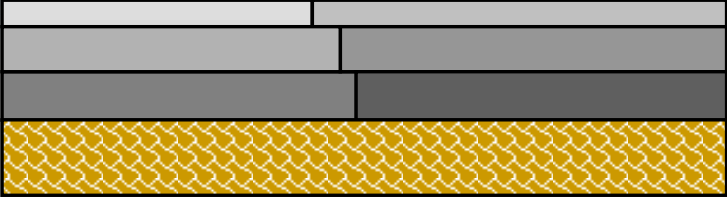


40


Echelon paving is when two pavers are running next to one another. The cold joint between the two paving lanes is eliminated and tack coating the joint is not needed. Properly lapped and compacted, this longitudinal joint is difficult to see, and density in this joint will be similar to the density of the adjacent mat. Because of the need to maintain traffic and the need to minimize user delays, however, echelon paving is primarily confined to new highway construction and airports.

Longitudinal Joint Construction

2) Offset joints from layer below by 6”



Where should the top surface joint be located?



41

Scratch/leveling is not a layer

Longitudinal Joint Construction

Offsetting joints:

- Avoids plane of weakness down through pavement layers
- Locate surface joints near centerline but off of line striping locations





42

Offsetting joints increases the pavement strength in joint areas and prevents water penetration down through the entire pavement system if the surface joint opens.

Longitudinal Joint Construction

- **1st pull of paver leaves unsupported edge**
 - Needs to be clean, straight, uniform
 - Will have lower density than rest of mat

43

Unsupported edges create a potential weakness in the finished pavement, and it must be handled carefully to minimize problems. It takes less effort to construct the joint properly than to repair it later!!

What We Don't Want




44

This is a prime example of what we do not want. Attempting to maintain a constant overlap when laying the adjacent lane will be nearly impossible, resulting in a poor performing joint. The sign on the right is certainly true!!

First Roller Pass on Outside Edge REMEMBER

**Rolling Uncompacted Edge
(First Paver Pass)**

Vibratory Roller

Edge of drum on the unsupported edge

**These methods can cause
cracking and lateral
movement of unsupported
edge**

**Rolling Uncompacted Edge
(First Paver Pass)**

Vibratory Roller

Edge of drum inside unsupported edge

45

Although there has been extensive research investigating differences in accepted methods of rolling the joint, the methods shown above have been determined to not give consistent superior performance experienced by the overlap method.

PA's Notched Wedge Joint Placement Requirements

**Paint TOTAL joint face
with PG 64 -22**

**1st pass AFTER
COMPACTION**

46

This profile of first pass is after rolling, not “as laid”.

Longitudinal Joint Construction Placement Requirements

- 5) Paint joint faces with PG 64 -22 binder**
- Or PG in mix
 - Thin even application
 - Helps bonding, waterproofing and filling voids



47

Longitudinal joint faces shall be painted with a PG 64S-22 asphalt or the PG binder used in the mix to help fill voids and create a better bond and waterproofing. For a notched wedge joint, the entire face of the joint including the top vertical surface, the beveled wedge and the lower vertical surface should be painted.

PAINTED means THIN application of the binder.

What we don't want




48

Entire surface of NWJ is not covered. Also note the lack of a notch at the top of the notched wedge joint.

Longitudinal Joint Construction
Placement of 2nd Pass Requirement


6) Overlap 1-1½” onto cold mat coming out of paver screed

- Paver augers should push mix up tightly against face of joint NO ROLLDOWN



49

Set the screed end plate properly on the cold lane and produce a clean tight joint with an overlap of 1 to 1½ inches. The end plate should be in contact with the surface and leave a tight edge. Eliminate rolldown and segregation!!

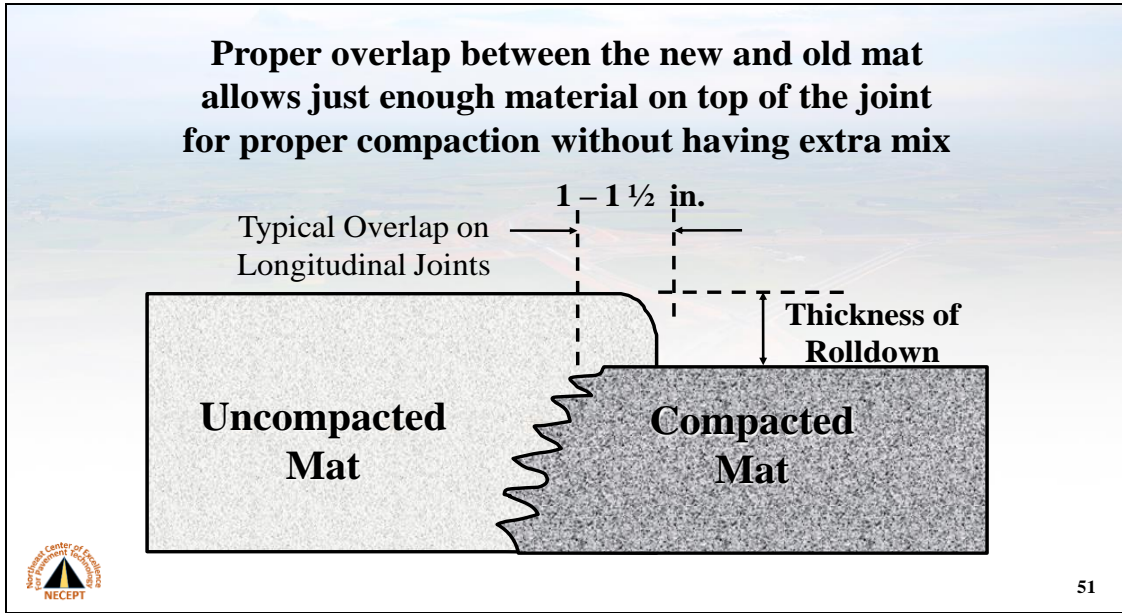


Proper overlap of longitudinal joint

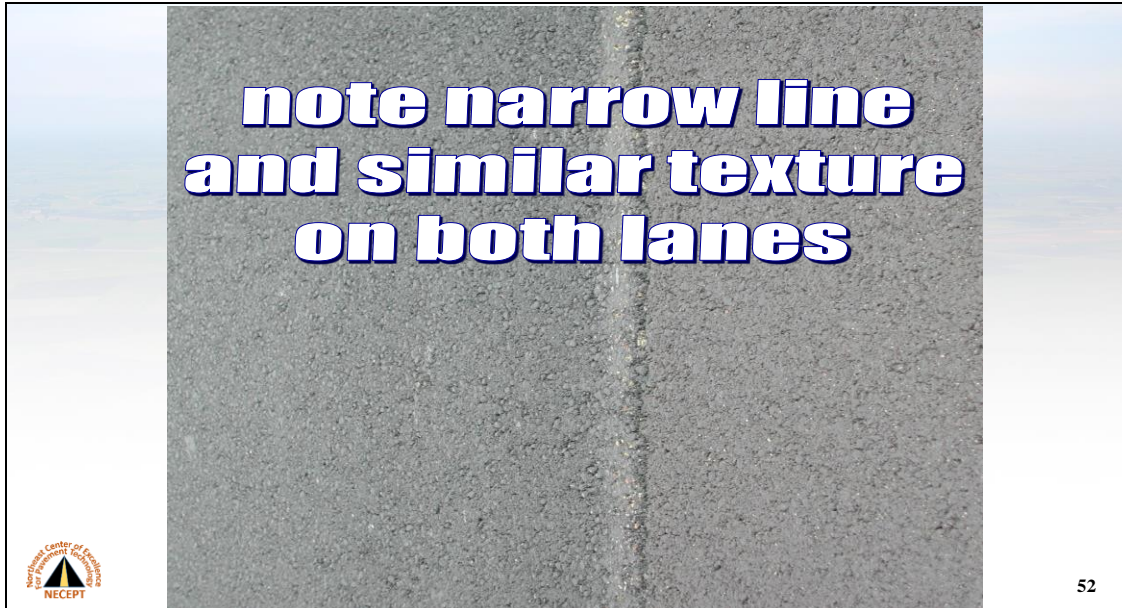
1” to 1 ½” as given in Section 413.3 k,1.a

50

Note the joint matcher and PG binder at the edge of the mat.



Overlap is 1-1 ½ inch whether both vertical joint and NWJ.



The white line caused by crushed aggregate should be narrow (2” or less) and some of it should be on the hot side of the joint!

Longitudinal Joint Construction

**Do not “bump” material, NO Luting-----
just roll overlapped material into pavement**




53

DO NOT bump the material back to the joint with the lute. This was the standard practice in the past. The material, once laid, will simply be rolled into the pavement. This method has proven to provide good density.

“DO NOT”



Do Not Bump Mix Back to Joint

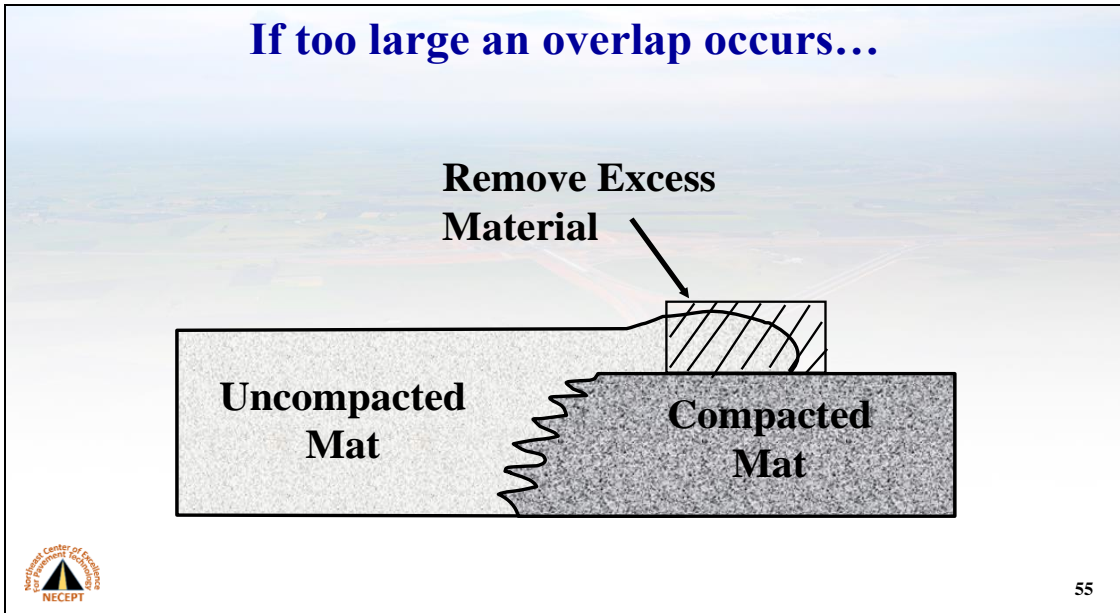



Do Not ‘Cast’ Mix back over Mat



54

If the amount of material is properly placed, “bumping” of the mix with the lute will not improve the joint density or performance. This action of luting flattens the joint, pushing all of the coarse aggregate away from the joint and onto the mat and will produce both a poorly performing and an unsightly joint. The first paved lane at the unsupported edge will have lower density than the remainder of the mat. When the second mat is placed and then over-luted at the joint, the material that could have been forced down into the joint to increase the density has been now removed and is no longer there. Now, both sides of the joint have low densities and will be prone to raveling. In the photo, the joint failed and the area was cut out and reconstructed.



If too large an overlap occurs, the excess material needs to be removed prior to compaction rolling. **DO NOT** lute the excess material across the mat.



Material was not placed according to the rule of 1/4” per 1” of rolldown at the joint.

Obvious Bridging from Excessive Overlap and/or Starved Joint



57

Note drum cuts on the second mat.

Rolling Longitudinal Joint



58

Note width of un-compacted mat at centerline.

Finished Joint Appearance

This method results in a crushed stone line that is mostly cosmetic and will wear off in time



59

On NWJ, some of the white line should be on hot side of mat and both lanes should appear to have the same texture, if not, bridging may be an issue.

Joint Construction Issues

Filling the joint fully and getting good density is what's important for good performance.

White line of crushed aggregate is excessively wide.



60

NOTE width of white line.

Joint Construction



Remember!
Properly set up, the transverse and longitudinal joints will need minimal handwork.



61

Uniformity in depth and overlap depend on a true line of paving with the first pull of the paver.

Issues and Problems in Joint Construction



62

All pavements have one weakness, and that is joints. Joints in asphalt pavements probably cause more problems than any other area.

Problem

- Insufficient material to form joint or cold lumps at endplate
- Left open too long?



notched wedge joint?



Longitudinal Joint Tight Joint – no luting / handwork



Good joint construction will reduce the need for any handwork or luting.

NEW “quick adjust” NWJ



65

Minimize Number of Joints Shoulder joint eliminated



66

Of course, the best construction will have the least number of joints. Care must be exercised when rolling joints and roadway when placed as in photo. A split or tear may be caused by roller action at the break.

Module 7 - Review

- **Joint Types & Construction**
 - Transverse Joints
 - Longitudinal Joints
- **Issues and Problems**



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Module recap



PennState

Discussion



pennsylvania
DEPARTMENT OF TRANSPORTATION



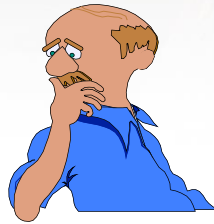
68

Quiz

Module 7

Joints

?



1. Proper compaction of the joints is achieved only when density near the joint is equal to density of the mat.

- a. True
- b. False

Answer:

2. On rolling an unsupported edge of a newly laid mat, the roller should

- a. Roll with the edge of the drum directly in line with the edge of the mat
- b. Stay back from the mat edge by 6 to 12 inches
- c. Overhang the edge of the mat by 3 to 6 inches

Answer:



3. When starting to pave from the transverse joint, which of the following apply to the screed?

- a. Needs to be heated
- b. 1" to 1 ½" behind the vertical joint edge
- c. Raised approx. ¼" per inch to account for roll down
- d. All of the above

Answer:



4. Which of the following is NOT a good practice for proper longitudinal joint construction?

- a. Ensure the joint receives at least as many roller passes as the mat**
- b. Keep the joint face free of PG binder**
- c. Make a straight first pass of the paver**
- d. Offset joints by 6" from the layer below**

Answer:



5. When paving in echelon the longitudinal joint remains hot enough to ensure a tight joint and does not need to be tacked.

- a. True**
- b. False**

Answer:



6. PENNDOT specifications allow the use of two longitudinal joints, the vertical (butt) joint and the notched wedge joint.

- a. True
- b. False

Answer:

7. A transverse joint is required by the specifications to be rolled in the transverse direction.

- a. True
- b. False

Answer:

8. PENNDOT specifications call for the location of longitudinal joints in multiple layers be offset by

- a. 2 inches
- b. 3 inches
- c. 6 inches
- d. 12 inches

Answer:



9. A typical overlap in forming the longitudinal joint is

- a. 1 inch
- b. 3 inches
- c. 6 inches

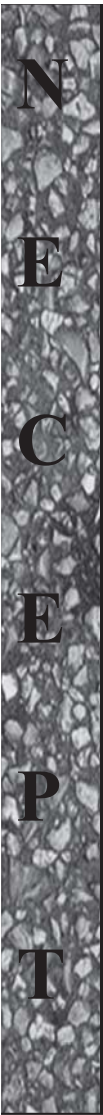
Answer:



10. Luting of a longitudinal joint should be emphasized to broadcast the material back over the hot mat.

- a. True**
- b. False**

Answer:



Asphalt Pavement Construction Program

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Course of 2022

Module 8: Compaction



Asphalt Construction Program

Certified Asphalt Field Technician - 2022

Module 8: Compaction



1

A good mix will perform poorly under traffic if it is not compacted to the proper density.

Importance of Compaction

- **Compaction is the single most important factor that affects the performance of Asphalt Pavement***

- ***Asphalt Paving Handbook**



2

Module 8 - Objectives

- **Terms & Definitions**
- **Importance of Compaction**
- **Factors Affecting Compaction**
- **Equipment**
 - **Types of Rollers and Maintenance**
- **Operating Techniques**



3

Compaction: Related Definitions

- **Density:** A measurement of the weight of material that occupies a certain volume of space (lb./ft³)
- **Compaction:** A process to reduce the volume of the mix through compression
- **Pass:** The entire roller moving over one point in the mat one time
- **Coverage:** The roller moving over the entire width of the mat one time
- **Time Available for Compaction (TAC):** The time in minutes that a particular mix is in the right temperature range for effective compaction



4

Knowledge of these terms is essential for successful compaction practices.

Compaction Importance

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



5

Compaction is what makes a highway out of asphalt!

4 Primary Factors Affecting Compaction

1. Properties of the Materials

- Aggregate size and shape
- Asphalt binder (Cement)
- Mix properties
- Lift thickness versus aggregate size

2. Environmental Variables

- Air and base temperature
- Mix lay-down temperature & layer thickness
- Wind velocity
- Solar flux



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4 Primary Factors Affecting Compaction

3. Laydown Site Conditions

- Lift thickness uniformity
- Existing Surface Condition

4. Compaction Equipment

- Type of Rollers
- Maintenance
- Operations

7

Laydown site conditions also include existing surface texture, profile and stability. Compaction equipment must be properly sized for the project and be able to effectively handle the material

Aggregates

Carry the Load!

Important Properties:

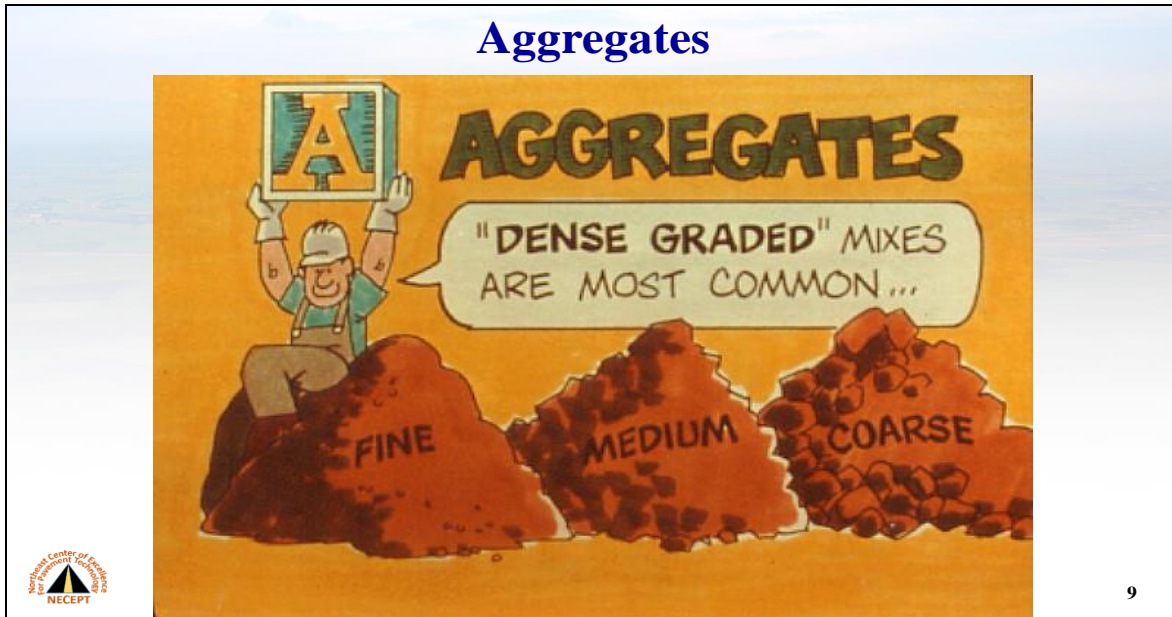
- Particle Shape
- # fractured faces
- Surface texture

**Quarried
Aggregates**

**Crushed
Gravel**

**Rounded
Gravel**

Aggregates vary greatly in properties such as surface texture, porosity and particle shape. Aggregate may be natural (limestone, sandstone, granite, shale, dolomite, quartzite, etc.) or manufactured (steel or blast furnace slag). *Angularity of aggregate particles, crushed material content, nominal maximum size, gradation, and hardness* control the amount of compactive effort to achieve density. **Aggregate is “the rock that carries the load.”**



Dense graded mixtures are the most common types of asphalt mixtures used in pavements worldwide. Dense graded mixtures are comprised of coarse, medium and fine aggregate particles. However, mixtures with other aggregate gradations are also used in asphalt mixtures. For example, some Superpave mixes tend to be coarser. Stone Matrix Asphalt (SMA) is a gap-graded mixture that also tends to have a much larger proportion of coarse aggregate.

Skid Resistance Level (SRL)

PennDOT Pub 242, Table 5.4
SRL CRITERIA



INITIAL OR CURRENT ONE-WAY ADT	INITIAL OR CURRENT TWO-WAY ADT	SRL DESIGNATION
Above 10,000	Above 20,000	E
2,501 – 10,000	5,001 – 20,000	H; Blend of E and M; Blend of E and G
1,501 – 2,500	3,001 – 5,000	G; Blend of H and M; Blend of E and L
501 – 1,500	1,001 – 3,000	M; Blend of H and L; Blend of G and L; Blend of E and L
0 – 500	0 -1,000	L
* E = Excellent, H = High, M = Medium, L = Low		

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Skid Resistance Levels (SRL) for aggregates are specified according to the ADT (Average Daily Traffic). A higher ADT, requires a harder aggregate with a higher skid resistance level. This design Table shows the required SRL Designation and blends for the aggregates for the different ADT levels.

Asphalt Binder

- Holds (binds) particles together
- Prevents air and water intrusion into mat
- Lubricates the mix during compaction

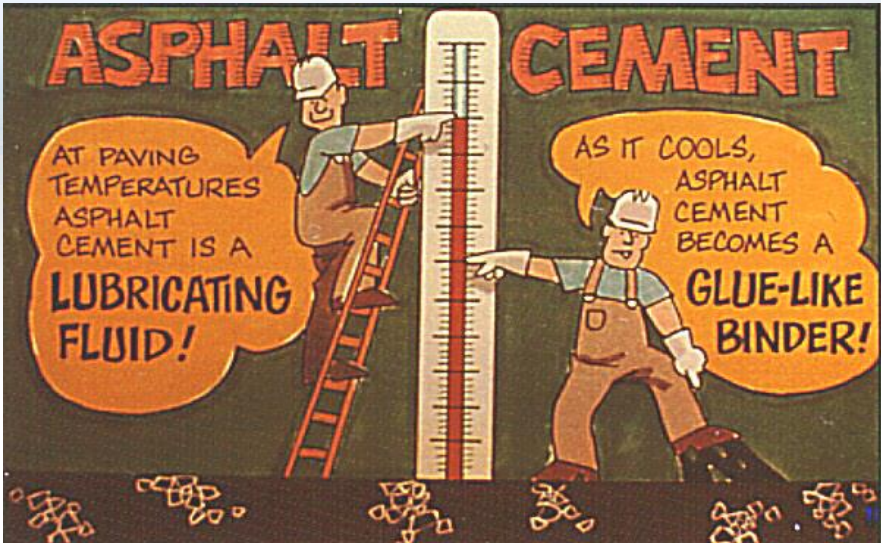
Can of Asphalt Binder



11

The grade (stiffness) and amount of *asphalt cement* (binder) affect our ability to densify the mix. As the binder becomes stiffer (for example, using PG 64E-22 instead of PG 64S-22), it will require higher mix temperature to assist with workability of the mix and the compaction process to achieve density. In some cases, higher grades of binder require modification of the binder with polymers, and often this modification increases the compactive effort needed to obtain density.


Asphalt Binder



ASPHALT CEMENT

AT PAVING TEMPERATURES ASPHALT CEMENT IS A LUBRICATING FLUID!

AS IT COOLS, ASPHALT CEMENT BECOMES A GLUE-LIKE BINDER!



12

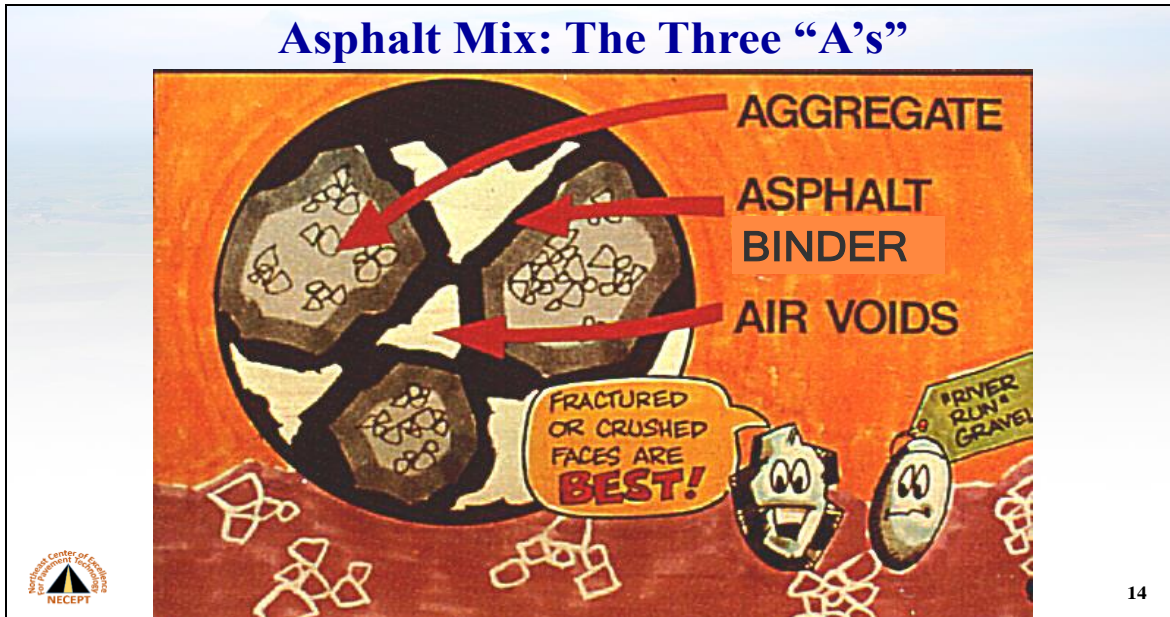
Simplified Theory

You need to push wiggle and jostle the aggregate materials tightly together in the brief time that the mix remains hot enough to allow the asphalt material to act as a lubricant.



13

You may experience a tender zone, or “zone of awareness” within a certain temperature range with each mix. You must learn to identify and work with this characteristic. Document parameters, techniques and results for future reference.



14

Asphalt paving mixture after compaction is made of three components: aggregate, asphalt, and air voids. The densification behind the rollers typically delivers between 3% and 8% air voids for a properly designed mix. A mix that is placed at a higher temperature will compact differently than a mix that is laid at a lower temperature.


Mixture properties vary based on the type of mixture specified. Type of mixture specified varies directly with traffic loading (Equivalent Single Axle Loadings, ESAL). Properly designed and compacted mixtures are a must in delivering a durable long-lasting pavement. A good asphalt pavement has acceptable range of air void, high strength, and adequate flexibility to stand expected traffic load.

The amount of asphalt plays a significant role in the way the mix gets compacted as well as how it performs long term. In general, a mix with lower asphalt content (also referred to as dry or lean mix) will be stiffer and may require an increase in compactive effort, whereas a mix with higher binder content (also known as wet or rich mix) will be more flexible and may require a decrease in compactive effort. The amount of asphalt must be designed properly to deliver performance. Too little asphalt makes the mix brittle and susceptible to raveling and cracking. Too much asphalt makes the mix susceptible to shoving under the rollers and rutting, shoving, and bleeding later under traffic.

Asphalt Mix – Layer Thickness

- **Uniformity**
 - Maintain uniform thickness
 - Uniform compaction helps with uniform thickness.
- **Thickness is Limited by Nominal Maximum Aggregate Size**
- **Rule of Thumb:**

Minimum layer thickness = 3 to 5 times the nominal maximum size of the aggregate




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Acceptable density is easier to obtain in an asphalt layer that has a constant thickness as covered in module 3.

Thickness of Superpave Mixes

Mix	Minimum Lift (in.)	Maximum Lift (in.)
6.3 mm	0.75	1.25
9.5 mm FG*	1.0	1.5
9.5 mm	1.5	1.5
12.5 mm	2.0	2.0
19.0 mm	2.5	3.0
25.0 mm	3.0	5.0
37.5 mm	4.5	8.0

*fine grade



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Scratch or leveling courses are routinely less than the 1.5 inches thick and suggested for placement with a 9.5-mm mix.

Environmental Variables Affecting Rate of Cooling

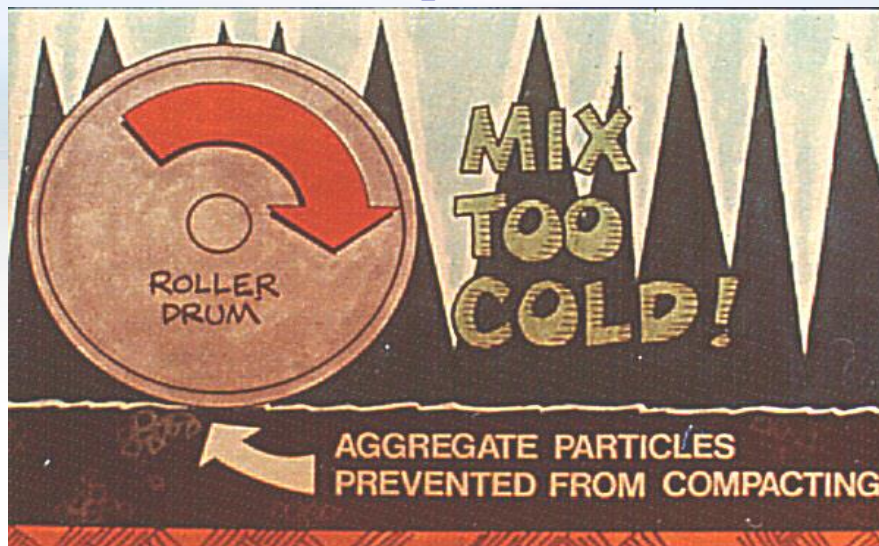
- Layer thickness
- Air temperature
- Base temperature
- Mix temperature
- Wind velocity
- Solar flux



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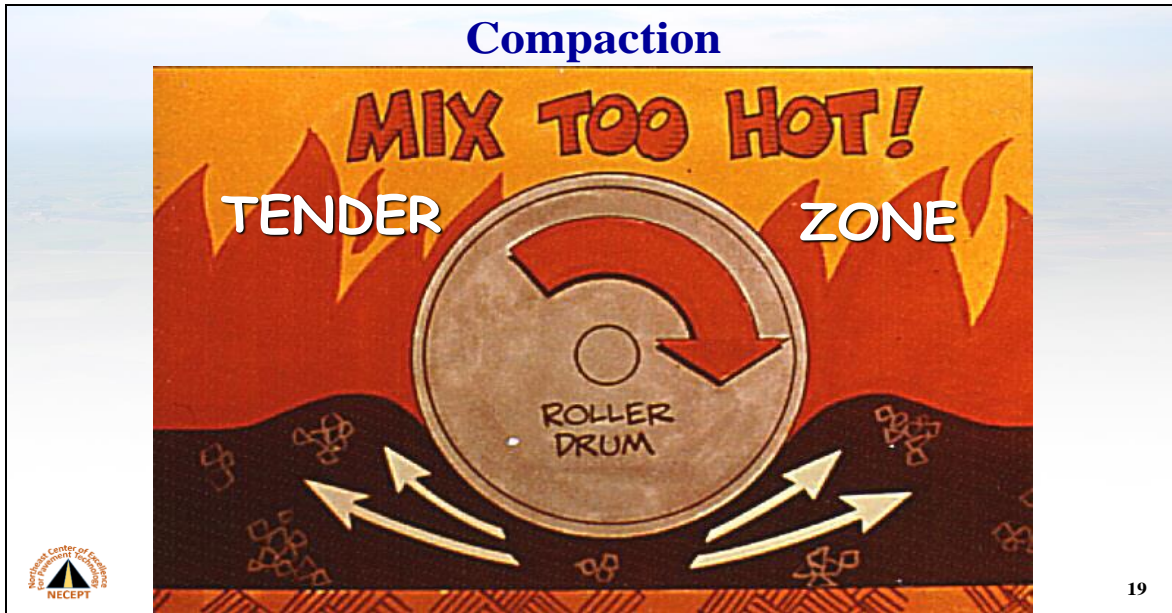
Research work and field experience show that once an asphalt pavement cools to a certain temperature, the internal friction and cohesion of the mix increases to the point that little density gain is achievable. With Warm Mix Asphalt (WMA), because of the viscosity reducer effect in the mix, it is possible to get to lower temperatures compared to conventional hot mix asphalt before gaining density stops.

Compaction



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If the mat is too cold, the asphalt binder's viscosity increases, and the binder loses its lubricating ability. The result is that the aggregate particles are prevented from compacting further. At low temperatures, the asphalt is already acting as a glue to bind the aggregate particles in place, rather than providing lubrication to the aggregates for further movement.



If the mat is too hot, the roller will just move the mix around and cannot compact the mix. Bow waves will appear in front of the roller drum. This can also happen during the ‘tender zone’. Tender zone, in regards to Superpave mixes, will be discussed in detail later in this module.

Time Available for Compaction (TAC)

Major Factors Affecting Rolling Time	allows MORE time	allows LESS time
Mat Thickness	THICK	THIN
Mix Temperature	HIGH	LOW
Base Temperature	HIGH	LOW
Warm Mix Additive	YES	NO

The NECEPT logo is located in the bottom left corner of the table area, and the number '20' is in the bottom right corner.

TAC is affected by mat thickness, mix and base temperatures, and WMA additives. If a thin Asphalt mat is being laid with a low mix temperature and a low base temperature, all the factors are working against you. Asphalt mixes produced between 270°F and 325°F can lose from 5°F to 25°F or more from the plant to the paver. Higher placement temperatures = more TAC. WMA additives have been demonstrated to extend time available for compaction.

Wind and Excessive Water can cause “Checking”

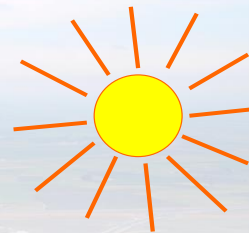


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A thin layer of mix will cool more quickly in a strong wind which has a greater effect at the surface of the mix than within the mix. This can cause the surface to cool so rapidly that a crust will form and ‘checking’ of the asphalt may occur and may actually create a sliding condition that will separate the mix into layers as in this case. Excessive water on the roller drums will cause a more rapid cooling through evaporation, and can even result in longitudinal tears in the mat. This can also occur when paving over water on the underlying surface.

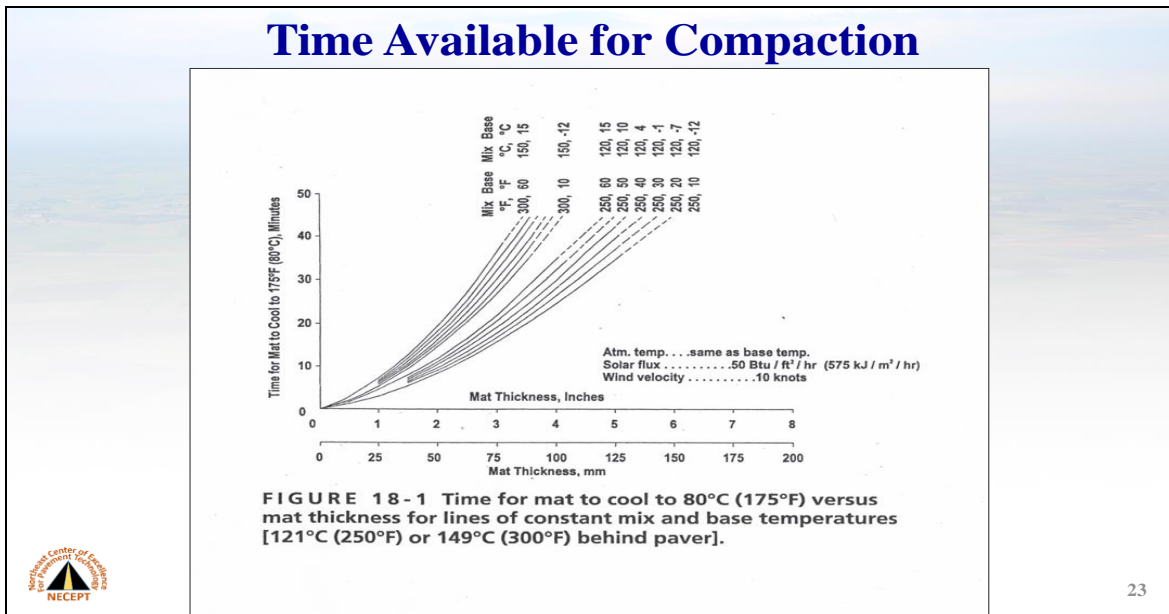
Solar Flux

- **Radiant energy from sun**
 - Position of sun above horizon
 - Distance of project above sea level
 - Amount of haze in air
 - Degree of cloud cover



22

Solar flux relates to the amount of sunshine, a mix will cool more slowly on a sunny day than a cloudy day. The amount of solar flux has a greater effect on the temperature of the base surface where the mix is placed rather than the temperature of the mix being placed. However, the solar flux does affect the cooling rate of the mix.



23

A series of “cooling curves” for asphalt mixtures illustrate the amount of time available for compaction under different combinations of the variables. The figures shown assume air temperature to be equal to the surface temperature of the base. A constant wind velocity of 10 knots and a constant degree of solar radiation is also used to generate the graphs. The curves then provide the time in minutes, for the mix to cool from the laydown temperature to a minimum compaction temperature for different compacted layer thicknesses. This chart is for laydown temperatures of 250°F and 300°F. There is also a chart for laydown temperatures of 225°F and 275°F. (Reference: Hot-Mix Asphalt Paving Handbook 2000). A full-sized chart is in the handout and will be used later in this module.

For a thickness of 2 inches and a base/air temperature of 40°F, the time to cool to 175°F increases from 9 min to 16 min as the placement temperature increases from 250°F to 300°F. For a 3-inch course and a base/air temperature of 60°F, a change in laydown temperature from 300°F to 250°F reduces the time available for compaction from 36 min to 21 min. The effect of mat laydown temperature is more significant at lesser mat thicknesses and lower base temperatures.

IN SHORT !



- **Density is a function of temperature.**
- **It is not how hard you hit it, it’s when you hit it.**


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Learning and recording the temperature related characteristics for each mix and roller train combination is the most fickle and demanding part of your job.

Time Available for Compaction (TAC)


Computer Program used to determine TAC

 **PaveCool** Asphalt Pavement Cooling Tool
 © 2000-2006 Minnesota Department of Transportation

Free Download from Website:

<http://www.dot.state.mn.us/app/pavecool/>


Mod 7
25

Pave Cool computer software has been developed by the Minnesota DOT to assist contractors, inspectors and engineers to make rapid decisions regarding cool-weather paving. The user enters the time of day, date and latitude of the paving job, along with the type of mix and type of surface being paved. The surface temperature, air temperature, wind speed, lift thickness, and mixture delivery temperature are then entered, and finally the amount of cloud cover. A heat flow model is used to compute the temperature drop in the mat and the time it takes for the mix to cool from its delivery temperature to 175°F.

website: <http://www.dot.state.mn.us/app/pavecool/index.html>

Laydown Site Conditions

- **Lift thickness & NMAAS**
- **Lift uniformity**
- **Base Conditions**




Proper Surface Preparation


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If surface preparation does not provide the uniform level platform on which to pave, density will be much harder to achieve. Asphalt leveling courses that, by their very nature and purpose, are non-uniform in thickness, are often difficult to densify uniformly, when placed over a rutted or wavy road. In Superpave mixes there will be some larger material and the rule of thumb is 3x NMAAS for lift thickness except for scratch/ leveling courses.

Compaction Equipment

Types of Rollers

- Static Steel Wheel
- Pneumatic / Rubber Tired
- Vibratory
- Oscillation



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The type of equipment used to compact the asphalt mix obviously has a significant effect on the degree of density that can be obtained. Four types of compaction equipment are currently being used: static steel wheel rollers, pneumatic tire rollers, vibratory rollers, and oscillatory rollers.

How Do Rollers Compact?

**By applying their load
over a given area!**

Contact Pressure!

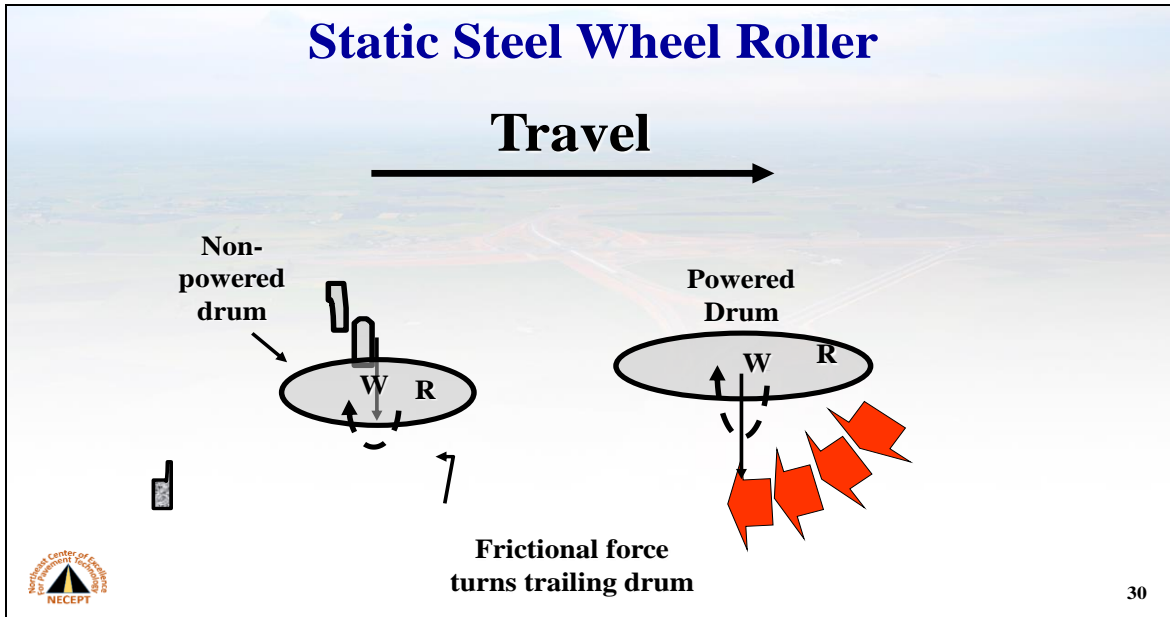
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Contact pressure moves the aggregate particles together and removes air voids. Each roller type applies contact pressure slightly differently, but the concept is the same. In practice, compacting isn't so simple because of the many variables involved. We know *densification* increases stability by recalling that if we walk across a freshly laid mat, without any roller passes, that we sink in the mat; yet after even one pass of the roller we make few marks.



Static steel wheel rollers normally range in weight from 3 to 14 tons and have drums that vary in diameter from approximately 40 inches to more than 60 inches. The gross weight of the roller can usually be altered by adding ballast to the roller, but this adjustment cannot be made while the roller is operating and is not normally changed during the term of a project.

Drawbar pull is defined as the horizontal force required to move the roller forward. Rollers with large-diameter drums have lower drawbar pull (rolling resistance) because they do not tend to penetrate as far into the mix as does a roller with smaller-diameter drums.



Always run with the powered drum toward the paver. The red arrows represent the rotational force on the wheel which is transmitted to the mix and tends to move the mix under the wheel results in nearly direct vertical force. The tiller wheel has a tendency to push the mix causing a wave in front. Analysis reveals two forces, one a vertical force downward (weight), and a horizontal force forward. Densification occurs as a result of the downward force and not as a result of the horizontal movement within the mix (shoving) which can and often results in a reduction in density. Once the size and weight of a static steel wheel roller is selected, the variables under the control of the roller operator are the speed, position of the roller on the mat in relation to the paver, the number of passes and **temperature of the mat**.



Roller Contact Pressure Is ***GREATER*** as the mat cools

Below is an example of contact pressure for a 12-ton static roller as depth of roller penetration into the mat decreases.

Penetration Depth (inches)	3/4	1/2	1/4	3/16	1/8	1/16
Contact Pressure (PSI)	36	46	63	74	88	132

PSI is pounds per square inch.



Effective weight or contact pressure, in terms of pounds per square inch of contact area (PSI), is the key variable for this type of equipment and is dependent on the depth of the penetration into the mix. The greater the depth of penetration, the greater the contact area and the less the contact pressure. On the first pass, when the indentation of the drums into the mix is the greatest, the contact area between the roller and the mat is the largest, and therefore, the roller exerts less contact pressure on the mix. On subsequent passes, as the mix becomes denser, the drums penetrate less and the contact pressure increases. As the pressure increases, as some point, the roller “walks out of the mat” as the roller cannot cause further indentation and cannot increase density. At this point, internal strength of the mix increases to a level that does not allow further movement under the roller pressure. As shown in the chart, during the first passes of a typical 12-ton static roller, the contact pressure may range from 36 to 46 psi as the drum sinks in $\frac{3}{4}$ to $\frac{1}{2}$ of an inch, depending on the initial stiffness of the mix. With additional passes, the mix becomes stiffer as the aggregate is packed together and air voids are reduced. The drum eventually “walks out” of the mix and the contact pressure becomes extremely high. Roller contact pressure increases as the mix’s internal strength increases during compaction. At 1/16-inch penetration, the contact pressure is 132 in. lbs./in², a 366% increase over the original pressure!

Pneumatic (Rubber Tire) Roller

Factors affecting Ground Contact Pressure

- Wheel load
- Tire inflation pressure
- Tire design (ply rating)

All tires should be the same size, same ply, and same air pressure resulting in uniform ground contact pressure.



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Most pneumatic or rubber tire rollers are operated in the intermediate roller position, behind a vibratory or static steel wheel breakdown roller and in front of a static steel wheel finish roller. These rollers are sometimes used for initial rolling of the mix as well as occasionally for finish rolling. Pneumatic tires tend to pick up fines from the mix, and mixes with higher binder contents are especially susceptible to pick up by pneumatic tires. Pneumatic tired rollers are therefore not used on those mixes (such as SMA).

For a pneumatic roller, the compactive effort applied to the mix is a function of the wheel load of the machine, the tire pressure, tire design, and depth of penetration of the tires into the mix. Changing any of these parameters from tire to tire will change the ground contact pressure and result in uneven compaction across the width of the roller. The greater the contact pressure between the tire and the mix (higher air pressure in the tires), the greater the compactive effort applied by the roller.



Once the size of the pneumatic roller and the tire pressure are selected, the variables that can be controlled by the operator are the rolling speed, location of the roller with respect to the paver, and the number of roller passes. If the compactive effort applied by the pneumatic roller is not adequate, the operator should alter the wheel load on the tires (ballast) and/or change the inflation pressure in the tires. Pneumatic rollers are ideal for uneven courses such as scratch and leveling.

NOTE: Pneumatic tired rollers should always be operated in a specific temperature zone, and NEVER back into the water on mat left by the trailing rollers.

You can help to avoid picking up of fines by driving the pneumatic tire roller back and forth numerous times before going onto the hot mat as this will help to warm the tires.

Pneumatic Tire Rollers

- Indentation tracks from pneumatic tire roller should be evident after finish roller on scratch/leveling courses due to differing depths of material (wheel ruts, etc.)
- If not, was the roller used at an effective temperature range?

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Pneumatic tire rollers should operate in a specific heat range to maintain uniformity of tire temperature. Providing a Non-contact thermometer is just good sense.



This photo illustrates the need for a pneumatic tire roller when paving on surfaces with raised areas or depressions. Note the bridging of the steel drum roller on this scratch course. The very left edge is well compacted, where the material is thinner, then the next several feet across the mat received very little compaction due to roller bridging.

Vibratory Rollers

- Amplitude
- Frequency
- Impact Spacing





Double Drum Vibratory

Double Drum Vibratory

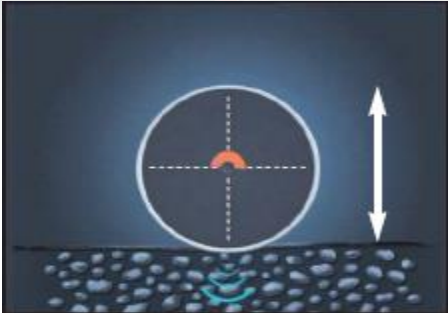



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Vibratory rollers come in a variety of configurations. Roller speed, temperature of the layer being compacted, number of passes, amplitude, and *IPF* can all be varied. Vibratory rollers come in rigid-frame, single-articulated-frame, and double-articulated-frame models. Vibratory rollers can be operated in any one of three modes: static (vibrators off); one drum vibrating, one static; and both drums vibrating. Vibratory rollers have two types of compactive forces: static weight which is the weight of the drums and frame, and dynamic (impact) force produced by a rotating eccentric weight located inside the drum(s).

Vibratory Rollers

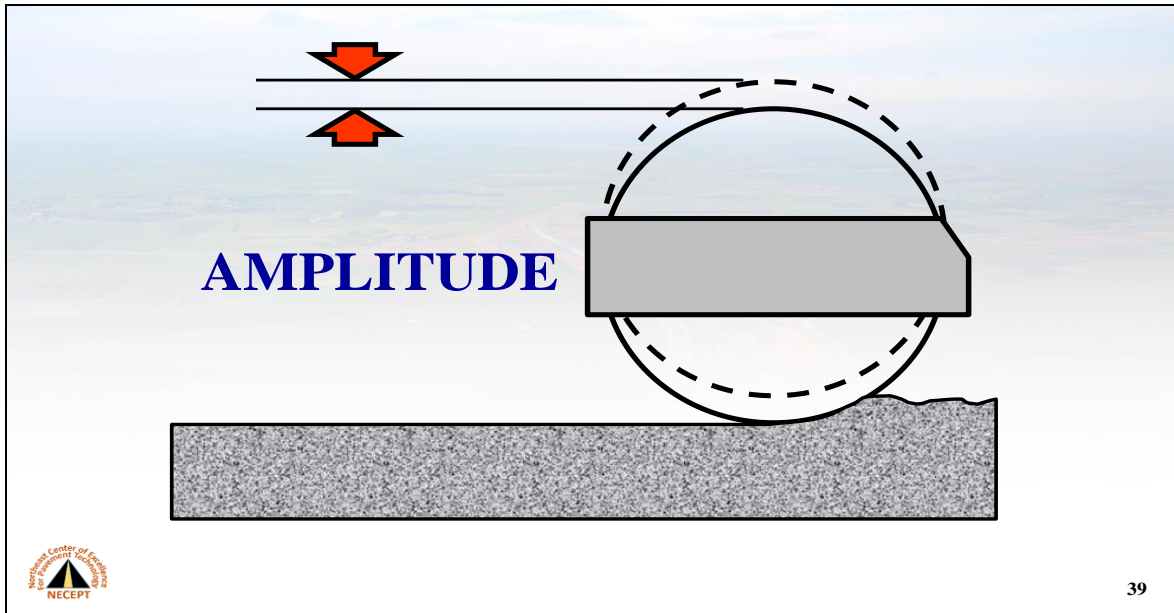
- **Vibration = Vertical impact forces**
 - Uses an eccentric weight in the drum, rotated at high speeds causing drum to vibrate and vertically move or ‘jump’, generating vertical impact forces into the asphalt.



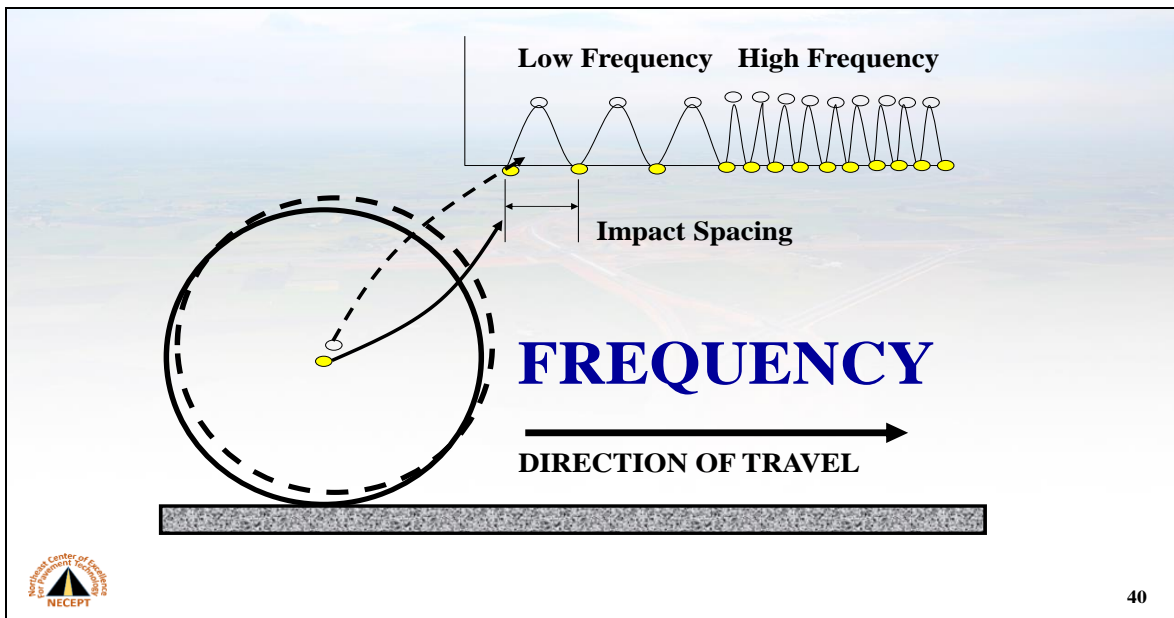


Courtesy of Hamm Compaction Division, Wirtgen America, Inc.

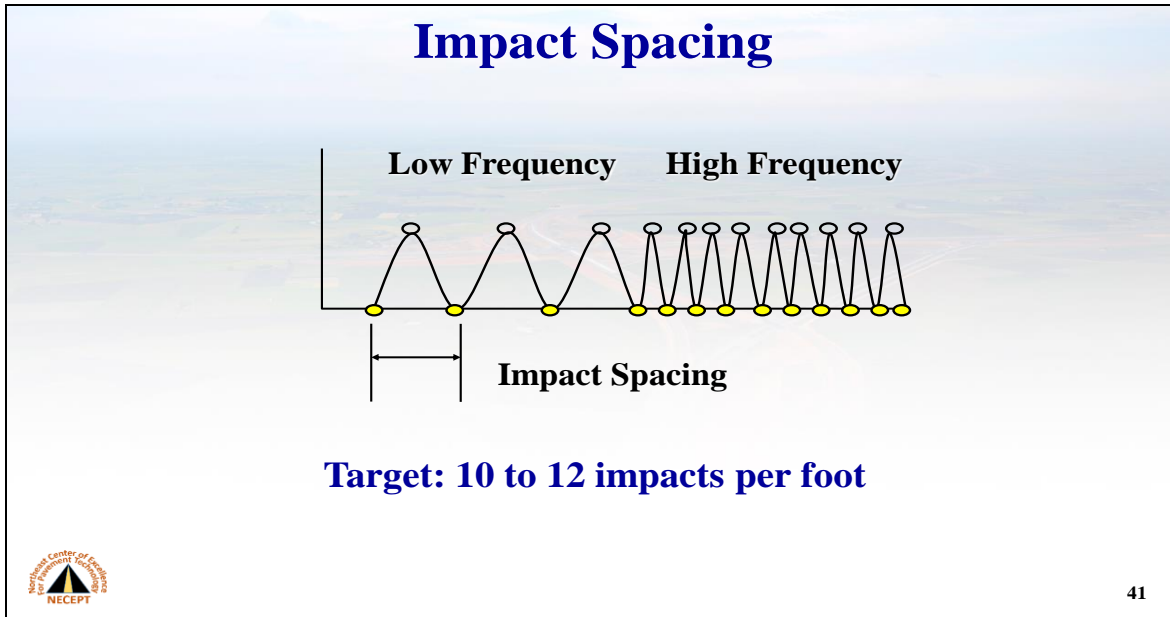
38



Amplitude is simply the vertical distance the drum vibrates. Normal values of amplitude range from 0.01 to 0.04 in. Some rollers can operate at only one fixed amplitude, others have “high” and “low” amplitude positions, and others are variable. As the layer thickness increases, it is often advantageous to increase the amplitude. Unless ‘high’ amplitude is needed to achieve a density, the vibratory roller is usually operated in ‘low’ amplitude.



The frequency of vibration is the number of complete cycles that the eccentrics rotate per minute (vibrations per minute or VPM). The faster the rotation of the eccentrics, the greater the frequency of vibration. Vibratory rollers may operate at only one frequency, while other vibratory rollers can alter the frequency of the applied load between 1600 and 3600 vibrations per minute. Frequencies <2000 VPM are not normally used to compact asphalt mixtures.



The spacing of the applied force is a function of the frequency of vibration and the travel speed. Impacts per foot (IPF) should be in the range of 10 to 12. That translates into 1.0 to 1.2 inches between impacts, to ensure the highest efficiency of the vibratory rollers and reduce the possibility of leaving ripples in the finished pavement. Proper impact spacing and amplitude at the correct temperature are the keys to successful compaction.

Typical Data for Vibratory Tandem Rollers

<i>Vibratory Steel Tandem tons</i>	<i>Oper. Wt. lbs.</i>	<i>Drum Diam. ins.</i>	<i>Drum Width ins.</i>	<i>Static Drum p.l.i.</i>	<i>Dynamic Drum p.l.i.</i>	<i>VPM</i>	<i>Nom. Amp. in.</i>
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
> 12	30000	59	84	185	420	2,400	0.030

p.l.i. = pounds per linear inch

A review of the chart gives us an opportunity to familiarize ourselves with the values used for analyzing vibratory rollers. Notice the comparison of capabilities with the vibrators on versus off. Drum rollers are often specified having a certain p.l.i. (pounds per linear inch) of roller width at a drum contact arc of 1 inch. However, this may differ on each drum of a double drum roller since the weight is not equally distributed on both drums.

Vibratory Roller Control Panel



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Vibration frequency, vibration amplitude, and direction and speed of travel are under control of the operator who should be well trained in the selection and interaction of these variables. All of these factors have an effect on the density achieved under the compactive effort applied to the mix. On many rollers amplitude is still manually controlled by rotating a drum mounted wheel.

Vibratory Rollers



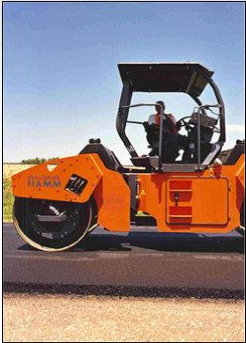
- **Caution! Vibratory rollers can cause damage to:**
 - Underground utilities
 - Box culverts or other structures
 - Bridge and bridge decks




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Oscillation Rollers

- Rocking motion – not a vertical pounding
- Maintains constant pavement contact
- Faster compaction
- Less concern for damage to underground facilities or bridges

Photos Courtesy of Hamm Compaction Division, Wirtgen America, Inc.


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Oscillation technology is a completely different type of Asphalt compaction. Oscillation compaction is non-aggressive because it compacts with a gentle rocking motion, not a vertical pounding. Oscillation compaction creates compactive effort through generation of horizontal shear forces, as opposed to vertical amplitude, and with no damage to adjacent structures, including bridges and underground facilities.

Oscillation Rollers - New technology!

- **Oscillation = Horizontal shear forces**



- Uses dual, opposed, eccentric weights rotating in same direction around drum axis



- Gives drum a rocking motion instead of a vertical jumping motion
- Creates horizontal & downward shear forces




Photos Courtesy of Hamm Compaction Division, Wirtgen America, Inc.


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The oscillatory system uses dual, opposed, eccentric weights rotating in the same direction around the drum axis causing the drum to move in a rocking motion instead of a vertical or jumping motion. This rocking motion creates horizontal and downward shear forces that achieve compaction without the ‘bounce’ of a conventional vibratory drum. The surface of the mat is smooth and flat. Oscillation movement helps to ensure that the asphalt will be compacted without damage to the aggregate.

Roller Maintenance

- Water Systems
- Hydraulic Systems
- Mechanical Systems
- Vibratory Systems
- Drums, Tires, Pads, Scrapers



Vibrating Reed-Type
Tachometer




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The technician and the operator should know what needs to be done to ensure that the roller is working properly and does not pick up the asphalt mix or damage the mat. A roller maintenance diagram depicting where to find key parts of the roller as well as showing an owner’s recommended frequency to lubricate, change and check parts on the roller. The Reed Tachometer is a valuable tool for verifying vibratory performance or diagnosing problems when involved with a sensitive or difficult mix.

Computing Impacts per Foot (IPF)) Target 10-12

- Divide the frequency of the roller (VPM) by the desired Impacts per Foot (IPF) to obtain the correct speed in Feet per Minute (FPM)
- Example: 2,700 VPM divided by 12 IPF =225 FPM
- 3,000 VPM divided by 10 IPF =300 FPM

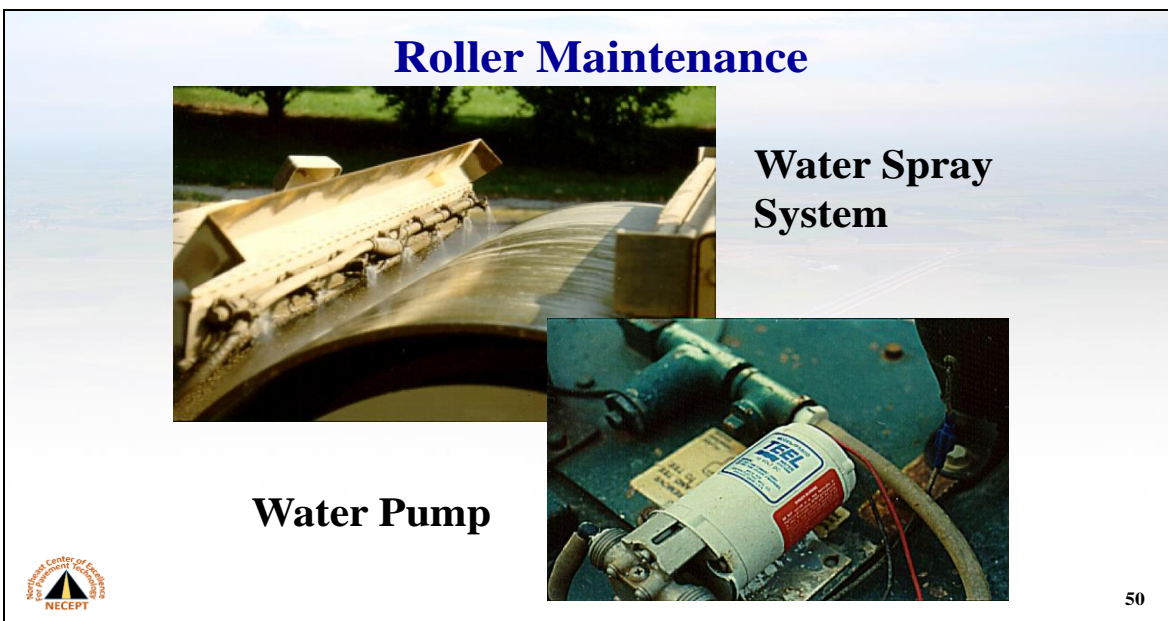


48

Establishing the maximum speed (FPM) at which a roller can operate while producing the desired impact spacing is critical to obtaining acceptable densities and balancing paver speed. Vibrations per minute (VPM or *frequency*) are a constant on some machines, others have high and low, and some are infinitely variable within certain limits.



In this photo, the roadway shows evidence of roller impacts and the impact spacing is approximately 4 impacts per foot, and the material has a slight washboard effect. This was likely done on a cold mat. This photo was taken in spring following the fall paving.



The water system is designed to keep the mix from sticking to the drums or tires and is typically the highest maintenance item on a roller. The top left photo shows uniform spray ensuring uniform wetting and uniform pavement cooling. Spray systems that clog will cause asphalt to adhere to the steel or rubber tired rollers. Use the minimum amount of water, just enough to prevent pick up. Excessive water is wasteful and requires more frequent refills and too much roller downtime. A stream of water running off the edge of the drum can create cold streaks and lead to rips or tears in the mat. For pressure fed systems without a gravity flow backup, keeping an additional water pump and spare nozzles available is a good idea.

Roller Maintenance



Scrapers and Pads






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Spare pads and the means for attaching them should be readily available. Scrapers also wear down and need replacing and should be made of material that will not gouge the drum surface. Scrapers on rubber tired rollers are as important as those on steel rollers. Rollers are the last equipment on and off the pavement and should be checked for maintenance needs at the end of each day. The last pavement placed must receive the same attention to detail and compactive effort as the first section.

Roller Operating Techniques

Topics we discuss as related to roller operating techniques:

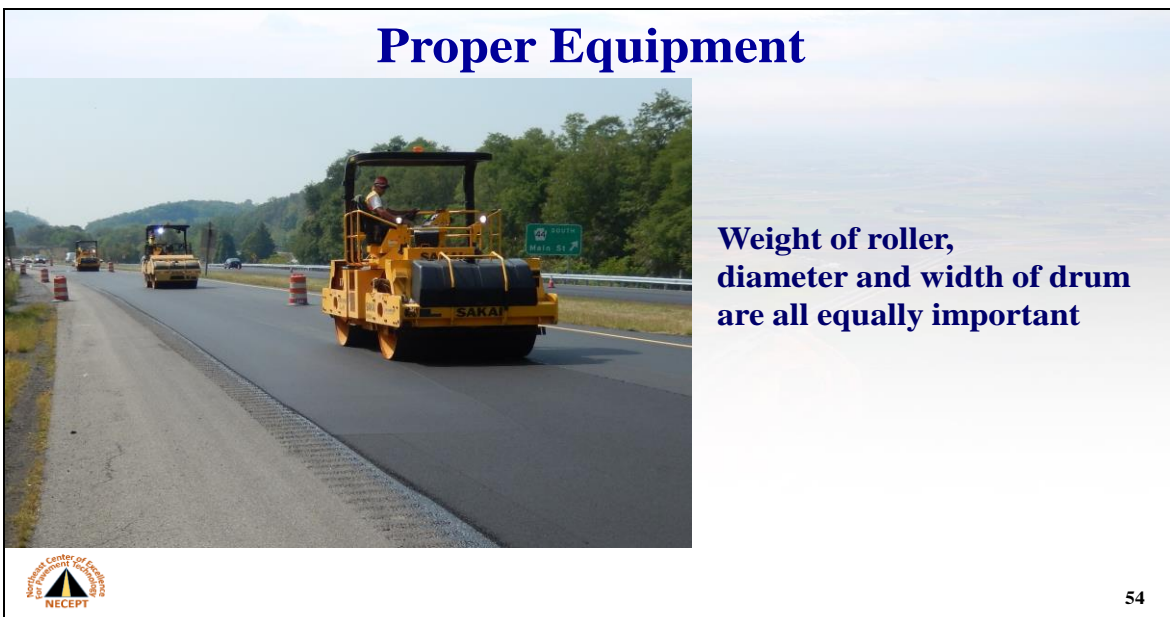
<ul style="list-style-type: none"> • Proper Equipment • Compaction Variables • Control Strip Construction • Establishing Roller Patterns 	<ul style="list-style-type: none"> • Breakdown Rolling – Joints • Intermediate Rolling • Finish Rolling • Re-watering • Opening to traffic
--	---



52



Different mixes may require considerably different levels of compactive effort and thus different compaction equipment and rolling procedures. An asphalt mix containing large aggregate, for example, may need different types of rollers to achieve a required level of density than an asphalt mix made with smaller size coarse aggregate.




The selection of rollers that were utilized on a previous project for a present job may not be the most cost-efficient or effective due to the variables involved in the present job. Although vibratory rollers are usually used for breakdown rolling and pneumatic tire rollers for intermediate rolling, a greater degree of density with fewer roller passes might be obtainable with a different combination. Determination of the “optimum” combination of rollers is key, along with a control strip to determine the proper pattern.

Compaction Variables

- Roller Speed
- Amplitude
- Impact Spacing
- Number of Coverages
- Rolling Zone
- Rolling Pattern

“Operator’s Knowledge/Experience”



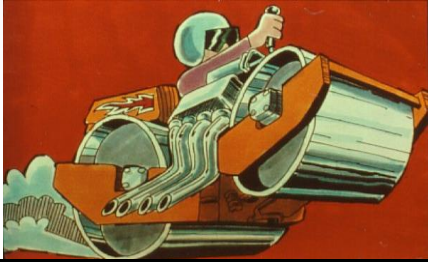

55

Each of these factors influences the level of density achieved under the compactive effort applied to the mix. **The most important variable is the knowledge and experience of the roller’s operator.**
NOTE: Excellent communication with the Density Gauge Operator is required.

Roller Speed

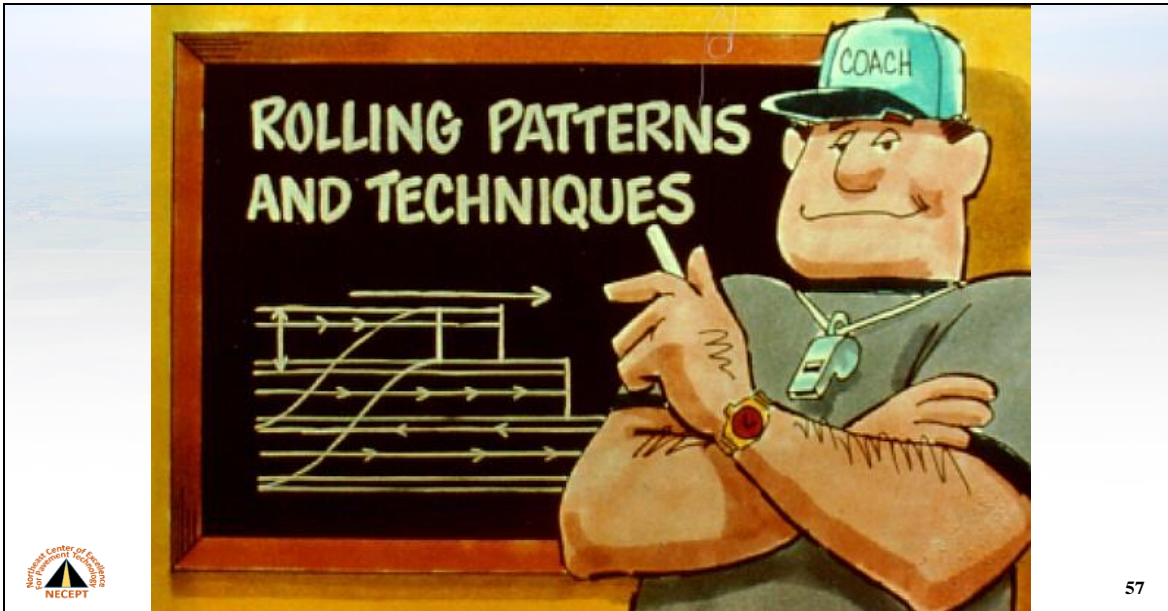
Typical Range of Roller Speeds (mph)

<i>Type of Roller</i>	<i>Breakdown</i>	<i>Intermediate</i>	<i>Finish</i>
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	2.5 to 3.5	-----

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The faster a roller passes over a particular point in the new asphalt surface, the less time the weight of the roller “dwells” on that point, meaning that less compactive effort is applied. As the roller speed increases, the density achieved with each roller pass decreases. Speed selected is dependent on a combination of factors: productivity, layer thickness, and the position of the equipment in the roller “train.” If the mixture moves excessively under the rollers, the speed of the compaction equipment should be reduced as long as it does not affect the impact spacing. Mat temperature is critical when deciding roller speeds and paver speed. **Speeds may change substantially with an increase in thickness of loose mixture being placed.**



Rollers are “busy” most of the time on a paving project. The question is whether they operate correctly and effectively. Numerous compaction studies have shown that the middle of the width of the paver pass typically receives more compactive effort than the edges of the pavement. This is unfortunate, because traffic uses the wheelpath areas and travels near the edge of the pavement more often than in the center of a lane.

Use of an 84” drum on a 12 ft. pass will cause the center of the lane to receive at least twice as many “hits” and twice as much cooling as the wheel path area. This can and often does create inconsistent density across the mat.

Control Strip Construction

- Simulating Actual Conditions
- Establishing Roller Patterns
- Calculating Effective Roller Speed



The actual rolling pattern to be used to compact the mix on a paving project can be determined at the start of the project through the construction of a roller control strip which will remain as part of the final pavement structure. The mix should be the same material to be produced for the project and the thickness of the layer should be the same as that used for the rest of the project. Length may vary but should be long enough to ensure that the results are representative of a full-day production. A control

strip determines the most effective sequence of rollers to achieve the required compaction, smoothness of the mat, and economical production.


Two Vital Questions

How many passes are needed to cover the width of the mat one time ?

How Many Repeat Coverages to Assure Acceptable Target Density?

90-100% target on base courses
 91-98% target on binder courses
 91.5-98% target on standard wearing courses
 92-98% target on RPS wearing courses

Target consistency in the center of the range for best chance at density incentives!



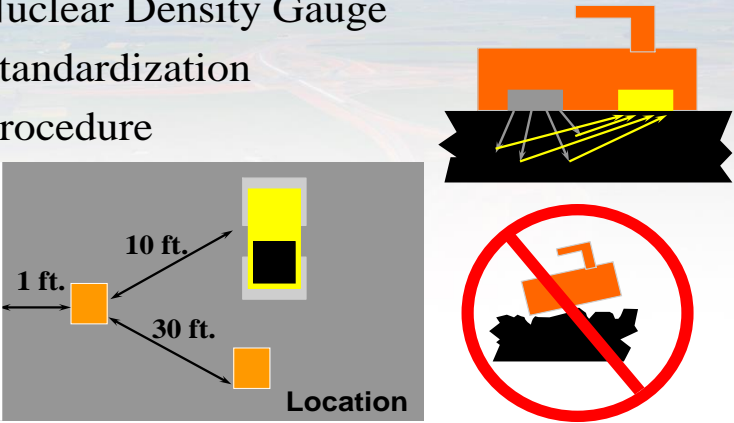

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To obtain the target air void content and uniform density in an asphalt mixture, it is necessary to roll over each point in the pavement mat a certain number of times. Thus, the two vital questions become: 1) how many passes of the roller are needed for each coverage and 2) how many coverages are needed to obtain required density of the mix?

What is Maximum Density allowed and why???????????

Determine In-Place Density by use of a Nuclear Gauge PTM 402

- Nuclear Density Gauge
- Standardization
- Procedure

60

A common method for monitoring changes in density with roller passes is through the use of a nuclear density gauge, which transmits gamma rays into the mix and measures the amount of radiation reflected back to the device in a given time. The gauge must be calibrated to the mixture and must be standardized every day. PENNDOT specs call for the back scatter method. Direct transmission is to be used only when approved for the project. Some gauges give counts, which are converted to density, while others read density directly.

Gauge must be *standardized* every day. Follow guidelines as given by manufacturer or PTM 402 and record on TR-4276B

Determine In-Place Density Using Electrical Impedance Measurement Methods PTM 403

TransTech



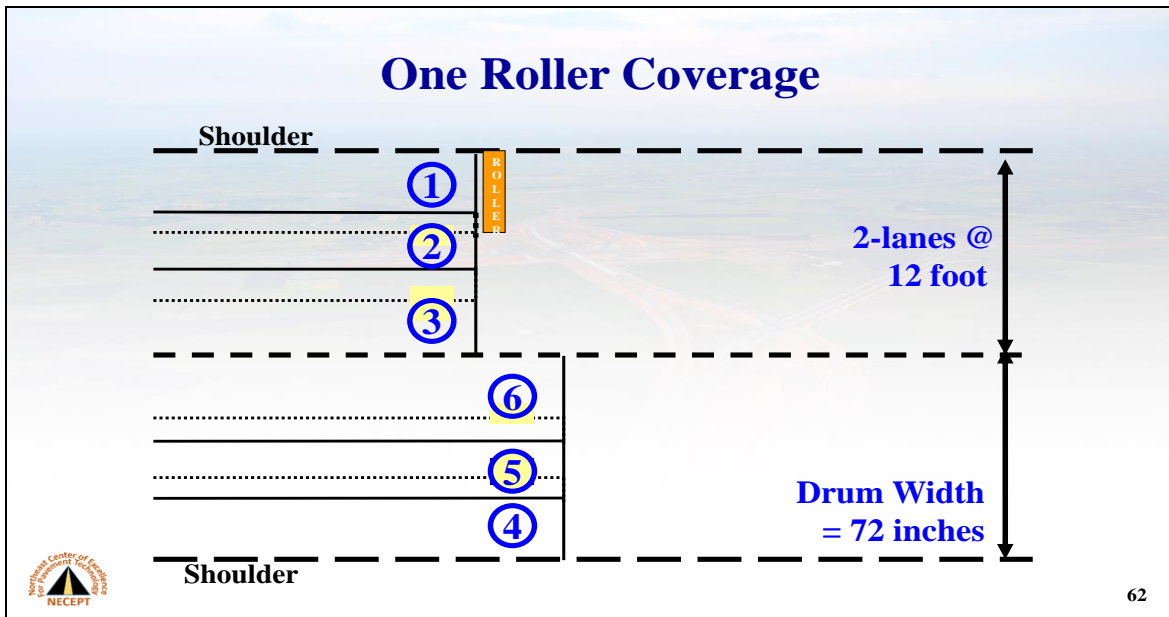
Pavement
Quality
Indicator
PQI 301



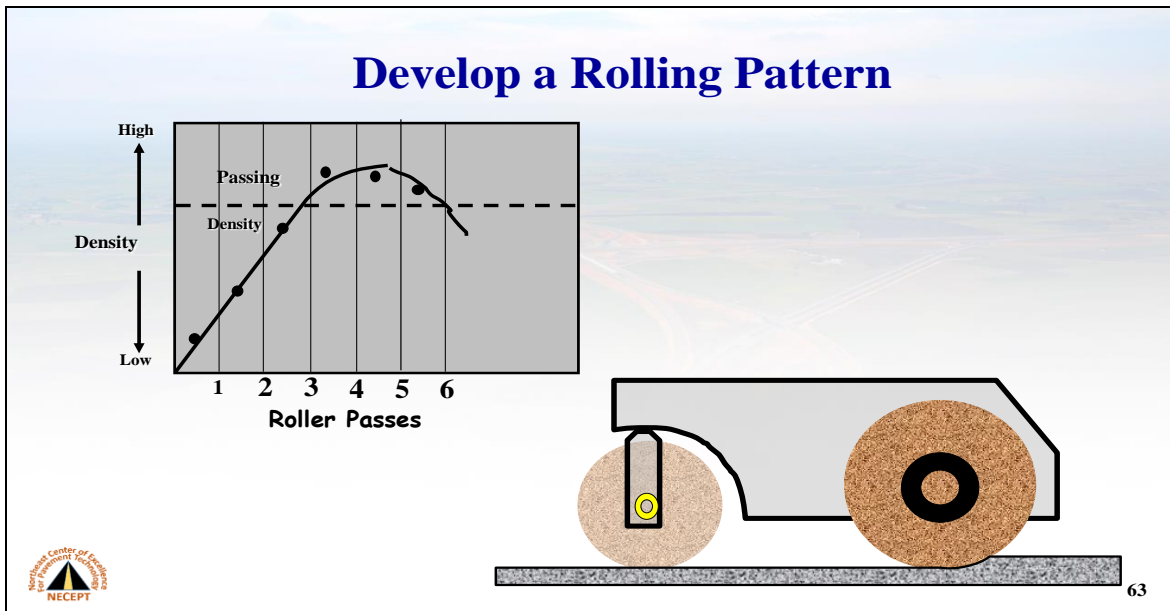



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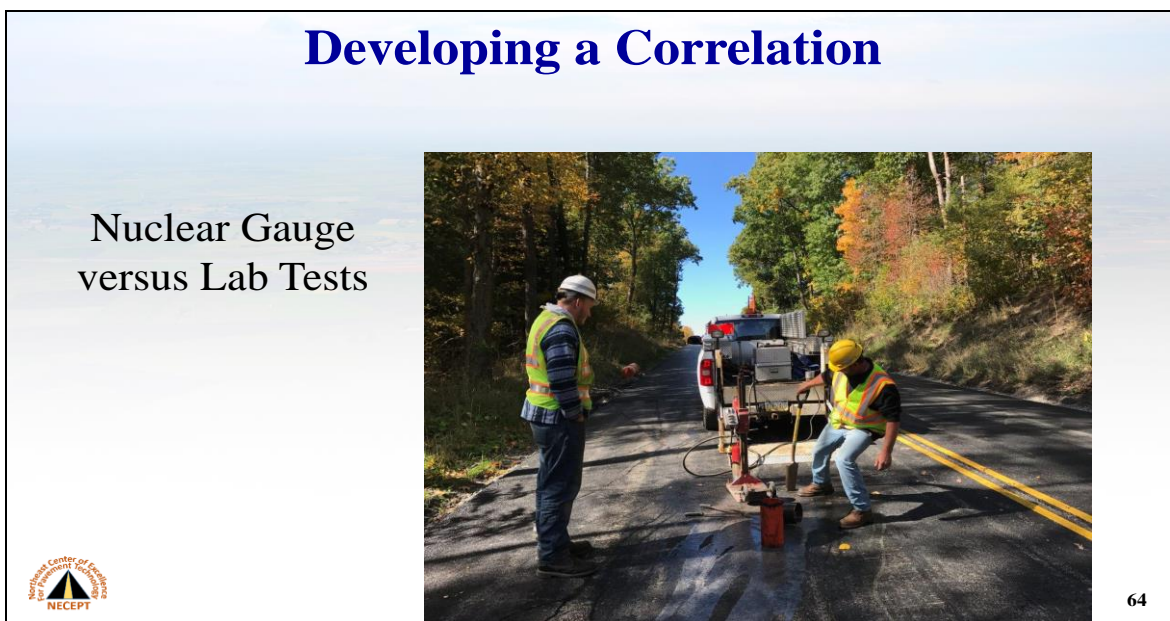
Using an electrical impedance device to determine density is a nondestructive technique as is the use of nuclear density gauge. **Density reading are relative** and require calibration with a known density sample. The density gauge, referred to as the Pavement Quality Indicator, uses low voltage with an impedance sensing head. Reflected, or back-scattered alternating frequency is measured by a sensor. The density is calculated from the amount of electrical resistance and reactance to flow of alternating current. The PQI is designed and built to provide quick readings of density, temperature and moisture content on asphalt pavements. The PQI unit takes readings in about three seconds, allowing the test technician plenty of time to run a series of tests quickly and get out of the way of the roller. The PQI is in use by contractors, QC/QA facilities and highway officials. Its electromagnetic field is safer than devices based on nuclear sources.



Standard paving widths of 10, 12, 14, and sometimes 16 feet can affect the efficiency of certain rollers. Ideally, the roller that can cover the width of paving with the fewest number of passes will be the most efficient. Smaller width rollers are routinely used, but the number of total passes will increase. For each roller employed on a project, the mat width can be divided by the width of the compaction drums to determine the number of passes needed to cover each transverse point in the surface. If the width of the roller drum is 84 inches, only two passes of the roller are needed to cover the 12-foot-wide lane, including a 6 in overhang at each edge of pavement. Three passes of the 72 in wide roller would be necessary to properly compact the lane. If the roller had drums that were 60 inches wide, three passes of the roller would also be required, similar to the roller with the 72 in wide drums. A 54 in drum needs four passes for one coverage.



Density readings should be taken after each *pass* of each roller, and the rate of increase in density after each pass determined. For acceptance by *Optimum Roller Pattern*, when no appreciable increase in density (>3 lbs./cu. ft.) is obtained with 3 consecutive passes, the maximum relative density for that mix has been obtained, **at that temperature range and with that machine only**. The density value determined with the nuclear or electrical Impedence gauge is relative and is generally not the same as the density value obtained from cores cut from the pavement. Compaction efforts with less than a noted continual improvement of 3 lbs./cu. ft. or less with 3 passes are wasting time and generally lead to crushed aggregate and shortened pavement life.



A correlation must be developed between the density reading and the actual unit weight of the pavement. That unit weight must be compared to the theoretical maximum unit weight of the mix in

order to calculate the actual in-place air void content of the layer. This correlation has to be updated constantly, so that in the end the project meets the void criteria.

Establishing Roller Pattern

- Width of paving
- Width of roller
- Impact Spacing
- Number of coverages needed
- Density testing
- Paving upgrade or down grade



65


All of these items come into play in establishing an optimum rolling pattern. Target value of impact spacing is 10 -12 impacts per foot (IPF).



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Optimum Roller Pattern

- Optimum—greatest degree attained under implied or specified conditions
- Pavement life concerns
- Mat quality
- Time constraints

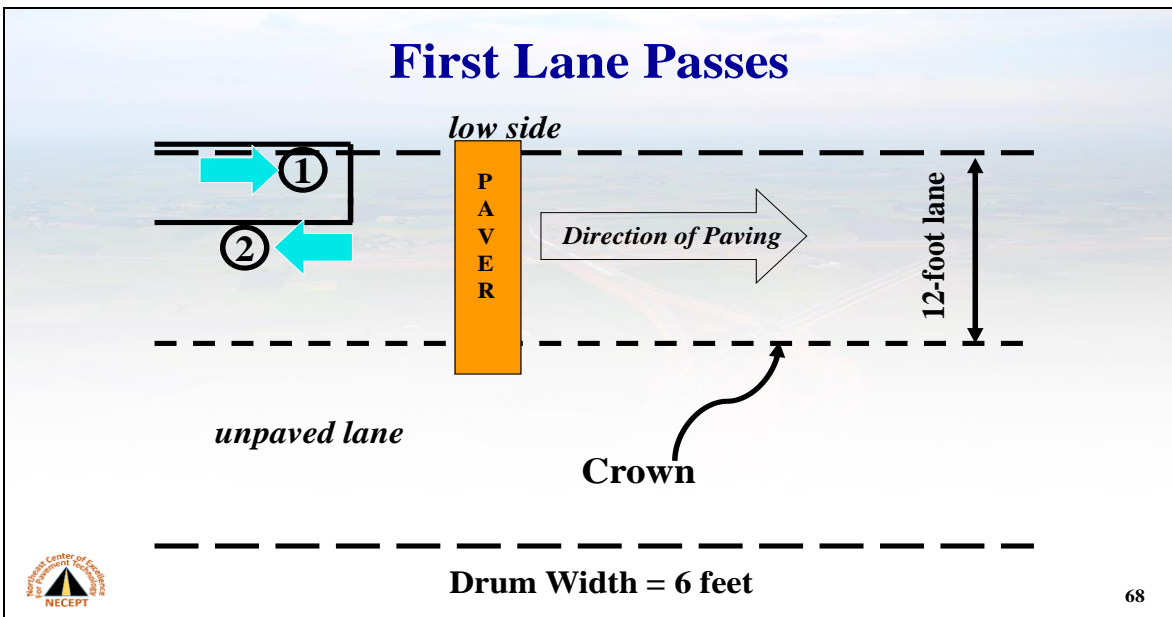


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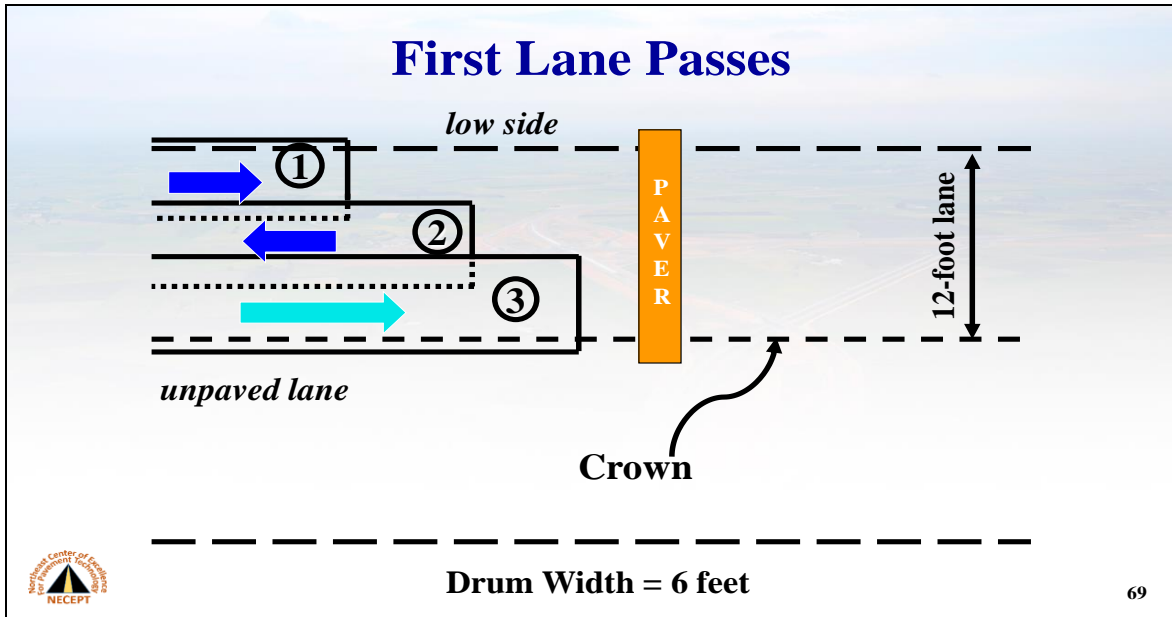
Pavement life: acceptable density while avoiding crushed aggregate.

Mat Quality: absence of ripples, waves, severe polishing, roller marks.

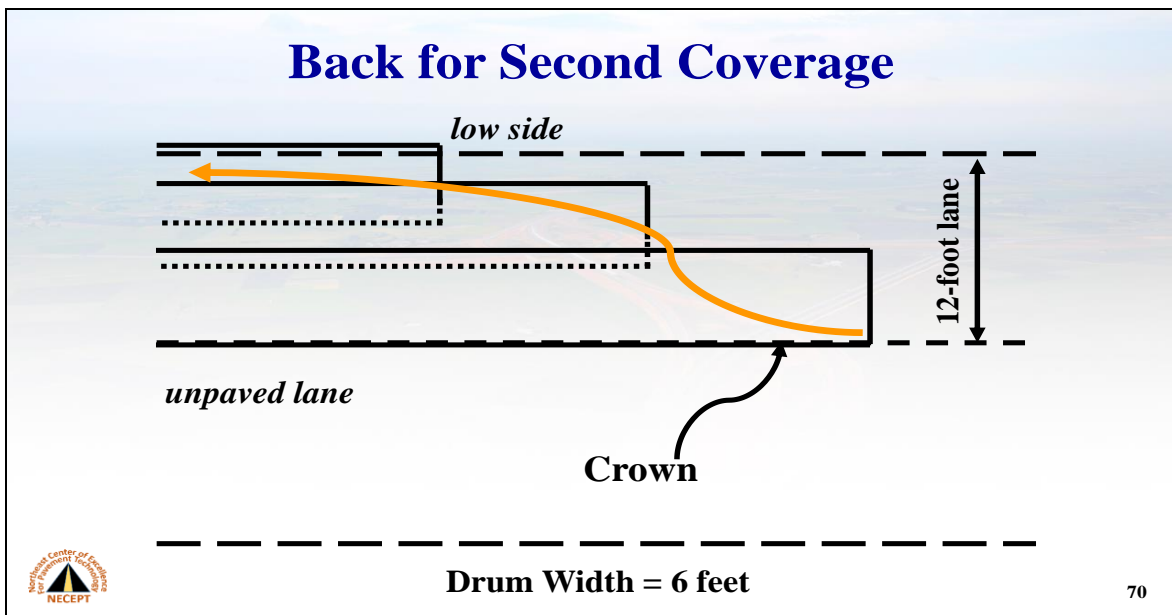
Time constraints: establishing number of coverages required and ability to keep up with paver.



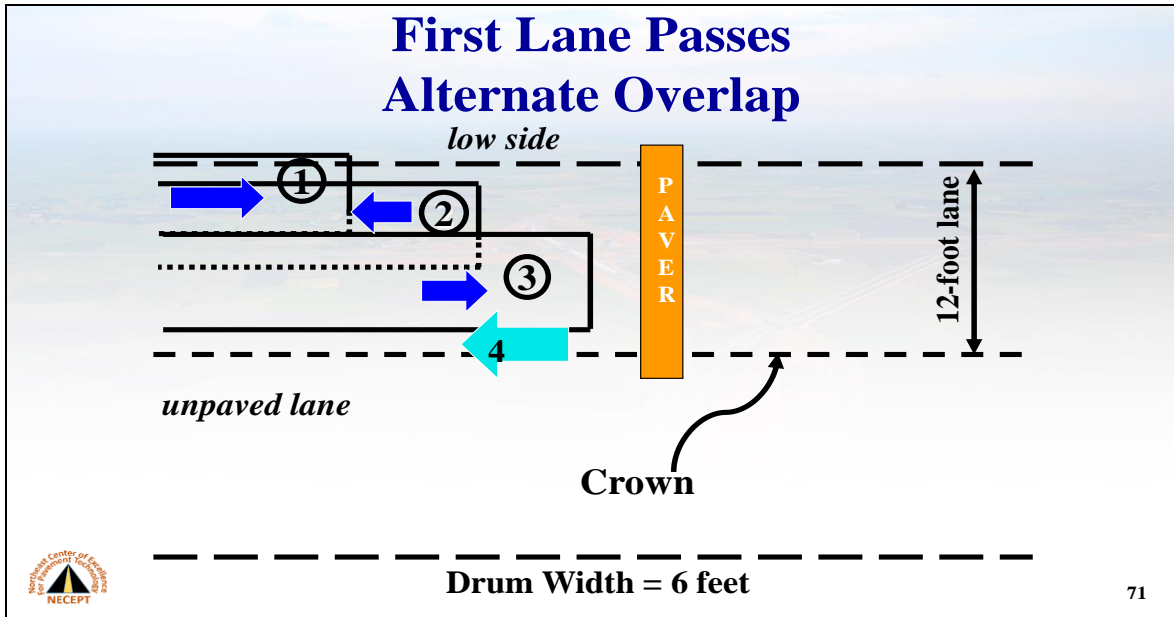
To the paver and back is two passes, utilize the overlap to determine density increase from two “hits”



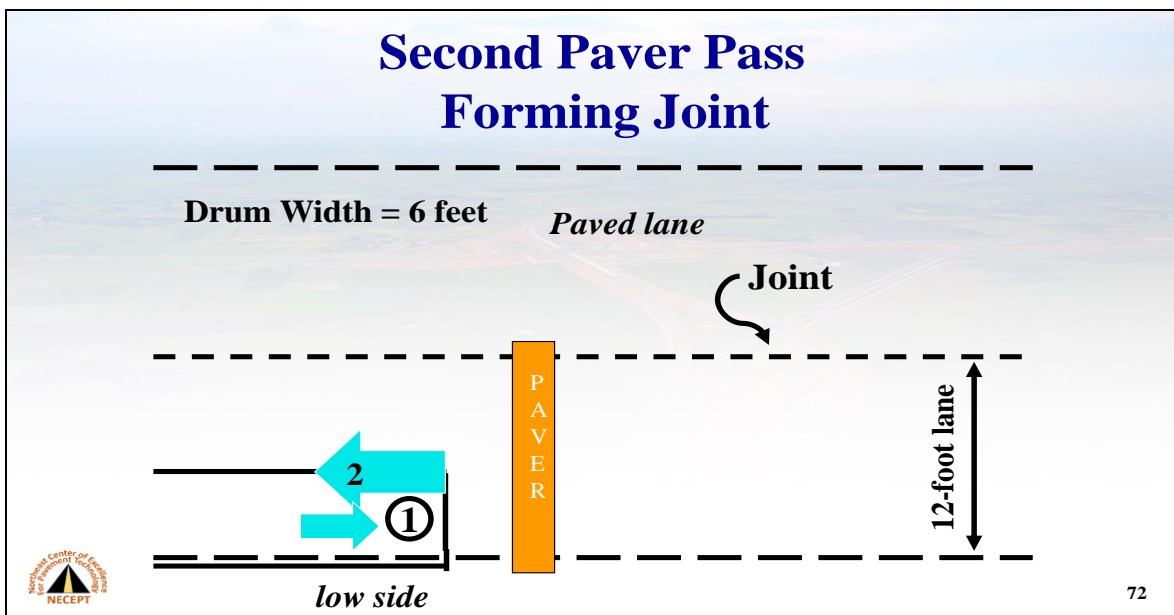
Note that the roller is overhanging each edge and should be changing directions at different locations with a slight turn, and avoiding going back in the same path. We now have two overlapped areas that have received two passes. The width of the roller drum will also help to determine the number of passes required for a *coverage*.



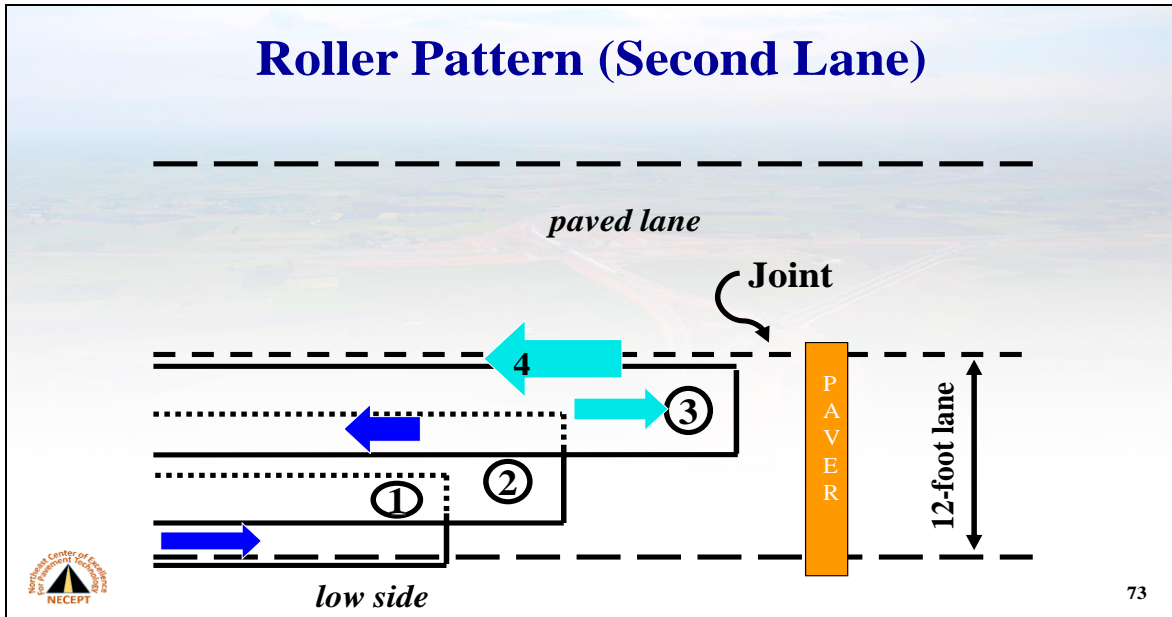
Second pass on low side will have occurred as the roller returns to beginning of the pattern. Vibrating (preferred) or static operation during the transition from high to low side and passing back through the change of direction areas will result in a smoother ride. Avoid traveling in the same pass as much as possible.



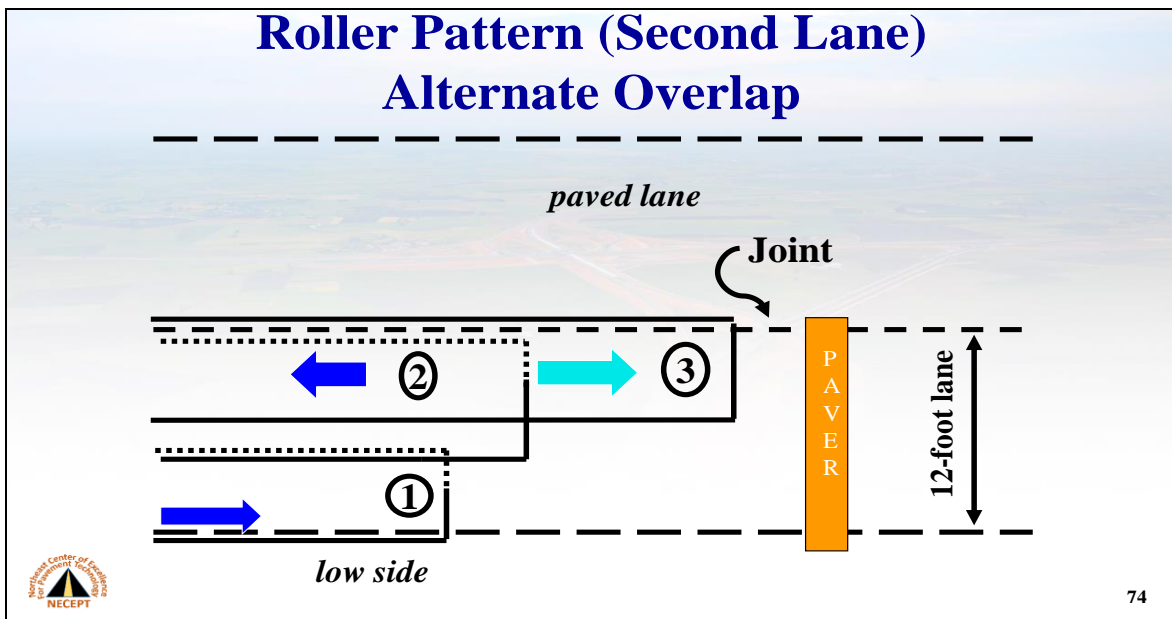
This alternate method results in wider overlaps and does not allow the roller to vibrate back through the change of direction locations. Some contractors use the previous pattern and this one in combination to help ensure uniform density across (transverse) the mat by varying the location of the overlaps.



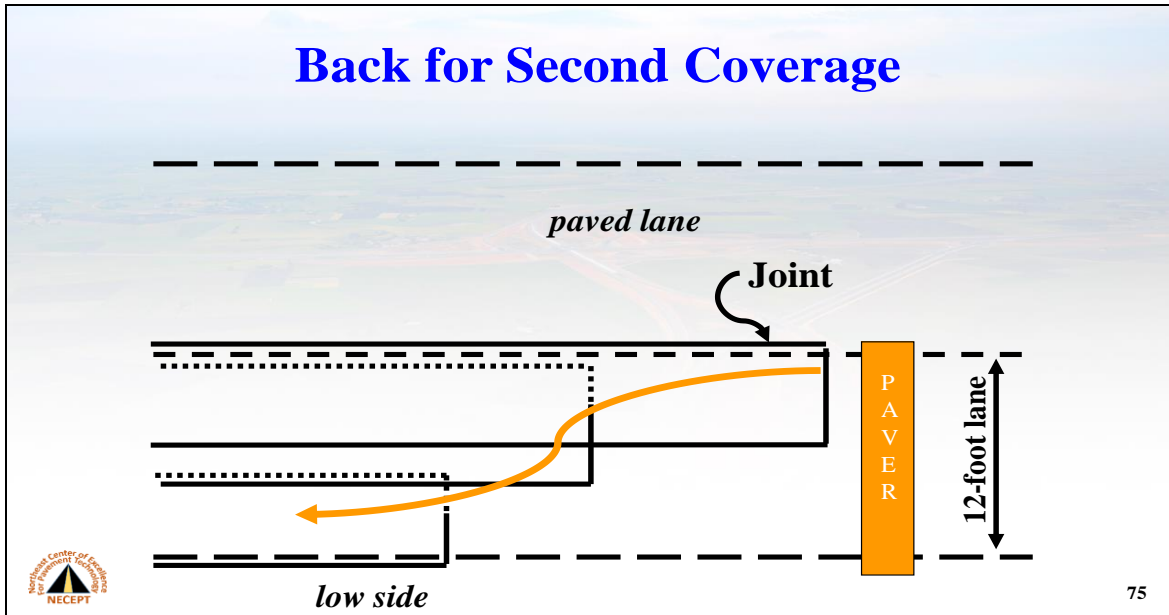
When compacting the second lane, rolling should again begin at the low side and overlap the unsupported edge 3 to 6 inches.



The next to the last pass (3rd) will be made 6 to 12 inches away from the joint, following the longitudinal joint construction procedures. The 4th pass will position the roller at the beginning of the temperature related pattern.



The next to the last pass (2nd in this scenario) will be made 6 to 12 inches away from the joint, following the longitudinal joint construction procedures.



This method allows the roller to vibrate back through the change of direction bumps. Gradual, shallow turns are required at any time while compacting asphalt and are especially necessary when operating near the edge of pavement. The roller will be at the back of the pattern following the 3rd pass of second coverage in this scenario and will create an extra pass on a portion of the roadway and differing densities will be noted in that area.

Overlaps and Hits in Rolling

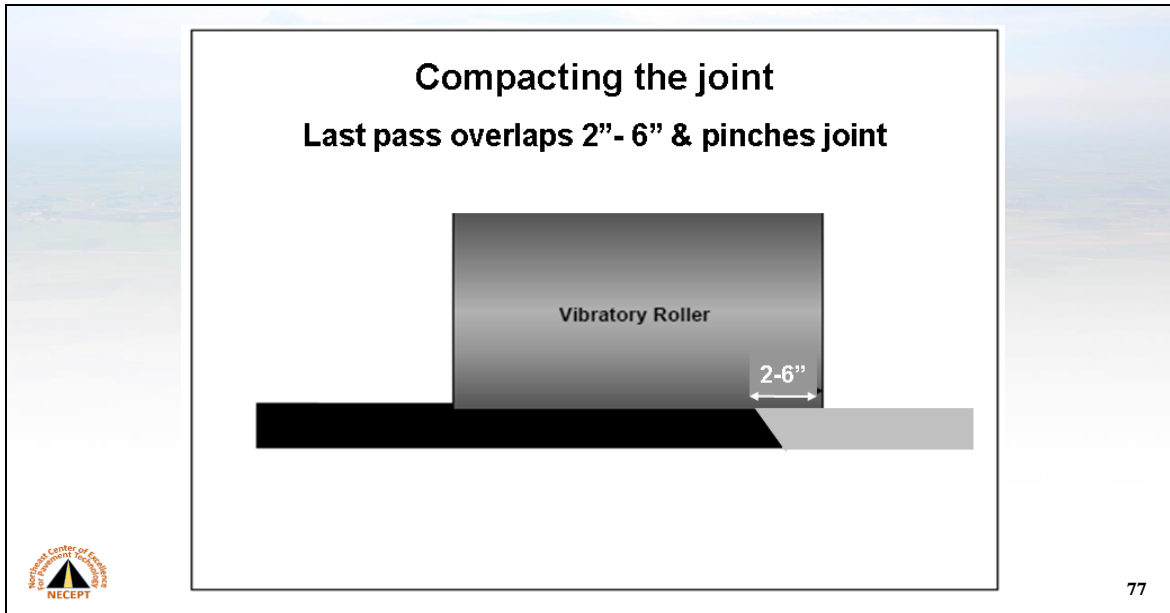
All roller patterns will create some additional “hits” and varying overlaps.

Density at change of direction areas for break-down roller will not be indicative of overall compaction—difference should be less after 2nd pass.

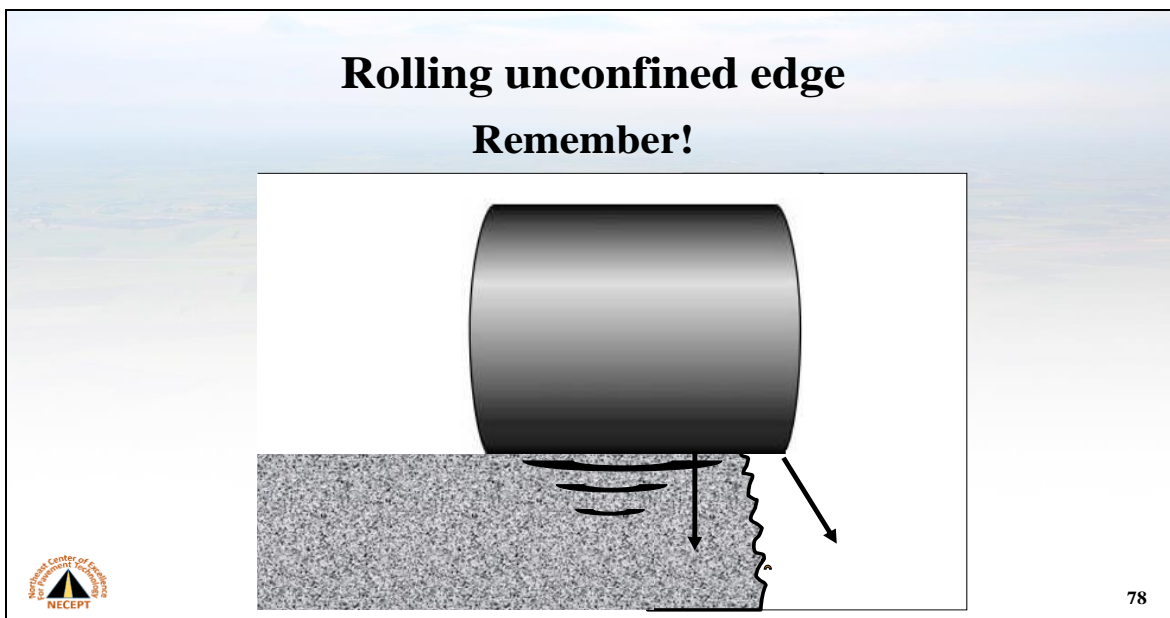
Use overlap streaks to check density increases created by additional “hits.”



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Remember, next to last pass across mat leaves 6 to 12" uncompactd at the joint. The last pass then pinches the longitudinal joint by overlapping onto the cold mat by 2 to 6 inches.



Remember, rolling the first pass along the unconfined edge, overlap the edge 3 to 6 inches to get the optimum vertical compaction force.

Breakdown Rolling

- Majority of compaction is obtained with breakdown rolling
- Check density now!
- The first vibratory pass at the proper temperature will usually obtain 60 % of that rollers results



Be alert for loss of density (de-compaction) during last pass of breakdown roller---*TENDER ZONE Awareness*

79

The majority of the compaction is obtained during breakdown rolling, so it is important to keep this roller moving as much as possible. When the roller does stop, it should be parked diagonally on a cold mat. Otherwise, you may leave marks. Density testing should be done periodically right behind the roller during breakdown rolling. If enough density is not obtained at this point, proper density will not be able to be achieved.

Density readings of less than 89 % behind the breakdown roller require immediate adjustments!!!!!!!!!!!!

Intermediate Rolling

- Follow roller pattern
- May or may not be required to achieve density
- “Tender Zone” may develop in Asphalt Superpave mixes between 190°-240° F.
- WMA mixes have also shown tender zone characteristics



80

If adequate density cannot be achieved with the breakdown roller, an intermediate roller may be needed. Intermediate rollers should follow a roller pattern and not concentrate on running down the middle of the mat. Some projects will require use of a pneumatic tire roller for surface texture and kneading action. A “tender zone” may develop in Superpave mixes between 190-240°F. Mix will shove and possibly crack under a steel wheel roller and you can either let the mat cool or use a pneumatic roller. This tendency for tender zones to develop is prevalent in Superpave and other coarse aggregate mixes. (A recommendation is to make a pass with the roller after each 5 or 10°F drop in temperature and monitor density readings, when the density starts to increase continue to roll.)

Finish Rolling

- Static steel wheel or vibratory roller in static mode
- “Irons” out any roller marks for smooth surface
- Do not count on obtaining additional density



81

Finish rolling is the last step of the operation and is a cosmetic process. **“NEVER FINISH ROLL IN THE VIBRATORY MODE.”** Finish rolling is not the place to count on obtaining additional density.

Remember!



- Placement of cooler Asphalt mixes creates pavement areas near cessation temperature
- No significant compaction occurs below cessation temperature
- WMA cessation temperatures vary as to method of production.



82

Some contractors equip all roller operators with an infrared thermometer so that rolling can occur within a range of temperatures. Some newer equipment has an infrared thermometer mounted directly on the roller.

The finish roller is normally well behind the paving operation and operating alone. Traffic safety devices must remain until finish rolling is complete. The operator and any additional personnel, performing a coring operation or monitoring density for example, must be careful of stray traffic entering the site. The traveling public may not see a lone roller or technician bent over a density gauge until it is too late.

Monitoring the Temperature Thermometers



- Various types (including roller-mounted)
- Essential for monitoring temperature of mix
- Compare with QA (correlate readings)



How do we check accuracy?

83

From the moment of delivery until the rolling operation is completed the temperature has to be monitored. Several types of thermometers are available, but all do the same thing...they measure temperature. The more expensive ones tend to do it faster and more accurately.

When monitoring the mix, take enough readings to develop a comfort index with the specific conditions you are working in. Occasionally compare your temperature value with the quality assurance department on the job. Achieving density in a consistent and quick way is directly proportional to the temperature of the mat.

The photo shows four different temperature measuring devices and if we could see the readings, they would all be showing a different temperature. Never completely trust a single thermometer; run a couple of checks. For a precision check, insert several probe thermometers into the center of a hot mix pile and wait a minute – they should all read the same temperature. If you are using an infrared unit, aim it at the same pile and compare the probe measurements to the infrared. This will allow you to develop a simple correlation between surface and depth temperatures.

For a quick accuracy check, place probe thermometers in a pan of boiling water, you should get 212 °F at sea level. Thermometers need to be calibrated at least weekly .

Compaction Rolling

- **Develop roller pattern**
- **Determine the rolling zone by:**
 - Experience
 - Estimating
 - Density

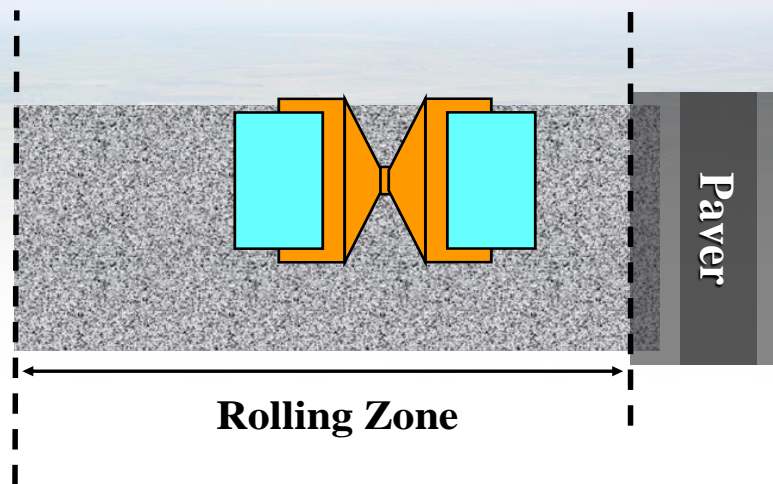


84

Breakdown rolling is the first interaction between the roller and the asphalt mat and can be a friendly or a troublesome meeting. Most contractors use steel drums. Some use a pneumatic tired to breakdown the mix, increase the mat density, and establish the mat smoothness. Rollers should stop and start slowly on uncompacted mix and angle the drum when stopping to reverse.

All compaction should be accomplished by the breakdown and intermediate rolling. Establishing a rolling pattern within a temperature zone is the most efficient and effective means of achieving desired density.

Rolling Zone

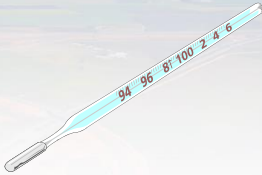


85


All compaction must be achieved while the viscosity of the asphalt cement in the mix and the stiffness of the mix is low enough to allow reorientation of the aggregate particles under the action of the rollers. As the proper level of air void should be obtained before the mix cools to 175 °F, the rolling zone is the area in which the available compaction equipment can provide the required coverages to achieve desired density within the proper temperature range. Initial compaction should occur directly behind the paver while the temperature is still very hot, if the stability of the mixture is acceptable at high temperature. Superpave with polymer modified binder has shrunk the distance between the roller and the paver to as little as 3 to 15 feet.

Time Available for Compaction (TAC) Compaction of Asphalt Mat

Temperature Range
175 °F ↔ 300 °F

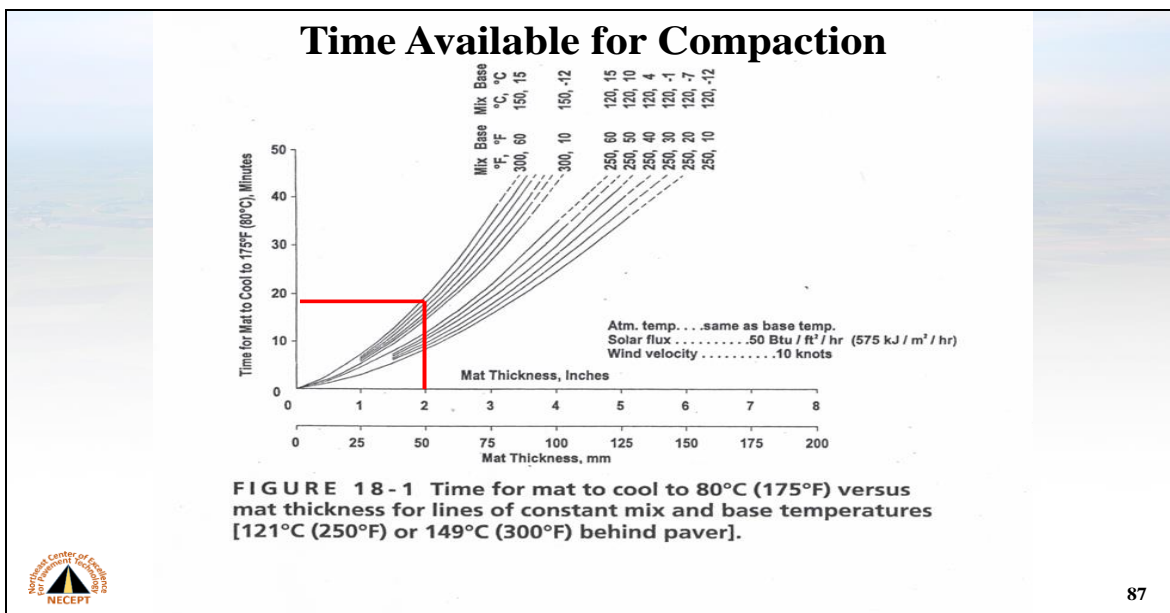


Need sufficient number of rollers with the compaction operation moving at the proper speed to balance production & achieve required density within the TAC



86

Remembering the Time Available for Compaction is the time (in minutes) that a particular mix is at the right temperature range for efficient compaction, and all compaction must be accomplished before the asphalt mat cools to a temperature below 175-185°F. It is good practice to complete rolling on WMA by 175°F as well, although some additional compaction may be achievable depending on the particular WMA technology. Rolling at cool temperature will lead to over rolling, crushed aggregate, and loss of density.



Going back to our chart on “cooling curves” for asphalt mixtures, we now can use the information obtained from the compaction production problem to determine the rolling zone. If we are laying down a two-inch mat with a mix temperature of 300°F and a base/air temperature of 50°F, we can plot these parameters and find that we have 18 minutes as the time available for compaction.

Rolling Zone

- **28 fpm x 18 min. (TAC) = 504 feet**
- **~ 500 foot rolling zone**



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Since our compaction production rate is 28 feet per minute and we have 18 minutes, our rolling zone calculates to 504 feet. Thus, we have an approximate rolling zone of 500 feet behind the paver where efficient compaction is possible.

Re-Watering During Paving



- Close available source
- Rewater during any lull in paving (refill half empty tank)



89

Maintaining a spray system that uses the minimum amount of water will reduce these re-watering stops, but not eliminate them. It is best to re-water during a temporary lull in paving, and refill a half empty tank, than to wait until production is peaking and run out of water. If this cannot be avoided, and the mix is cooling too rapidly to wait, the intermediate or finish roller should be moved to the breakdown position until the original breakdown roller is available. Ensuring access to local fire hydrants should be taken care of prior to the start of the project with the appropriate owner of the water facilities. Usually water companies or municipalities assign contractors portable meters for payment as shown here.

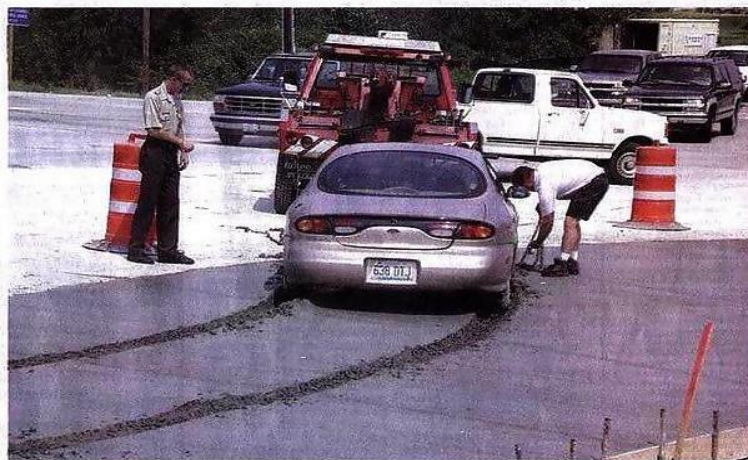
Opening to Traffic



90

If the mix hasn't cooled below a mix-specific temperature before opening to traffic, additional densification can occur in the mix with traffic creating wheel path ruts. The temperature of asphalt mixes (surface or internal?) should be down to at least 140°F before the pavement is opened to traffic. Intersections, night paving, and ramps plus driveway entrances are key areas. Artificial watering is not allowed. WHY?

Of course, some drivers get in a hurry!



91

What are a Field Technician's Responsibilities Concerning Compaction?

Monitoring

- Temperature
- Roller Pattern
- Compaction Process

Documentation

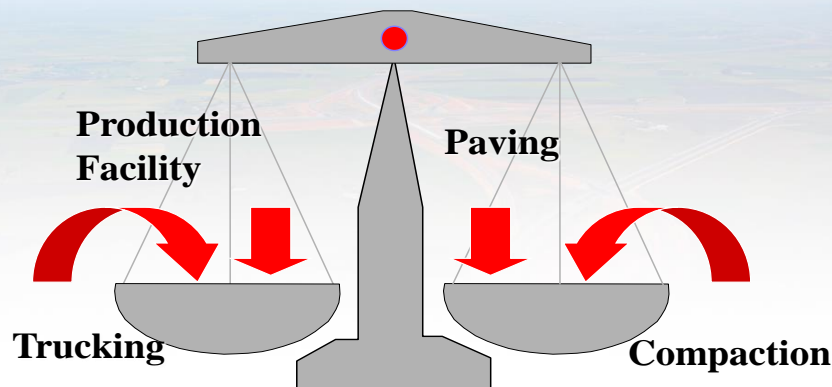
- Core Locations
- Density
- Thickness
- Smoothness



92

Although the duties of the Certified Field Technician will vary depending on the employer, they should be aware and able to perform any of the above activities. Although responsibilities will vary, we will treat each technician as if they were responsible for each function.

Balancing Production Paver Speed With Compaction



93

As was discussed in the previous modules, the entire paving operation is a balancing act. It starts at the asphalt facility with how much can the producer supply to the project and how many trucks will be available to transport the asphalt to the paver. Now we have to determine the speed of the paver to ensure a constant flow of material with a minimal number of stops. Schedule ahead of time to balance all of these rates. Understanding the variables that can affect each rate is the key to adjusting the others when changes occur—and be assured, changes will occur. Keeping the rates in balance will lead to a better pavement, and more production. If you have a number of trucks waiting, should you speed up the paver to empty them? Not necessarily -- the roller operator may not be able to achieve compaction if the paver speeds ahead. Also, if you change the speed of the paver, you may need to change the amount of mix delivered to the augers to compensate for the change. Automatic material flow control will adjust for these changes. Speeding up the paver will change the *pre-compactive* effort by the screed, requiring more compactive effort from the rollers. All of these things come into play and all need to be considered as the paving operations continue down the road.

Roller Production Scenario Calculations

Balancing breakdown roller production with paver speed

Paver Speed is 27.3 feet per minute (FPM) at 12 feet wide.

78 inch drum (6.5 feet) with 6 inch overlap = 72 inch (6 ft.) effective width

Minimum of three passes required to construct longitudinal joint as per method spec.:
Section 409.3 (k) 1.a or PTM 402 or 403

2 coverages required to obtain specified density, but $2 \times 3 = 6$ (an even number), so roller will be at back of pattern, which then requires a "catch-up" pass. SO: 7 X 27.3 = 191 FPM

Plus, add 10% for reversal factor: 191 + 19 = 210 FPM *minimum required average speed*



94

If a 4-foot shoulder is being placed simultaneously, 4 passes per coverage will be required:

4 passes X 2 coverages = 8 passes, but 8 is an even number, so a "catch-up" pass is required. Therefore, 9 passes are required.

$9 \times 27.3 = \underline{245.7}$ FPM. Plus 10% for reversal factor = $245.7 + \underline{24.57}$ (24.6) = 270.3

270.3 FPM *minimum required average speed* required to keep up with paving operation IF the paver does not stop.



95

Desired impact spacing 10-12 impacts per foot (IPF). Roller speed is computed by dividing machine frequency (vibrations per minutes – VPM) by the desired impact spacing.


2700 VPM Roller Computations

$2700 \text{ VPM} / 10 \text{ IPF} = \underline{270} \text{ FPM}$	$270 \text{ FPM} / 88 = \underline{3.068} \text{ (3.1) MPH}$
$2700 \text{ VPM} / 12 \text{ IPF} = \underline{225} \text{ FPM}$	$225 \text{ FPM} / 88 = \underline{2.556} \text{ (2.6) MPH}$

If 3000 VPM machine: *Divide FPM by 88 to obtain Miles per Hour (MPH)*

$3000 \text{ VPM} / 10 \text{ IPF} = \underline{300} \text{ FPM}$	$300 \text{ FPM} / 88 = \underline{3.40} \text{ (3.4) MPH}$
$3000 \text{ VPM} / 12 \text{ IPF} = \underline{250} \text{ FPM}$	$250 \text{ FPM} / 88 = \underline{2.84} \text{ (2.8) MPH}$

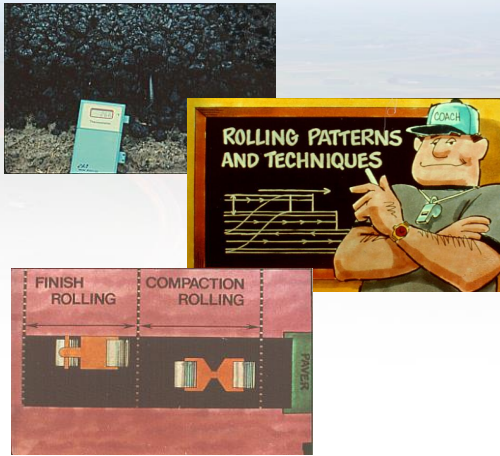

Rollers need to be refilled with water throughout the day and this creates a need to increase the operating speed to maintain the *minimum required average speed*. If the proper impact spacing (IPF) cannot be produced at the higher speed, density reading will suffer and substituting a breakdown roller with a higher frequency, or reducing the paver speed is suggested. Time Available for Compaction (TAC) will be computed for entire operation.



96

Activities To Be Monitored

- Temperature
- Roller Pattern
- Compaction Process



97


Activities that need to be monitored are temperature, roller pattern and the compaction process.


Documentation

- Core Location
- Density

Diagram showing a LOT (Lot) divided into 5 equally sized sub-lots. The diagram includes a stationing marker '100+00' and arrows pointing to the sub-lots.



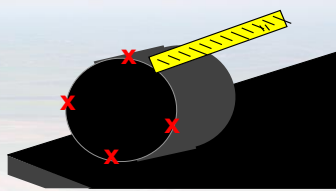







Documentation that will be required are core location and density monitoring.

Documentation

- Thickness
- Smoothness







Additional documentation will be required to check the pavement thickness and smoothness.

You Should Know!

- How to control density
- What to do if density is not achieved
- What the specifications requires (line of action)
- What are the density requirements- acceptance/rejections
- Thermometer use and correlation
- Who will be running the tests.



100

Problem Identification

Problem:
Too little
compaction
or too much
(crushed
aggregate)

Result:
Raveling



101

Too little compaction can be a cause of raveling. Crushed aggregate from rolling at low mat temps is also a common cause.

This will only appear after roadway is under traffic for a period of time.

Problem Identification
Problem: Too Little Compaction
Result: Loss of Pavement Life

Effect of Voids on Life

Percent Pavement Voids	% Service Life
7	100
8	98
9	94
10	83
12	64

102

It has been shown that for every increase in 1 % voids above 7% there is a 10% decrease in the life of the pavement.


The above chart shows research results from Washington State, depicting the loss of pavement life. In other words, dropping 93% density to 92% decreases pavement life by 10%.

Problem Identification
Problem: Bleeding or Flushing
Cause: Over-compaction, poor mix, tack

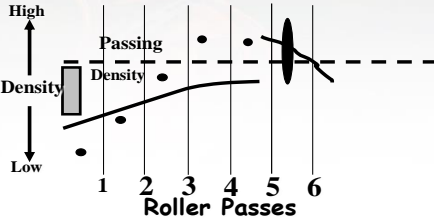
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The opposite problem is too much compaction which can be a cause of bleeding or flushing. Typically, this is a result of a poor mix or extremely excessive tack.


Solution



Develop a Roller Pattern-- PTM 402 or 403




Roller Passes	Density (Relative)
1	Low
2	Low-Mid
3	Mid
4	Mid-High
5	High (crosses Passing Density)
6	Very High


104

The development of a good rolling pattern should ensure acceptable densities.

NOTE: If densities above 96% are routinely being achieved, there probably is a problem within the material...NOTIFY THE PLANT

- **Establish Action Points**
- **What are Action Points?**


105

And the establishment of action points! Also, a **plan of action** with the knowledge of who to notify and what procedures are to be followed in case of undesirable results or an out of your control condition.

Conditions Requiring Action

- Low/high delivery temperatures
- Low densities behind breakdown roller
- Transverse Cracks (checking)
- Longitudinal Cracking/tears/splits
- Bumps, Waves or Ripples
- Density readings > 96 % or less than minimum requirements

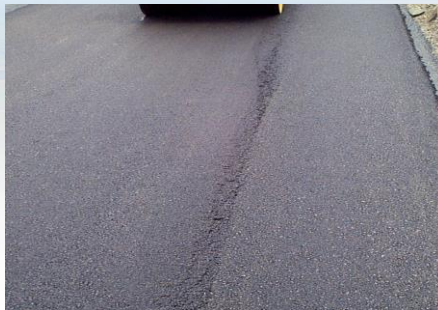


106

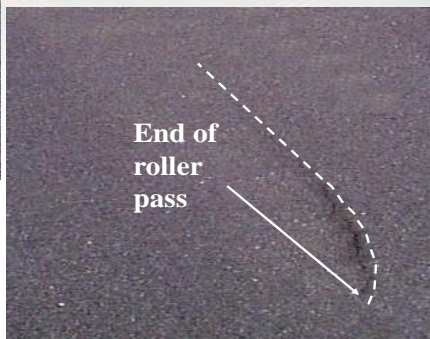
These action points are only for the compaction operation, MANY more exist!!!!

Problem Identification

Problem: Longitudinal Tears/Splits



Vibratory or Violent Turn



Excessive water?



107

Another problem may be cracking due to a tender mat. This may occur during rolling or sometime in the future.

We previously discussed that a “tender zone” may develop in Superpave mixes between 190-240°F. If you do start to experience this, there are a few recommendations.



Too much rolling at the wrong temperature, or possible deep area? Did the breakdown roller operator miscount passes?



Rolling in the tender zone caused this. High roller speeds can make the condition worse. When you see a “bow wave” in front of the roller, stay out of that temperature area on the mat. If you experience excessively tender mix, notify the plant as mix design changes may be needed.


Problem Solution

When Cracking Occurs due to tender Zone:
Lay off the rolling,

Approximate Density Measurement	91% - 92% of M.T.D.	TENDER ZONE		94% - 97% of M.T.D.
Temperature Zones	300° - 285°	240° - 200°		170° - 150°
Distance	← 200 feet →	← 200 feet →	← 150 feet →	

COMPACTION OF SUPERPAVE MIXES

or..


110


When encountering a tender zone, it has been found that by holding back on the rolling until it cools sufficiently to allow further densification is one way to eliminate the cracking. To ensure proper density can still be achieved, you may want to double your break-down rolling with two rollers to achieve greater density sooner and before the tender zone appears.

Problem Solution

When Cracking Occurs due to tender Zone:
...use a pneumatic roller

Approximate Density Measurement	91% - 92% of M.T.D.	92% - 92.5% of M.T.D.	94% - 97% of M.T.D.
Temperature Zones	300° - 285°	240° - 200°	170° - 150°
Distance	← 200 feet →	← 200 feet →	← 150 feet →


COMPACTION OF SUPERPAVE MIXES


111


Another method to try would be using a pneumatic roller on the tender mat. This roller will also seal the surface, slow the cooling rate and enhance the void structure thus reducing oxidation.

Problem Identification

Problem: Ripples/corrugations due to improper impact spacing and cold mat



112



The spacing of the impacts of a roller is a function of the frequency of the vibration and the travel speed of the roller. Proper impact spacing and amplitude are the keys to successful pavement compaction and smoothness.

NO IMPACT SPACING (static rolling) was the correct operation here!!!!!!!!!!

Poor Impact Spacing and Material Too Cold!!!



113



This makes a very noisy ride.


Problem Solution

Proper roller frequency and proper speed

Low Frequency **High Frequency**

Impact Spacing


Target: 10 to 12 impacts per foot


114

To eliminate the wash board effect, the operator should check and verify mat temperature, that the frequency is set properly, and that he is not rolling too fast. The impact spacing should be in the range of 10 to 12 impacts per foot to ensure the highest efficiency of the vibratory rollers and reduce the possibility of leaving ripples in the finished pavement.

Problem Identification

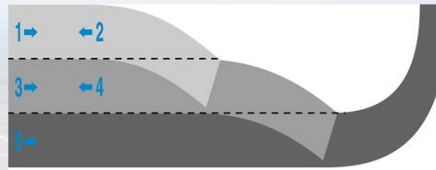
Problem: Mat surface deformations due to roller stopping and starting


115

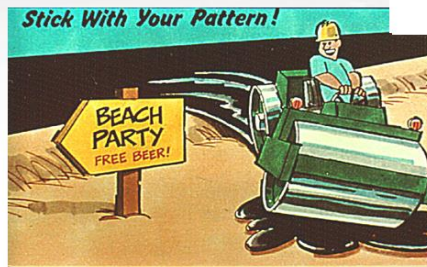
The roller operator needs patience when stopping and starting, to move in different directions, and to achieve acceptable compaction. Gradual slow movements will diminish deformations in the mat.

Problem Solution

Take it easy!



Starting and Stopping



Stick with pattern

Park on cold mat



116

Starts and stops should be done gradually. At the end of each pass as you bring the roller to a stop, roll so that you form a small arc. Roll completely through that a portion of that arc with your next pass and you will take out any small ridge you may have formed when bringing the roller to a stop.

The operator needs patience in staying with their rolling pattern for the entire day to ensure proper compaction of the pavement. And if there is a break in delivery, park the roller on the cold mat.

Problem Identification

Problem: Scuff marks made by the cold tires of a pneumatic roller or rapid change of direction.

The fines picked up here will be re-deposited on the mat.



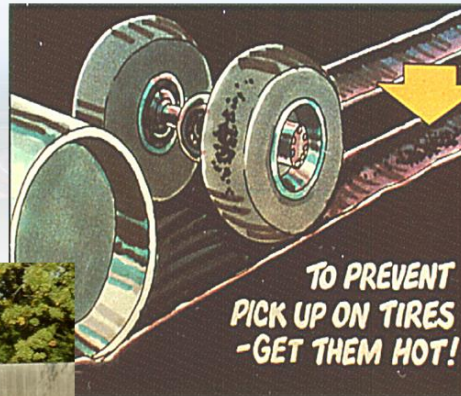
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Damage like this needs to be avoided. Although the density of the pavement is probably being achieved, the finished surface is mottled and will most likely have surface blemishes which may hold water.

NOTE: on a scratch or leveling course due to differing depths of material, some tracks of the pneumatic roller should be evident behind the finish roller.

Problem Solution

Some contractors do not use water or release agent!!!



Skirt



The key is to get the tires hot and keep them hot by keeping the roller moving. The tires on a pneumatic roller will often pick up certain mixes, especially if the mix being compacted contains particular additives. Most often, attempts are made to eliminate this pickup problem by spraying water or a release agent on the tires during the rolling process. Another solution is to allow the tires on the roller to reach the same temperature as the mix being compacted without adding water or release agent to the tires. Get the tires hot by running the pneumatic roller on existing pavement first and then by slowly getting them hot on the new pavement. The use of ‘skirts’ not only helps in getting the tires hot but also ensures that they will stay hot all day by limiting the winds cooling effects. Pneumatic rollers may not be suited for mixes that contain polymer modified binders. They tend to be very sticky and will pick up.

Module 8 - Review

- Terms & Definitions
- Importance of Compaction
- Factors Affecting Compaction
- Equipment
 - Types of Rollers and Maintenance
- Operating Techniques





Quiz

Module 8

Compaction

?



1. A coverage is defined as the roller moving over the entire width of the mat one time.

- a. True
- b. False

Answer:

- a. True

2. Under the percent within tolerance specification, the best way to maximize incentive payments for density is to...

- a. Stop rolling at minimum density**
- b. Consistently achieve densities in the center of the density range**
- c. Keep roller impact spacing < 8 impacts/ft.**
- d. Use only oscillatory rollers**

Answer:

- b. Consistently achieve densities in the center of the density range**



3. A pass is defined as the entire roller moving over one point of the mat two times (up and back).

- a. True**
- b. False**

Answer:

- b. False**



4. TAC (time available for compaction) is considered the time that the mix is within the temperature range of

- a. 140°F to 300°F
- b. 175°F to 300°F
- c. 240°F to 320°F

Answer:

- b. 175°F to 300°F



5. Compaction will reduce air voids, thereby increasing mat density and increasing pavement life.

- a. True
- b. False

Answer:

- a. True



6. The rollers compact by applying their weight over the area of the drum/tire that touches the mat (contact pressure).

- a. True
- b. False

Answer:

- a. True



7. When making the first pass with the roller, the contact pressure will be the highest.

- a. True
- b. False

Answer:

- b. False, the drum will penetrate the mat more at higher temperatures and at early stages of compaction when the mat is less dense, thus more of the drum is in contact with mat, reducing the contact pressure



8. The dynamic (impact) force of a vibratory roller is determined by the amplitude and frequency with the target impact spacing being

- a. 6 to 8 impacts per foot
- b. 8 to 10 impacts per foot
- c. 10 to 12 impacts per foot
- d. 12 to 15 impacts per foot

Answer:

- c. 10 to 12 impacts per foot



9. The faster a roller passes over a particular point in the new surface; the more compactive effort is applied.

- a. True
- b. False

Answer:

- b. False



10. Suitable minimum layer thickness for a mix with nominal maximum aggregate size of 9.5 mm (3/8") is

- a. 3/4"
- b. 1.25"
- c. 1.75"
- d. 2"

Answer: