OAPC
Segregation – Causes & Solutions / Identifying Poor Practice

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Segregation prevention or cause

- Dropping material
- The biggest cause of segregation is allowing materials to be dropped on to a pile.

Rocks roll off pile

Courtesy of Brian Keveryga
Visual Segregation

SUBJECTIVE

None/Blemish  Slight  Moderate  Severe
Material Management

Key Points in Prevention of Segregation:

- Keep Material Contained
- Prevent Excessive Rolling of Materials
- Move Material in a Smooth Uniform Uninterrupted Manner.
Adjusting the proper head of material.

Looking across the tunnel will tell you a lot about the head of material.

You could resolve this problem by adjusting the flow gates or slow down and adjust the pile height.
What is Segregation:

Two Types:

1. Gradation Segregation – *non-uniform distribution of coarse & fine aggregate:*
   - Large Stones Separating from smaller stones and fines:
     - Usually occurs on a plie (sloped surface) during Handling
   - Heat and Asphalt Separated with the Fines
     - Result is Thermal Segregation
   - No Asphalt to hold large aggregate together
   - Mostly Visible on the pavement
     - Minor Tractor / Screed adjustments could sometimes hide

2. Thermal Segregation
   - Material cooler that specification .... Crust, cold material from stopping
   - Also created by Gradation Segregation
Root Cause of Asphalt Pavement Failures - Placement Related:

Low Density - Root Cause of Failure

Root Cause of Low Density

1. Low Temperature: Symptom of Thermal Segregation – from Crust / Cold Mix
   Symptom of Gradation Segregation also
2. Poor Gradation: Symptom of Gradation Segregation
3. Low Asphalt Content: Symptom of Gradation Segregation

Would it be Reasonable to conclude that:

- Gradation Segregation Influence all 3 Root Causes
- Thermal Segregation from Crust / Cold Mix influence 1 Root Cause
- Thermal Segregation Ideal for Detecting Gradation Segregation???
- What Should we Remix??? ........Gradation Segregation??

Nars
Root Cause of Asphalt Pavement Failures, Placement Related:

2 Types of Pavement Blemish:

- Resulting in Cracks and Raveling

1. Continuous Longitudinal Streaks:
   - Gradation Segregation Causing Low Density
   - Thermal Segregation a Symptom:
   - Paver Induced – Not Resolved By MTV

2. Intermittent Open Texture / Voids:
   - Gradation Segregation Causing Low Density
   - Thermal Segregation a Symptom:
   - Resolve with MTV but could Reintroduce in Paver
1. Must Understand the Free Floating Screed and Impact of Segregation
   - Vibratory Screed Compaction
   - Impact of Segregation on Forces holding screed to Grade

2. Best Material Handling Practice to Minimize segregation
   - At the Plant
     - Proper Stock Pile Management
     - Adequate Remixing at the Plant
     - Proper Material Transfer from Plant .....to Silo ........to Trucks
   - At the Jobsite
     - Trucks Dumping in Paver
     - Use of MTV
Placing HMA

- Segregation Trouble Spots
  - Trucking Operations
    - Improper Loading
    - Improper Unloading
  - Paving Operations
    - Improper hopper wing dumping
    - Running the paver hopper dry and moving forward before hopper is recharged
Segregation Checklist

- Stockpiles
  - Construct in layers
  - Use high wall bulkheads
  - Loader should dig in and curl bucket

- Cold feed bins
  - Avoid adjacent bin spillage
  - Avoid coning of materials
  - Maintain constant levels
  - Use multiple bins for coarse aggregate
Principles of the Free Floating Screed

Review of Key Components of the Paver:

- Tractor
- Tow Point (Pull Point)
- Screed
- Mat Depth
- Equilibrium Angle of Attack (5 Forces in Balance)
Segregation checklist

- Paver
  - Minimize folding wings (to prevent mixture cooling at wing walls)
  - Never let hopper run less than 25%
  - Never expose the conveying system
  - Adjust flow gates to deliver a continuous and adequate amount of mix to the augers
  - Augers need to be proper length
Continuous Segregation
Feeder shadows
Random Segregation
Principle of the Free Floating Screed

Also The screed is held to grade by 5 Force

- R & F influenced by the Internal Frictional Resistance of the aggregate
  - Fines, Asphalt & Heat changes the Internal Frictional Resistance
Principles of the Free Floating Screed

Vibratory Screed Compaction:

- **Main Screed**
- **Main Strikeoff**
- **0 Compaction at Strikeoff**
- **Screed Compaction (Angle of Attack)**
- **Max. Compaction at Trailing Edge**
- **Material Flowing Under Screed**
- **Mat Thickness**
Principle of the Free Floating Screed

Substantial Segregated material flowing across width of Screed

- Inconsistency in AC, Temperature and Gradation – (R & F)
- Screed Dips and seeks new Grade - INTERMITENT
- Inadequate Fine / Asphalt Cause Raveling

Segregated material flowing under screed

Change internal frictional resistance

Screed seeks new Grade – Usually a Dip - Little asphalt / No fines - Dynamic loading starts raveling
2 Examples of Root Cause for Intermittent Blemish

- Running hopper ....or Insert ....or Auger Chamber too Low:

Principle of the Free Floating Screed
Principle of the Free Floating Screed

Segregated Streaks flowing at specific location of Tractor & Screed

- Inconsistency in AC & Gradation to Cause Longitudinal Cracking
- Not adequate to Change Grade
- Minor Adjustments Could Hide
- Temperature Differential Could Identify

![Diagram of the Free Floating Screed](image-url)
Two Potential Locations for **Continuous Longitudinal Streaks**:

- **A**: Centerline Segregation – Under the Auger Box
- **B – C Segregation**:
  - At Insert Side Wall during Filling / Bearing Hanger / Edge of Mainframe
  - Could be Individually Defined or Overlap
Control Segregation with Proper Material Handling

Material Handling during the paving Process:

1. Trucks Dumping in the Paver Hopper

2. Trucks Dumping in MTV Hopper & MTV Feeding Hopper Insert

   Tractor delivering to Screed – Weather Pushing Trucks or Using MTV

Same with 1 & 2
1. Controlling Segregation – Truck Dumping In Paver Hopper

a. Running The Hopper too low
   - Creates two valleys at the middle of flight Chain
   - Two streaks appears in middle of the tunnel
   - Would appear only when hopper is too low
1. Controlling Segregation – Truck Dumping In Paver Hopper

b. Segregated Material at the side wall of the Hopper:
   - Larger Stones at side of Truck Bed at side of Hopper
   - Dump Hopper Only When Needed
     - Streaks in the form of a chevron
     - Chevron pointing towards Paving direction

(No different from end of Insert – Will Discuss Later)
1. Controlling Segregation – Truck Dumping In Paver Hopper

c. Gradation Segregation at the End & Start of Dumping

- Follow Proper Truck filling & Dumping Practice
- OR Use Material Transfer Vehicle (MTV)
Segregation Checklist

- Truck loading
  - Load in 3 or more drops
    - Far front, far back, then center
  - Discharge from surge/silo gate in large masses
  - Surge the tail gate during unloading by tilting of the truck bed
  - Flood the paver hopper
  - Accelerated bed raising near end of load to drop mix in mass
2. Controlling Segregation when Using MTV & Hopper Insert

Why MTV???

a. Provide Non Contact Continuous Paving
   ▪ Receive material from truck & deliver to the Paver
     ▪ Eliminate stopping to exchange truck / Truck bumping the Paver

b. Provide Adequate Surge & Remixing
   ▪ Surge to exchange truck without Stopping
   ▪ Surge to Remix segregated material with Non-segregated Material
2. Controlling Segregation when Using MTV & Hopper Insert

MTV - Material Transfers Vehicle

- 2 Types – Shuttle and Non Shuttle Type
- Providing Non-Contact Continuous Paving & Remixing

1. Shuttle Type

2. Non-Shuttle Type
MTV’s
What are we Remixing????

Gradation & Thermal Segregation Created in the Paving Train

- 5 Potential Locations………3 Before the MTV and 2 After the MTV

1. Gradation - Large stones at the side walls
2. Gradation - End & Start of Load
3. Thermal - Crust from Hauling
4. Gradation & Thermal - Large stones & Crust at the Side walls
5. Gradation & Thermal - As the material drops in front of Screed or cool down from stopping too long
1. Remix Stones that rolled to the truck bed Side Walls

Solution: Variable Pitch / Re-mixing Augers in MTV Receiving Hopper

- Auger Re-blend Large stones from the side walls
- As it moves to the center
2. Remix Segregation from End & Start of Dumping

Solution: Re-mixing Augers & Front Tilting Hopper:
- Hopper Dumps on top of Augers
- Auger Re-blend End & Start of Load Segregation

Also Potential for Thermal Segregation
3. Remix Cold Crust on surface & side wall of truck bed & Insert

Cold Mix from Transportation / around the Insert – Could Occur anytime

Around the walls of the Paver Hopper Insert

On the surface & side walls of the truck bed
3. **Remix Cold Crust on surface & side wall of truck bed & Insert**

**Solution 1:**

**Combination of Re-blending Augers and Flight Chains**

- Augers re-blend cold crust as it moves the material to the belt
- Several flight Chains brakes up the crust as it moves to the next conveyor
3. **Remix Cold Crust on surface & side wall of truck bed & Insert**

**Solution 2: Passive Remixing Insert with Grate Baffles System:**

- **Grate System:** Brake up Large Crust
  - Surrounding Hotter mix heats up smaller crust
  - Also Traps Clunkers from Plant etc.
4. Remix Segregated stones from Pile in Insert during filling

Larger stones from the pile……… rolled Until stopped by the insert walls

- **Flight chains remix Segregated stones along front & Rear Walls**
- **Segregated stones along the side walls flows to Edge of Conveyors**
  - **Placed from the edge of conveyor to Outer Bearing Hanger**
  - **Not Severe with All Mix Design**
4. Remix Segregated stones from Pile in Insert during filling

Solutions: Passive Re-mixing Insert with Baffles & Tapered Bottom Opening

- The Baffles Reduce the length of the slope of Pile
  - Also Provides Dual Capacities
- Tapered Bottom Spreads the segregated stones along the side walls
  - Also wider front allow more material movement from Front to Rear

- 17 Tons (10 cu yd)
- 23 Tons (13 cu yd)
4. Remix Segregated stones from Pile in Insert during filling

The Front of the insert usually Retains Colder Material

- The front opening should be behind the conveyor front Apron
  - Also, Narrower Rear Restricts material movement from Front
- Tarp around the insert could retain the Heat

![The Front of Insert Close to Rubber Covers front Apron](image1)

![The Front of Insert behind front Apron](image2)
The Evolution of Paver Inserts

- 1st Generation
- 2nd Generation
3rd & 4th Generation
5th Generation
5. Remixing Stones that separated as the Tractor delivers to Screed

Centerline Segregation (A)

- Reverse flights next to the auger box
  - RH Reverse Flight Pushes center segregated mix to the LH side
  - LH augers continues to move to the LH and re-blend
    (LH & RH Reverse Kickers tends to tuck segregated material to center)
  - Augers must Rotate Continuously to be Effective
Maintain Your Equipment
Screed Marks

- Extensions set too high or low
- Extensions starved for mix
- Lack of mix vibration
- Worn augers and/or plate
- Over sensitive automatic control
- Turning paver too sharply
- Checking/tearing under screed
5. Remixing Stones that separated as the Tractor delivers to Screed

Segregation from Edge of conveyor to Edge of Mainframe (B, C)

- Proper Material Handling In Hopper & Auger Chamber

Reduce Segregation at the hoper Side walls
Segregation from Edge of conveyor to Edge of Mainframe (B, C)

- Also Ensure Proper Material Delivery from Conveyor to Augers
  - Auger & Conveyor sensors set for Continuous Delivery
  - Use Material Chutes & Tunnel Extensions to Keep material closer to augers
  - Don’t run the Auger Chamber too Low

5. Remixing Stones that separated as the Tractor delivers to Screed
5. **Remixing Stones that separated as the Tractor delivers to Screed**

**Segregation from Edge of conveyor to Edge of Mainframe (B, C)**

- Optimum distance from Auger to Screed and Fender
  - 2 to 4” Depending on Manufacturers
Screed Marks

- Mat thickness to low for NMAS
- Variable head
- Brakes set on truck
- Truck bumps paver or not set square with the roller bars
- Incorrect screed setup
- Poor screed mechanical shape
- Cold screed
Mat Flaws due to Incorrect Screed Adjustment – Not Segregation

Usually Pronounced Line / Adjacent to difference in Texture

1. Inline with the edge of the main or Extension screed
2. At the edge of Shadows defined by any of the 3 screed sections
3. Edge of cold mix in between Front Mount Extensions
Continuous or Sporadic Texture difference (Blemish)

1. Under the Auger Box
2. From Edge of Conveyor Tunnel to outside of Mainframe
3. Chevron Shape
In cooperation with FHWA

NCHRP Report 441 on Segregation Study:

Investigate pavement failures and Develop Procedures:

1. To Detect, Measure & Classify Segregation
2. Verify that Thermal Image could detect & Classifying Severity of Segregation

Report 441

Segregation in Hot-Mix Asphalt Pavements

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Sponsored by AASHTO (American Association of State Highway and Transportation Officials) In cooperation with FHWA
Table X3.1—Temperature Differential Categories

<table>
<thead>
<tr>
<th>Range</th>
<th>Category</th>
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<tr>
<td>≤13.9°C [25°F]</td>
<td>Good</td>
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<tr>
<td>&gt;13.9°C [25°F] to ≤27.8°C [50°C]</td>
<td>Moderate</td>
</tr>
<tr>
<td>&gt;27.8°C [50°C]</td>
<td>Severe</td>
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Missouri Summary on use of Thermal Profile

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<th>150-ft Sublots</th>
<th>Range</th>
<th>Segregation</th>
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<tr>
<td>150’ Sub-Lot</td>
<td>ΔF ≤ 25°F</td>
<td>NO SEG</td>
</tr>
<tr>
<td></td>
<td>25°F &lt; ΔF ≤ 50°F</td>
<td>MODERATE</td>
</tr>
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<td>SEVERE</td>
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</tbody>
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Figure 15: AASHTO PP80 IR Analysis Method: Segregation categories
Paver Mounted Thermal Profile (PMTP):

Longitudinal Thermal Streaks:
- Paver Induced - Cannot be Resolved with MTV

Open Voids from Cooler segregated rocks
- Minimized with Most MTV
Vogele and MOBA Thermal Camera Systems:

1. Vogele Integrated Thermal Camera……..Display on the Tractor Control
   - Analysis base on Europe Requirement

2. MOBA System – Stand Alone
   - Separate Screen, Rev Counter etc
The following Process are referred to Intelligent Construction Technologies:

- All plotted on the same GPS Coordinates

1. IC - Intelligent Compaction
   - Manage the rolling Process

2. PMTP – Paver Mounted Thermal Profile
   - Document Pavement Temperature at back of screed

3. GPR – Ground Penetrated Radar - Document the Density after rolling

4. IRI – International Roughness Index - Future

5. 3D Milling – Future, Possible 3D Paving

VETA Interface allows each State to analyze Multiple OEM Systems.
Can we conclude Root Cause of Typical failures are as follows??

1. Longitudinal Cracks
   - Centerline (under the auger Box)
   - Edge of Conveyor tunnel to end of mainframe (Wheel Path)

**Root Cause:** Low Density due of Gradation Segregation Not Thermal????
- Mostly Tractor Related Issues – From Hopper Insert to Screed
- Current AASHTO PP80-17 Will not detect

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Figure 15: AASHTO PP80 IR Analysis Method: Segregation categories
Can we conclude the following are Root Cause of Typical failures??

2. Raveling:
   - At End / Start of Load or End of Insert
   - Cold mix in Auger from Stopping

   **Root Cause:**
   - Gradation Segregation – No fines / Heat
   - Thermal due to gradation segregation
   - Thermal Segregation from Cold Mix

3. Rough Ride:
   - Dip & Hump from Stopping
   - Grade Change from Inconsistent Mix

   **Root Cause:**
   - Screed Settling from Stopping
   - Slight Hump after takeoff
   - Grade Change from Segregation
Can we conclude the following:

Not all Mix designs are prone to Gradation Segregation:

a) MTV used for Non-contact Continuous Paving
b) Surge needed for Truck exchange & Re-blend End of Load Segregation
c) Remixing Ideal at Last Point of Handling ..... From Insert to Augers
d) Stop before insert in less than 1/3 empty

Use Screed Hold / lock / Freeze to minimize impact of stopping.
QUESTIONS
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