

ASPHALT INSTITUTE
EXECUTIVE OFFICES AND RESEARCH CENTER
Research Park Drive
P.O. Box 14052
Lexington, KY 40512-4052
USA
Telephone 859-288-4960
FAX No. 859-288-4999

Eliminate Twelve Segregation Snarls

Here Are Steps For Your Plan Of Attack

By Jay Hensley, P.E., Chief Engineer, Asphalt Institute

[Mix designs have changed](#)

[Coarser gradations are specified](#)

[Stockpile segregation more common today](#)

[Loading cold bins requires conscientiousness](#)

[Hot bins are prone to segregate](#)

[Kickback flights combat drum segregation](#)

[Pug and surge gates differ](#)

[Truck loading can cause segregation](#)

[Clam type bin gates prevent problems](#)

[Silo shapes affect segregation chances](#)

[Analyze and correct the problem](#)

Many elements are involved in the construction of strong, long-lasting asphalt pavements, including an experienced and committed crew, quality materials, and top-notch equipment. Four areas of the mix design and paving processes — segregation, laydown, compaction, and joint construction — play a crucial role in the life of the pavement, and moving through these stages carefully can make or break your operation. Here are suggestions from the experts on how to avoid mistakes and build it better.

Mix segregation is a common problem in today's hot mix asphalt road construction practice. The degree of segregation relates directly to maximum aggregate size: The larger the maximum particle size, the more segregation prone the mix becomes. In mixing and placing, segregation is prone to occur most often at 12 points. A study of these points can reduce or eliminate segregation in most of your asphalt mixes.

Defined as non-uniform distribution of various aggregate sizes throughout the mass, segregation departs from approved design, and does not exhibit properties and texture required by specs. A project which suffers from segregation is spotty and generally does not meet texture and smoothness specs. Highly segregated mixes often fail to meet in-place density requirements, especially when there is a substantial difference in specific gravities between coarse and fine aggregates.

Segregation most often occurs at these stages:

- mix design
- stockpiles
- cold bin loading
- cold bin feeding
- hot bins
- drum mixer operations
- pugmill gates
- surge and storage bins
- discharge systems
- truck loading
- truck unloading
- paver operation

There may be other sites, but these 12 are the most common and can easily be detected and corrected. An inspector can identify segregation from an extraction analysis. The asphalt film thickness on aggregate is proportional to the surface area, and this relationship can determine whether the mix segregated before or after mixing. All mixes and test samples, by nature, are subject to a certain degree of variation from the job mix formula. These variations, established by the agency based on its experience with mixes and sampling procedures, vary somewhat.

The most common types of segregation:

- Random, which occurs transversely across the roadway.
- Round spots at either side of the lane corresponding with beginning and end of truck loads.
- Continuous longitudinal streaks at either or both sides of the lane.

Each type of segregation is the result of a specific action in mixing and placing. Worn or improperly maintained mixing and paving equipment also leads to problems in handling and placing the mix.

Mix designs have changed

Over the past 15 years, percent minus 200 sieve material (P200) has increased in most agencies' mix designs. This increase has decreased voids in mineral aggregate (VMA), and reduced asphalt demand, which, in turn, has reduced the cohesion of the mix, as well as its workability and durability.

The best method to analyze a mix for cohesion is to observe where the asphalt content (AC) falls on the VMA curve. For maximum cohesion and elasticity in a mix, AC should be selected slightly to the left of the minimum VMA value. Figure 1 illustrates a typical VMA curve.

[Contents](#)

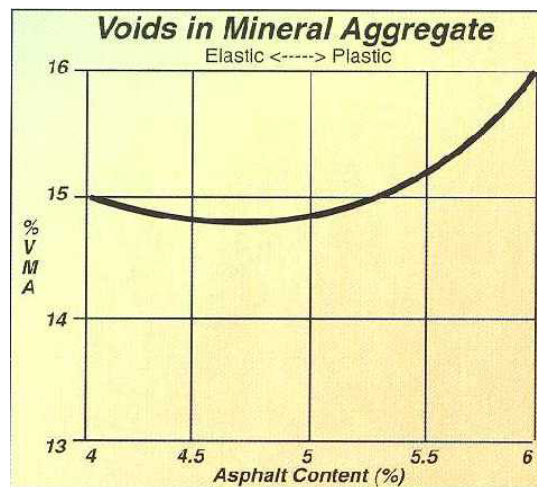


Figure 1

The minimum VMA value occurs at 4.7 percent AC. The design AC should never exceed more than one-half of one percent (0.5) below minimum VMA value. This is only a rule of thumb, and should be evaluated on each mix and aggregate type. Experience has shown mixes with ACs below this value are low in cohesion and prone to segregate. Compaction and moisture damage, or stripping, result in low VMA and ACs. Asphalt mixes with a design AC selected above the minimum VMA value will be over-asphalted, and result in a plastic mix prone to rutting and shoving.

An optimum AC selected by the guidelines from Figure 1 is about 4.2 percent. This is not enough AC to provide adequate cohesion and durability of the mix, which should be redesigned using a cleaner material with less P200.

[Figure 1](#) shows the typical relationship of VMA and AC high in P200. The low point of this curve is the critical point of a mix. It indicates the value of AC content that changes the state of the mix from elastic to plastic. For maximum cohesion, it should be selected near and to the left of maximum AC.

Coarser gradations are specified

The second point for possible segregation in mix design is the gradation. Some agencies have specified a coarser gradation to improve the stability and rut resistant properties of the mix. The result has been gap-graded mixes with a dip at the #4 sieve, which are prone to segregation. The job mix formula must remain well graded and should not vary from the coarse to fine side of the specification band. Otherwise, it can cause a pronounced hump or flat part in mix grading.

These coarse mixes may be allowed in binders or bases, but are prone to segregate and must be handled with caution.

Stockpile segregation more common today

Segregation of mineral aggregate in stockpiles is more common in today's operation because of the type of crushing operation used. Today's materials are of a broader range. They have coarser, drier gradings than older dense gradings, and require careful handling because of a lack of cohesion from a slight moisture content. Today, contractors use four or more cold feed bins to reduce segregation risk at the plant facility. Single size aggregates provide greater quality control than the old methods, which used only two or three cold feed bins with graded mineral aggregates. It is not uncommon to see up to six or seven cold feed bins used by some contractors, and those who do normally use single size aggregates to minimize stockpile effects. Conical stockpiles should be avoided because coarser particles tend to roll down the sides of the pile.

[Contents](#)

Stockpiles constructed by layers or material inclines with less than 30 percent slopes are preferred.

Loading cold bins requires conscientiousness

Changes in aggregate supply and equipment require the loader operator to be more conscious of equipment operation. How the equipment enters the stockpile and operates can cause a segregated stockpile or a load of segregated material. The loader operator should be alert for both segregation and uniform moisture conditions.

Material placed in cold bins by a loader naturally forms a conical shape, and coarse aggregates can separate at this point by rolling down the conical sides. As the material feeds into the cold feed belt, reverse coning, in which coarse material falls to the middle of the bin, can take place. The best way to prevent this is to keep the bins as full and level as possible.

Hot bins are prone to segregate

Batch plant hot bins are prone to segregate by the screening process of the mineral aggregate. Screening action forces coarser aggregate to the far side of the bin, and creates a pronounced pattern from fine to coarse at the inlet screen. This pattern results from two possible factors — the screen system override, and the material's taking the side-cone shape from the screening action. Coarser particles migrate to the far side of the bin.

Baffle plates can be installed on the bin walls to remix material as it enters the bins. Batch plant hot bins do not correct segregation from poor stockpiling or cold feed operations.

Kickback flights combat drum segregation

In drum mix plants there are no hot bins. Stockpiles are considered the equivalent, and there is no chance of segregated material remixing before the introduction of asphalt cement. Segregation occurs in the drum when coarse material comes through ahead of fine, and in such cases, the coarse aggregate does not have the same mixing time as the fine portion.

In drum mix plants, a series of kick back flights at the lower end of the drum kick the coarse aggregate back into the mix. If the mix has proper cohesion, it holds together and exits the drum in a uniform state. Stop and go operations of the drum plant make this segregation more pronounced.

Pug and surge gates differ

Gate openings on surge silos are different from those on the pugmill. Batch plant pugmills empty all the mix in a single drop. Their gates open very wide and allow a straight drop into the truck. Trucks used in batch plant operations have traditionally been smaller and limited the conical effect in loading.

Surge gates that slide open slowly allow some dribble effect at the opening and closing mode. This is common to both the batch and drum mix plants that use surge bins.

Truck loading can cause segregation

Material may segregate as it is loaded into trucks from either pug or surge systems. Trucks are much larger today, and care should be taken to prevent coning in the truckbed. Both pug and surge systems fall under the same loading recommendations, which include at least three drops — front, back, and center.

The mix should discharge first near the bulkhead to produce a stacking effect for the front and sides. The second drop produces the same conditions at the rear of the truck. The third drop should overlap the conical sides of the first two. This procedure does not eliminate segregation, but spreads it out and minimizes the effect.

For large trucks, the procedure doesn't require going all the way to the back of the truck, but balancing the drop, and creating an overlap in loading sequence from front to rear. Pugmilled batches dropped in small increments, similar in pattern to silos, have similar segregation patterns.

[Contents](#)

Clam type bin gates prevent problems

Several gate models are in use on surge and silo bins. They vary from rectangular to round, and can include plates and baffles. Gates are a common spot at which segregation occurs. Most agency specs require clam or other type of gate openings that will not cause segregation. They open both transversely or longitudinally to the truckbed. Type of gate opening may be secondary to segregation in the configuration of the silo.

Asphalt mixes are discharged from the mixing unit and placed in surge bins in two ways — drag slat and conveyor belt. To place material in the storage bin without segregation, the speed of these systems must be balanced with output tonnage. Small amounts of material on a fast belt will segregate when it is placed in the surge, and coarser material will be slung to the far side of the drop chute or other device in place to funnel material into the batch hopper.

Some silo systems allow material to be conveyed against a vertical side wall at the conveyor release point. This causes coarse aggregate to bounce back from the fine, and produces a coarse-to-fine side throughout the surge bin. The mix becomes coarse on one side of the truck and fine on the other, and results in continuous segregation along the side of a paving lane.

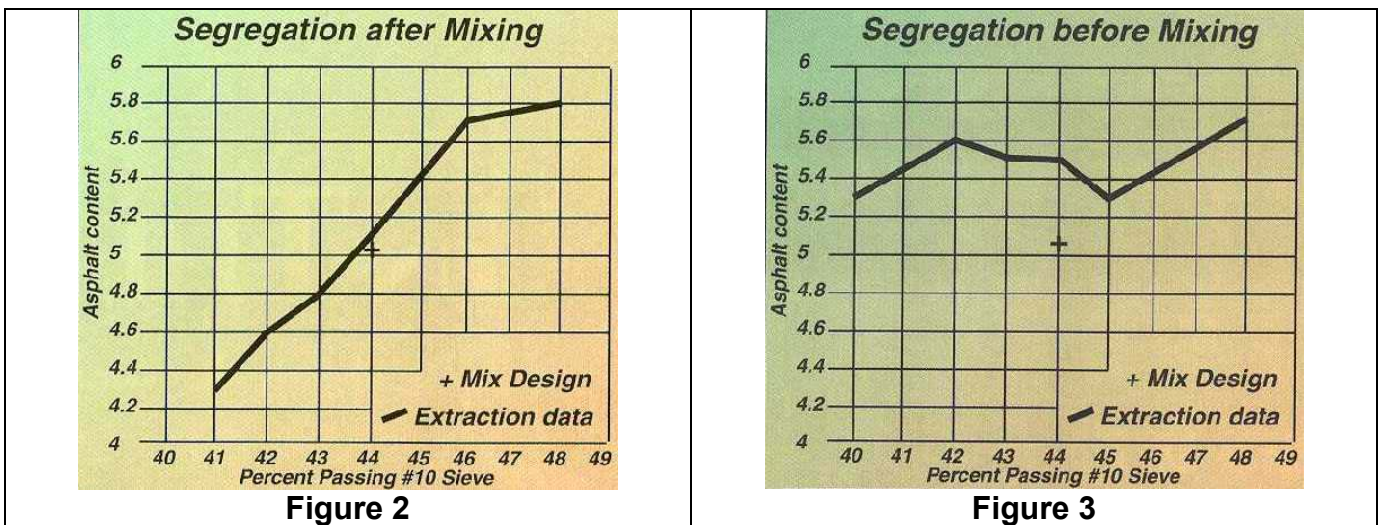
Silo shapes affect segregation chances

There are different types of silos with various side angles, gate openings, and inter-loading units. Some are more efficient than others. The ideal operating range for most silos is between 25 percent and 75 percent full. Segregation will increase below the 25 percent capacity as the mix falls below cone level.

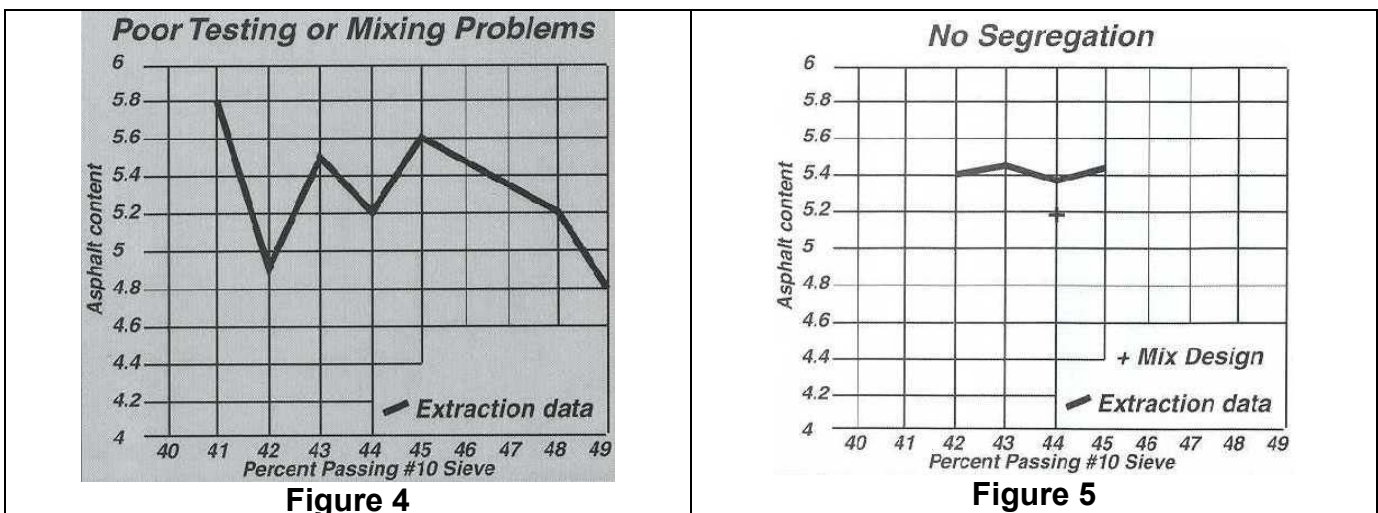
Analyze and correct the problem

When segregation occurs in the silo, a cone unit placed on the bottom of the silo will produce reverse coning and remix the material. Baffle plates installed on the bottom of the silo kick coarse aggregate back into the mix.

Extraction reports taken of material passing the #8 or #10 sieve can be plotted against AC. Extraction data should be arranged according to test source: Test reports from the plant site should be plotted separately from those of the roadway. If a straight line results, using several extraction reports, you know the mix segregated after mixing. The plot in [Figure 2](#) illustrates this analysis.



If the plot is horizontal or non-linear, chances are the aggregate segregated before mixing, as illustrated in [Figure 3](#). [Figure 4](#) shows no real pattern exists, and indicates two possible problems: poor testing or segregation before mixing. The plot in [Figure 5](#) illustrates no existing segregation. The variation is from the job mix formula, and is within tolerance range.



To determine when and how segregation occurs, extraction reports must be made on the mix at both the plant and roadway.

Extractions plotted in [Figure 2](#), [Figure 3](#), [Figure 4](#), and [Figure 5](#).

illustrate how segregation can be determined. Using this method, segregation can be identified and corrective actions taken.

The problem may not be apparent in the pavement until it is under traffic. Extraction reports from the roadway and plant must be kept separate to resolve the source of segregation.

When the extraction of a base or binder involves larger aggregate, the sample may be specially prepared. This procedure involves taking a large sample and separating it into +0.5 inch and -0.5 inch (+12.5 mm or -12.5 mm) portions. A ratio of these portions to the total sample is used to proportion the weight of the plus half and minus half. A proportionate amount of quartered samples are remixed for the extraction test, and this procedure assures the test sample will represent the mix.

[Contents](#)

When segregation occurs before mixing, a sample from the cold feed system should be obtained in drum mixing plants. In a batch plant, a resample of the hot bins should be made.

Segregation often occurs when material is placed into the silos. A conveyor system places the mix into a batch hopper or similar discharge system.

Timing systems on these units should be set in accordance with output tonnage to keep the mix from falling straight through the batcher into the silo and causing segregation by coning.

For proper operation, the mix should be discharged in small batches. The batcher gate should be operated in a pulsating manner and never completely empty during operation. For variable production rates, the gate timer should be adjusted accordingly. In the rotating chute and plate systems, operation speed depends on tonnage output. Operating the device slowly will prevent material from being slung to the sides of the silo and causing a reverse cone effect with coarse material on the outside and fine on the inside.

Four variables on silos govern the sensitivity of segregation:

- diameter
- height
- cone shape
- gate opening type

Each type of silo must be operated appropriately to obtain equal results. Diameter and height of the cone should be adequate to prevent reverse cone effects as mix leaves the unit.

Segregation from these units can be corrected by adding another cone or batcher to the bottom. This remixes the material before it is released into trucks.

Segregation occurs in the paver operation when the truck is in place to dump onto the roadway, the bed should be slightly elevated before the tailgate is released. This permits the mix to flood the hopper. Truck beds not elevated allow coarse aggregate to fall first, resulting in spotty segregation patterns.

Once the paver is in motion, the hopper should maintain 25 percent or more of its capacity at all times. Running the hopper dry before recharging causes random or wing type segregation, which is difficult to distinguish from spotty segregation caused by loading improperly from the silos.

Usually, each load can be identified, and spots will be to either side or in the center of the lane. Late model paving machines permit the operator to dump the side wings. Caution should be used in wing dumping, because dumping paver wings when the paver is less than 25 percent capacity without receiving a new load of material causes wing type segregation.

Paver augers should be turning approximately 85 percent of the time. Adjustments to the paver flow gates may be required periodically to obtain this goal. Paver kickback augers must be maintained in good condition to auger mix under the center gear. A center lane crack is characteristic of worn kickback augers or inadequate auger operation.

[Contents](#)