



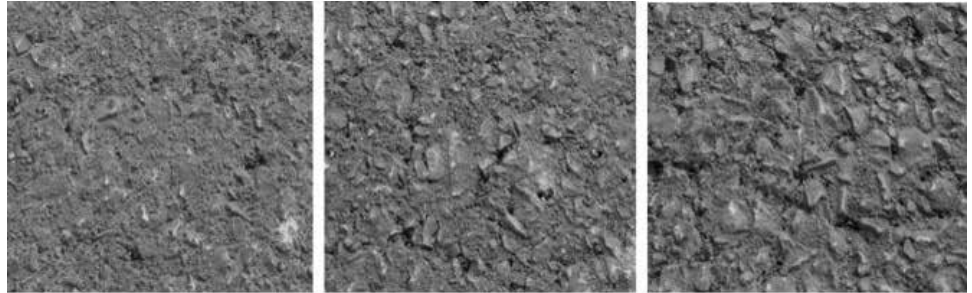
ONTARIO ASPHALT PAVEMENT COUNCIL

The ABCs of
Segregation
Causes & Cures

WHAT IS SEGREGATION?

Segregation in Hot Mix Asphalt (HMA) is simply defined as a separation between the coarse particles from the fine mass of the mix. This non-uniform aggregate distribution creates mixes that do not conform to the original job mix formula in gradation or asphalt content; thus, resulting in pavements with poor structural and textural characteristics, poor performance and have shorter life expectancy and higher maintenance costs.

SEGREGATION TYPES



(a) Fine aggregate segregation

(b) No segregation

(c) Coarse aggregate segregation

Segregation may develop at any stage of the paving process, i.e. during aggregate stockpiling, during production, during hot storage filling and loadout, and from transportation to placement. Regardless of the point of occurrence, each type of segregation affects the long-term durability of the asphaltic concrete pavement structure. Five (5) types of HMA segregation are discussed as follows:

1. Truck End Segregation:

Usually caused by improper truck loading/unloading, silo segregation, or running the hopper empty between loads. They are identified as longitudinally occurring segregated spots on either side of the lane being paved, and often referred to as wings. These wings constitute spots of coarse aggregate separated from the uniform mixture, and are typically much more open graded than designed and, if severe enough, will deteriorate in a short period of time leading to a pothole in the road.

2. Centreline Segregation:

As the name implies, this type of segregation normally occurs in the centreline of the lane and is primarily attributable to coarse aggregates during discharge from the conveyor system into the auger area. It then rolls underneath the auger chain drive or gearbox and concentrates in the centre of the mat being laid. Centreline Segregation is the second most common type of Segregation.

3. Joint/Edge Segregation:

This is the third most prevalent type of segregation. It occurs on the outer edges of the pavement being placed. It is caused from the augers not being run at sufficient speeds on the paver, allowing the coarse aggregate to roll to the outside of the mat. Other causes of joint/edge segregation include – not using auger extensions, and not using the tunnel extensions.

4. Truck End Segregation/One Side:

This type of segregation is a special case of truck end segregation, but is most commonly caused by improper loading of the batcher on the hot storage bin. An adequate head of material should be maintained at all times.

5. Random Segregation:

This type of segregation is the most difficult to find. It mostly occurs when improper mixing is taking place either in the batch plant or drum mixer, but can also occur in other places in the process.



This image shows segregated spots resulting from not having enough head of materials for the auger to spread and/or due to poor workmanship.

HAND WORK

Hand work usually results in a change in texture when compared to machine laid HMA. Poor hand work techniques can lead to segregation but modest differences in texture is not considered as segregation. Where possible, use fine graded mixes as they are more user friendly in hand laid areas.

In a municipal setting there are many situations where hand work is unavoidable. Care must be taken to avoid segregating the mix and removing any excess stone on the surface of the hand work area before rolling.

Longitudinal joints require proper paver set up for ideal overlap and lift height. If done properly, the joint should not require any hand work adjustment with the lute. If properly constructed, a joint having a slight ridge of stoney aggregate along the joint is not considered to be segregated.

MIX DESIGN

The following key considerations in mix design are important to avoid, eliminate or control segregation:

- Extra care and/or the use of mix additives may minimize segregation problems with gap-graded mixes;
- Low asphalt content mixes tend to segregate much more than mixes containing high asphalt content, regardless of the gradation;
- Increased film thickness dampens the tendency for mix to separate at transfer points. The use of fibres and polymers enables the use of a higher asphalt content which makes the film thicker;
- Mixes with gradations that fall directly on the maximum density line should be avoided. Designers should select approximately 2 to 4 percentage points above the maximum density curve if a fine textured mix is desired and approximately 2 to 4 percentage points below the maximum density curve if a coarse textured mix is desired. The maximum density line should only be

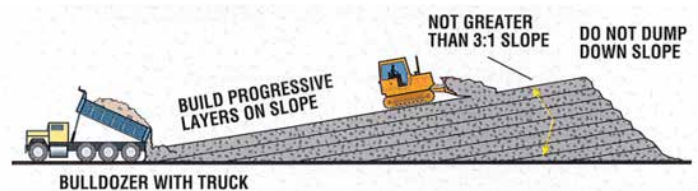
used as a guideline for uniform grading. Other criteria such as VMA, air voids, stability, and other specifications must also be met; and

- Mixes whose gradation curve are slightly bowed have less propensity to segregate than those that make the 'S' across the maximum density line.

STOCKPILING

Proper stockpiling techniques are necessary to ensure that the materials will be uniform when fed to the hot mix plant. The following key considerations are applicable to avoid, eliminate or control segregation in stockpiles:

- Avoid high stockpiles for single aggregate blends;
- It is beneficial to employ two cold feed bins to feed the same material when working with larger size aggregates since this practice tends to minimize wide variations by feeding smaller amounts of materials from two feed points thus increasing the chance of re-blending the material;
- Presence of a wide variation in gradation in fine-sized aggregates will result in a segregated mix. By building stockpiles in progressive (horizontal or on-slope) layers will assure significant material uniformity; and



- Dozer operations should be monitored (especially when dealing with softer aggregates) to minimize degradation.

It should be noted that the method used to remove material from the stockpile is as important in minimizing segregation as building the stockpile. The operator should work the entire face of the stockpile and must take care not to contaminate the stockpile with the materials on which the stockpile is built. When large stockpiles are observed to be segregated, it may be advantages to build a smaller, pre-blended, daily-use stockpile before production begins.

ASPHALT PLANTS

Asphalt is produced in a batch or drum mix plant. The most sensitive areas for segregation on any plant include cold feed bins, surge bins and storage bins. On a batch plant it can also occur within the hot bins which are not present on the drum mix plant. Segregation in cold feed bins can be prevented by utilizing a self-relieving bottom to ensure uniform feeding in the hopper. This eliminates material bridging.

Segregation can occur with all sizes of materials in hot bins (particularly in No.1 hot bin due to its large size and shape). Installing baffles within bin No. 1 allows the dust to slide to the centre of the bin where it is uniformly mixed with the coarse materials.

Segregation can be eliminated by equipping drag conveyors with floating hold downs and heated bottoms for cold start-ups. Keeping the drag conveyor as full as possible by running at higher production rates can minimize segregation. As such it is recommended to store any extra mix and shut down production earlier than usual when producing segregation prone mixes at production rates higher than the rate used by paving operations.

DRUM MIX PLANT

Segregation in a drum mix plant is primarily due to differences in particle sizes and material flow rate with

the coarse materials being more likely to segregate. Factors that negatively impact the coating quality of coarse materials and film thickness include the amount of material passing the 75 micron sieve in the mix, internal moisture and asphalt absorption. A reduction in the amount of material passing the 75 micron sieve is recommended for ease of uniform mix production and handling during trucking and laydown operations.

The negative effects associated with flow rate can be eliminated by adjusting the start/stop time intervals between the cold feed bins while better coating can be accomplished by increasing the mixing time by extending the asphalt line farther up into the drum mixer. Mixing time for hard-to-coat materials may also be extended by adding a dam (donut) or kickback flights. Alternatively, the dwell time can be increased by decreasing the drum slope to provide additional mixing time. It should be noted that increased dwell time may reduce the production rate if the drum drive motor is a limiting factor. Increased drying and mixing times using these methods are beneficial to eliminating segregation resulting from internal moisture.

Applying restrictions to the discharge chute in drum mixers or adding deflector plates or straightening vanes are also effective methods to ensure proper loading of drag conveyors in gravity type drum mix discharge. Alternatively, a plow or single discharge point may be installed in drum mixers. Bin-loading batchers are also good devices for eliminating segregation in surge and storage bins.



Aggregate delivery from the cold bins to the drum. Increased height may cause segregation.

THE FOLLOWING OBSERVATIONS AND PRACTICES SHOULD BE FOLLOWED WHEN USING A BATCHER:

- Batch size should be at least 2,500 Kg (more is better);
- Batcher should be loaded in the centre;
- Material should flow straight down into the batcher (no horizontal trajectory);
- Batcher gate timers should be adjusted so that gates shut with 150 - 200 mm of material left in the batcher;
- Do not allow any free flow through the batcher; and
- Batcher should be maintained so that the mix drops out rapidly as a slug (mass flow).

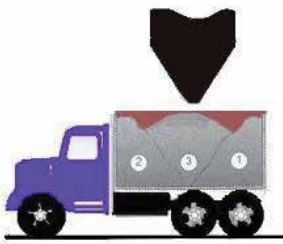
TRUCK LOADING AND UNLOADING

Single drop truck loading underneath surge or storage bins have a tendency for larger stones rolling off to the front, rear, and side of the truck. This results in coarse material being the first and last to be discharged from the truck bed and are subsequently trapped in the wings of the paver to be discharged between truck loads. It is recommended to load trucks in at least 3 different drops, with the first drop being very near the front of the truck bed, the second drop extremely close to the tail gate, and the third drop in the centre.

Uniform loading could also be achieved with the use of bins equipped with properly designed weigh batchers as these tend to re-mix the material prior to dropping into the trucks in a manner similar to the bin loading batcher.

The following considerations are recommended for truck unloading to minimize or eliminate mix segregation potential:

- Discharging materials as a mass instead of dribbling into the paver prevents an accumulation of coarse material at the outside portion of the paver wings;



- Material-run around can be minimized by rapid discharge into the paver hopper.

PAVER

The following considerations are recommended for managing segregation resulting from improper paver operations:

- Avoid complete hopper discharges between each truck load. This improves the chance for coarse materials caught in the hopper wings to mix with finer materials prior to placement;
- Dump hopper wings only as required to level the material load in the hopper. This eliminates valleys in the material bed, minimizes rolling and improves chances of mix flooding into the hopper;
- Do not dump hopper wings at the end of each load, or when the hopper gets low in asphalt;
- Material roll-off tendency can also be minimized by dumping the truck such that the hopper is flooded;
- Keeps augers full by opening hopper gates as wide or high as possible;
- Run the paver as continuously as possible. Start and stop only as necessary. Adjust the paver speed to balance paver production with plant production;
- Run augers in a manner that allows continuous flow of materials. Coarse strips will develop due to centre mat material deficiency if augers are running too fast;
- Using pavers with auger extensions will limit larger aggregate roll-offs, thus curbing outside edge segregation. »





MATERIAL TRANSFER VEHICLES (MTVs)

Material transfer vehicles (MTVs) assist the paver with HMA quality. Depending on the type of paver in use, MTVs will reduce the difficulty of mix dumping, provide additional surge volumes which ensures continuous paver operations, minimizes truck waiting time, temperature differentials, and mix rebinding if equipped with remixing augers. Insert Hoppers for pavers are used with the MTV's to smooth out the flow of mix from the MTV and the paver hopper. The newest generation of hoppers are designed with baffles to reduce segregation.

SUMMARY

The Ontario paving industry understands that segregation may occur due to physical (gradation) and thermal inconsistencies. The importance of checking every stage of the paving process to prevent or resolve any potential for segregation remains a core responsibility of design engineers, asphalt plant operators, paving contractors and roadway clients alike. Determining the presence or degree of segregation can be very subjective. Both the paving staff and the agency inspection staff need to be properly trained to understand, recognize and call out issues at early stages of the paving so that remedial action is taken quickly to reduce or eliminate problems as they occur.

Sources:

1. Joint Publication of the National Asphalt Pavement Association (NAPA) and the American Association of State Highway and Transportation Officials (AASHTO). (1979). Segregation: Causes and Cures. ISBN 1-56051-049-8.