




Technical Paper T-117



SEGREGATION: Causes and Cures

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I. INTRODUCTION

Hot mix asphalt mixtures that are properly designed, produced and placed provide a durable, long lasting pavement that requires very little maintenance.

However, there are a number of potentially damaging problems that can occur in the design, production and placement of hot mix paving mixtures. Of these problems, perhaps the most serious is segregation. Segregation is a frequently recurring problem that has caused concern within the paving industry for decades and receives widespread attention by contractors, state highway departments and equipment manufacturers. There are two types of segregation, aggregate segregation and temperature segregation. This paper covers the various places that aggregate segregation can occur and recommended solutions.

When segregation is present in a mixture, there is a concentration of coarse materials in some areas of the paved mat, while other areas contain a concentration of finer materials. Segregation creates non-uniform mixes that do not conform to the original job mix formula in gradation or asphalt content. The resulting pavement exhibits poor structural and textural characteristics and has a shorter life expectancy.

Problems associated with segregation are serious. Their elimination is essential to the production of high quality paving mixtures. Elimination of segregation is the responsibility of those who produce and lay asphalt mix, those state highway departments who design the mix and inspect the final product, and those manufacturers who design and market machinery for the paving industry.

This paper was written to help designers, plant operators and paving crews be aware of the causes of segregation and known solutions. Each portion of the plant, paver and trucking operation known to cause segregation is discussed separately. In addition, a diagnostic chart accompanies this paper to help identify types of segregation and probable causes.

II. MIX DESIGNS

Proper mix design is important in the effort to eliminate segregation. Mixes that are uniformly designed with no gap-grading are generally very forgiving. They allow mistakes in other areas of the plant operation or laydown operation without affecting the mix performance significantly.

Gap graded mixes are unforgiving. Consequently, any slight error in the plant, trucking or layout process can result in non-uniform surfaces. If the mix is gap-graded to a sufficient degree with a low asphalt content, it simply cannot be produced without segregation, regardless of the techniques used.

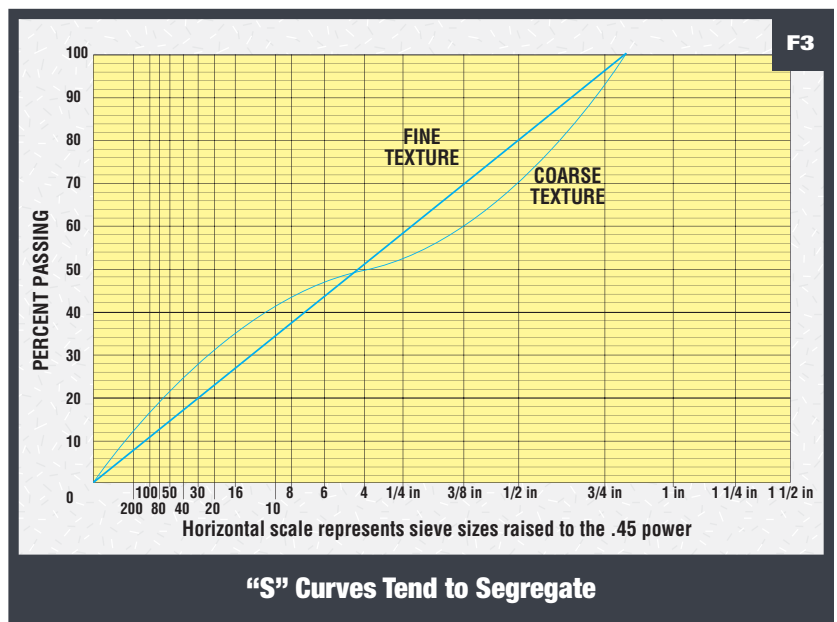
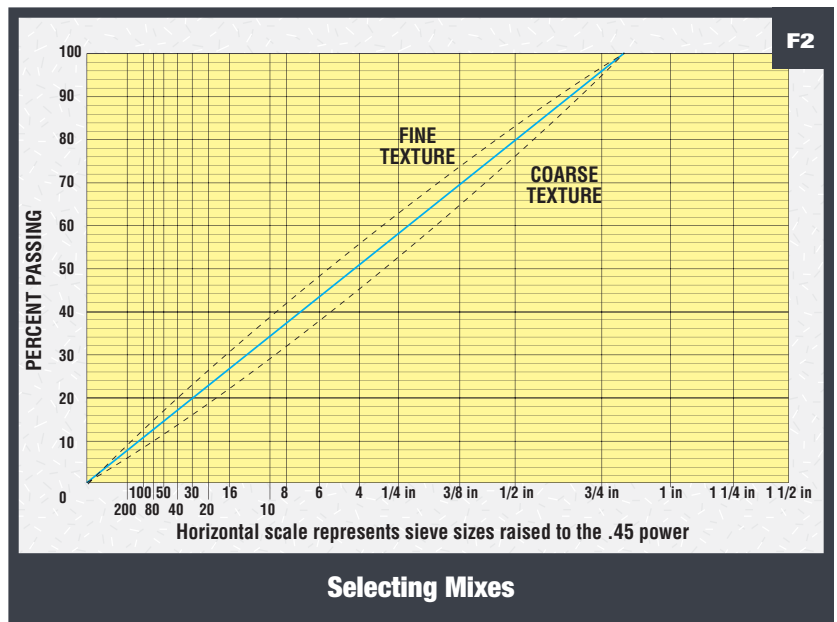
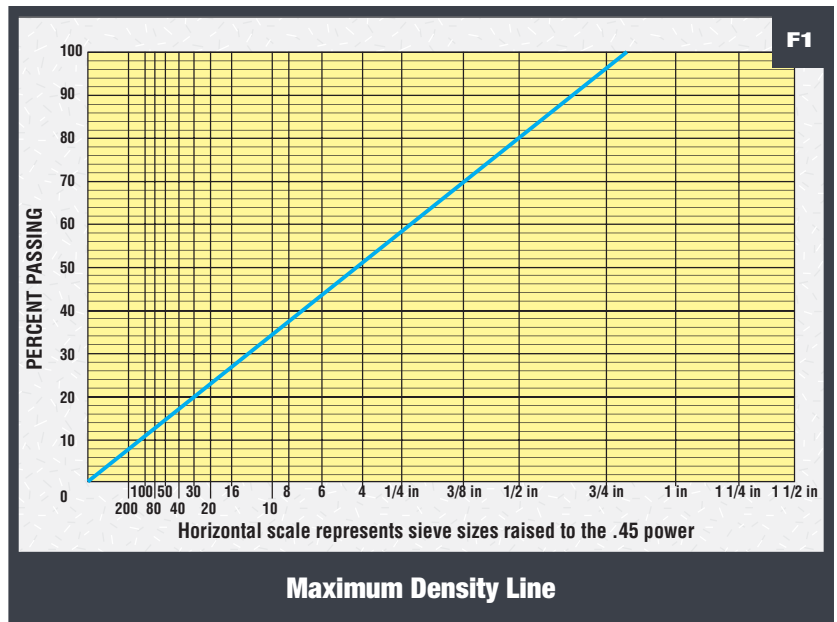
Gap graded mixes have been successfully used in England and throughout Europe. However, these mixes often have fibers or polymers, enabling the use of a higher asphalt content that makes the film thicker. A thicker film will reduce segregation significantly. Increased film thickness dampens particle-to-particle contact and reduces the tendency to separate at transfer points throughout the process. SMA and Superpave mixes in the U.S. are gap-graded. However, the addition of fibers and polymers allow film thickness to be increased from nine microns to 12-13 microns making them less sensitive to segregation.

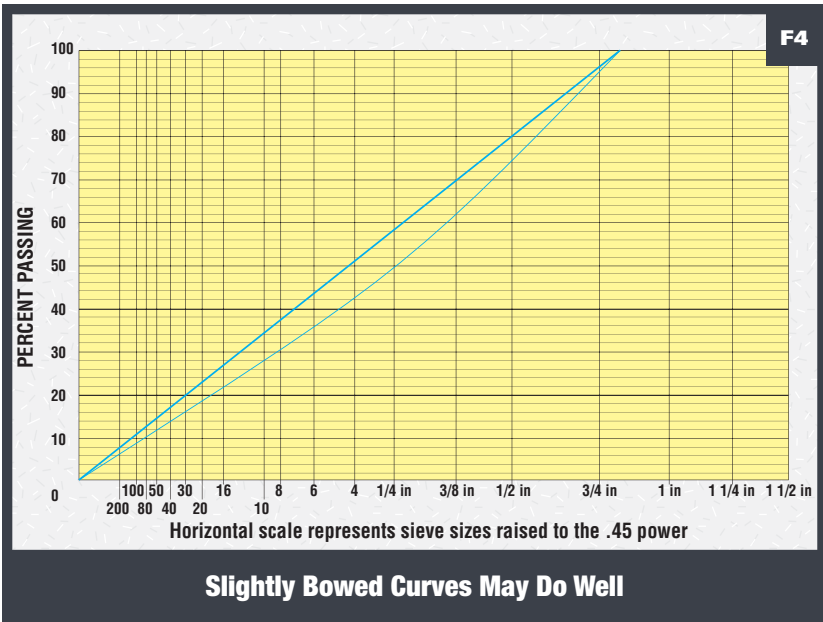
A maximum density line similar to the one shown in **Figure 1** can be utilized as a guide to uniform grading. To make a chart with a maximum density line for your operation, use a FHWA 0.45 Power Gradation Chart as shown in **Figure 1**. Draw a straight line between the lower left corner of the chart and the percent point for your largest sieve size that retains material. The gradation along this line will be the densest mix that can be produced.

Experience dictates that mixes with gradations that fall directly on the maximum density line should not be produced. Since there is insufficient room in the mixture for the liquid asphalt, a very dry mix results. It is suggested that the mix designer select approximately two to four percentage points above the maximum density curve if he desires a fine texture. He should select two to four points below the curve if he desires a coarse texture, see **Figure 2**. These bowed up and bowed down curves usually result in a good, forgiving mix with enough room and sufficient liquid to coat the rock, giving good durability.

Rarely does a mix that lies on the maximum density line contain sufficient *voids in the mineral aggregate* (VMA), especially if the design has a relatively high percentage of minus 200 material. A grading selected on a line approximately parallel to the maximum density line will produce a uniformly graded mix that will be very forgiving. The maximum density line should be used only as a guideline for uniform grading. Other criteria such as VMA, stability and other specifications must also be met.

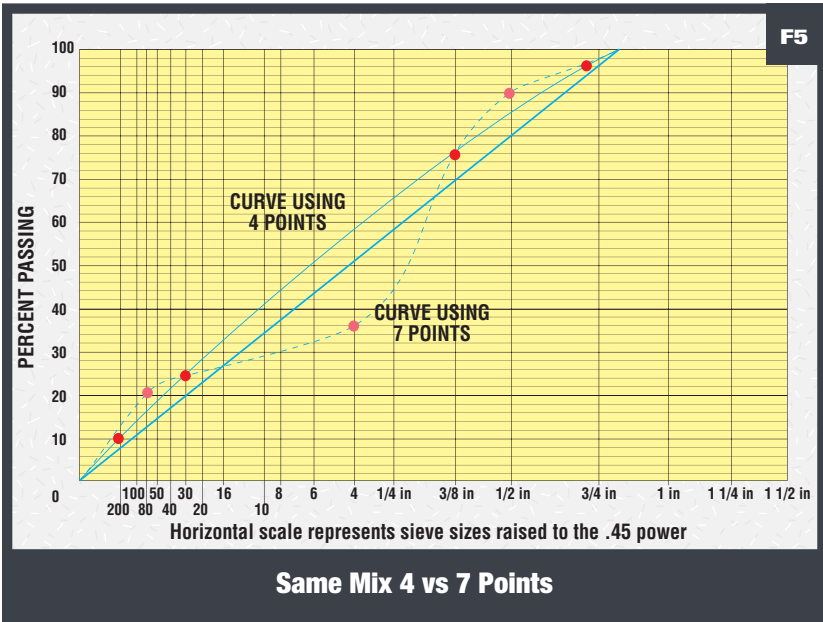
A mix design that makes an “S” across the maximum density line, as shown in **Figure 3**, can result in segregation problems.





The slightly bowed curve shown in **Figure 4** could result in good performance. But the potential benefit that a designer tries to achieve by gap-grading is too often negated by segregation problems.

When plotting a mix gradation, plot as many sieve sizes as possible. **Figure 5** illustrates how plotting to only a few points can result in a misleading graph. When only 4 sieve sizes are plotted as shown in **Figure 5** the curve may indicate a “forgiving” mix. But when seven sieve sizes are plotted, also shown in **Figure 5**, it is easy to see that the mix is actually gap-graded.



The graph in **Figure 5** illustrates how plotting to only a few points can result in a misleading graph. When only 4 sieve sizes are plotted as shown in **Figure 5** the curve may indicate a “forgiving” mix. But when seven sieve sizes are plotted, also shown in **Figure 5**, it is easy to see that the mix is actually gap-graded.



After aggregate is crushed, it is conveyed to vibrating screens as shown in **Figure 6**. Wire cloth on the decks of the screen separate the rock into distinct sizes. These single sizes can be stockpiled without segregating. Practically every country in the world single sizes. The individual sizes are blended together as either concrete or asphalt is produced. **Figure 7** shows a typical feed bin on an asphalt plant. **Figure 8** and **Figure 9** shows two piles of single-sized material.



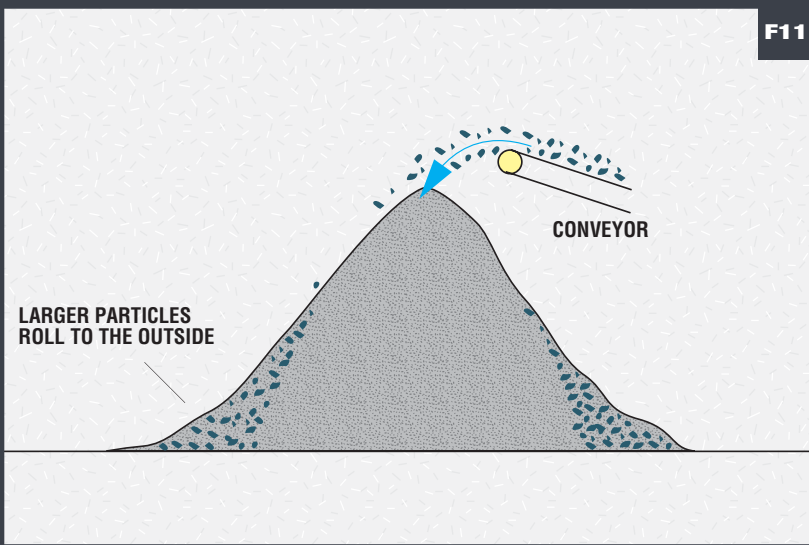
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Size Number	Normal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Openings), Weight Percent												
		4 in. (100 mm)	3 1/2 in. (90 mm)	3 in. (75 mm)	2 1/2 in. (63 mm)	2 in. (50 mm)	1 1/2 in. (37.5 mm)	1 in. (25 mm)	3/4 in. (19 mm)	1/2 in. (12.5 mm)	3/8 in. (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)
1	3 1/2 in. to 1 1/2 in. (90 to 37.5 mm)	100	90-100		25-60		0-15		0-5					
2	2 1/2 in. to 1 1/2 in. (63 to 37.5 mm)			100	90-100	35-70	0-15		0-5					
3	2 to 1 in. (50 to 25 mm)				100	90-100	35-70	0-15		0-5				
357	2 in. to No. 4 in. (50 to 4.75 mm)					100	95-100	35-70		10-30		0-5		
4	1 1/2 in. to 3/4 in. (37.5 to 19 mm)					100	90-100	20-55	0-15		0-5			
467	1 1/2 in. to No. 4 (37.5 to 4.75 mm)					100	95-100	35-70		10-30		0-5		
5	1 to 1/2 in. (25 to 12.5 mm)					100	90-100	20-55	0-10	0-5				
56	1 in. to 3/8 in. (25 to 9.5 mm)					100	90-100	40-85	10-40	0-15	0-5			
57	1 in. to No. 4 (25 to 4.75 mm)					100	95-100	25-60		0-10	0-5			
6	3/4 in. to 3/8 in. (19 to 9.5 mm)						100	90-100	20-55	0-15	0-5			
67	3/4 in. to No. 4 (19 to 4.75 mm)						100	90-100		20-55	0-10	0-5		
7	1/2 in. to No. 4 (12.5 to 4.75 mm)							100	90-100	40-70	0-15	0-5		
8	3/8 in. to No. 8 (9.5 to 2.36 mm)								100	85-100	10-30	0-10	0-5	

Grading Requirements for Coarse Aggregates

Figure 10 shows the ASTM gradations of various blends of aggregates in the USA. Asphalt mixes are produced by blending three or four of the blends together. Due to the wide variations in sizes the blends are prone to segregate in the stockpiles as shown in Figures 11, 12 and 13. The segregation can be significantly reduced by stacking the materials in layers as shown in Figure 14 and Figure 15. This can be accomplished automatically by using a telescoping stacking conveyor as shown in Figure 16. These stackers are programmable to form any shaped pile desired.

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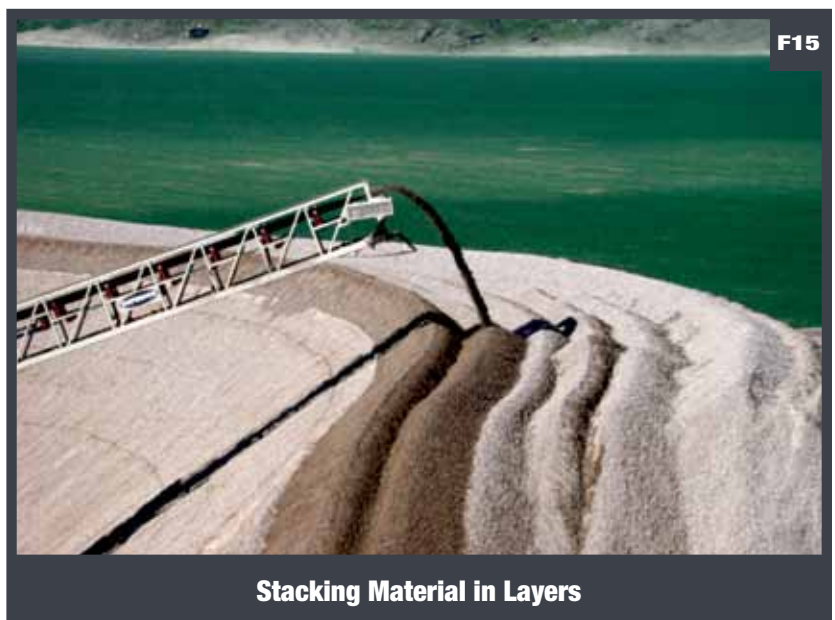
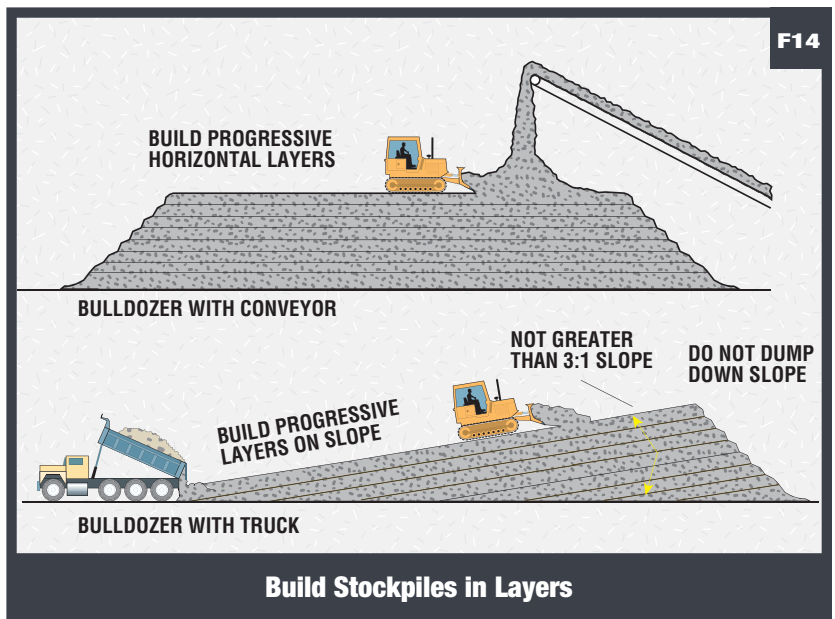
Segregation in a Pile

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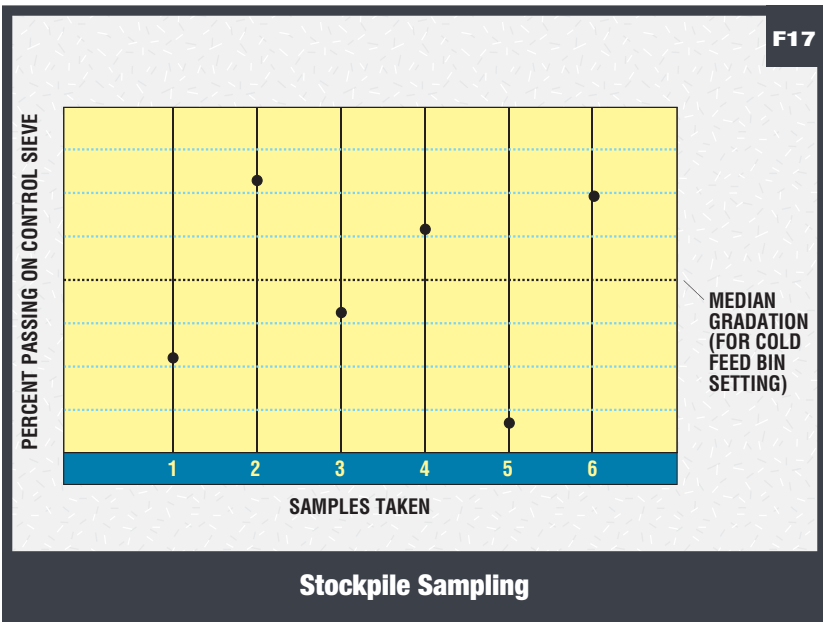
Segregated Aggregate

Aggregate producers have the flexibility to vary the gradation in the blends due to the wide bands allowable within the different grades. Notice in the 57 stone the minus 1/2" can vary from 25 to 60%. Blending gates in the discharge shoot from the screen decks allow diverting material from one deck to the next as demand for various sizes changes. This results in unknowing gradation changes for the customer and necessitates continuous sampling to ensure the correct final gradation.

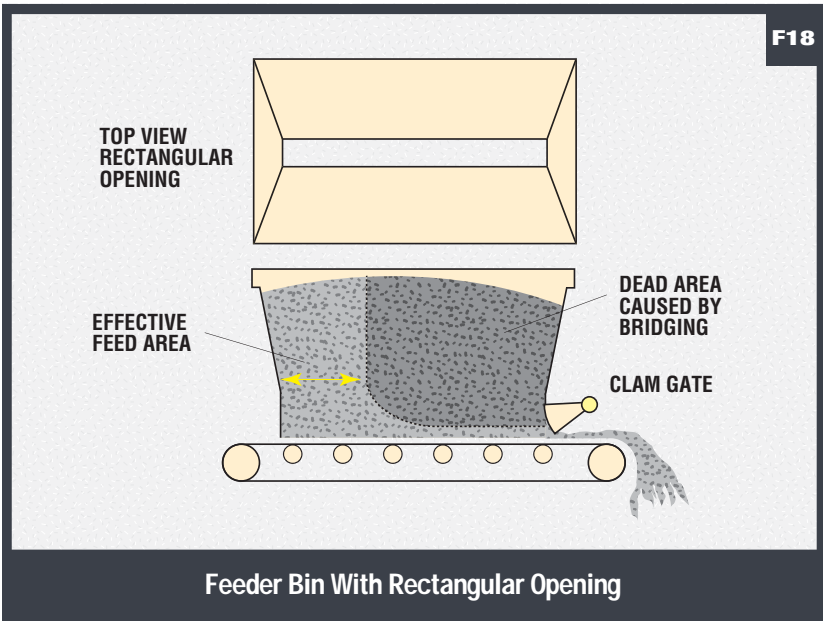




Telescoping Stacking Conveyor



Stockpile Sampling



Feeder Bin With Rectangular Opening

III. STOCKPILING

When sampling stockpile material to set up cold feed bin ratios, it is important to take several samples and use the median result as shown in **Figure 17**.

IV. ASPHALT FACILITIES

Segregation can occur at numerous points in a hot mix asphalt plant. The location at which segregation is likely to occur in a plant depends on what type of facility it is. On a batch plant, the points of most concern are cold feed bins and hot bins. On drum mix plants, surge bins and storage bins are the points of most concern.

COLD FEED BINS

Segregation in cold feed is usually not a problem unless the aggregate material consists of blended sizes. Segregation should not occur when a single size of aggregate is placed in each feeder bin because there are no different sizes to segregate. However, if bridging of material occurs in the hopper, see **Figure 18**, non-uniform feeding takes place, resulting in a segregated mix.

By utilizing a self-relieving bottom shown in **Figure 19**, uniform feeding will occur all along the opening of the cold feed bin, eliminating bridging as a source of segregation.

When working with blended aggregates that are segregated, it can be beneficial to use two cold feed bins to feed the same material. This practice tends to average out wide variations by feeding half of the of material needed from two bins, thus minimizing variations in gradation.

HOT BINS ON A BATCH PLANT

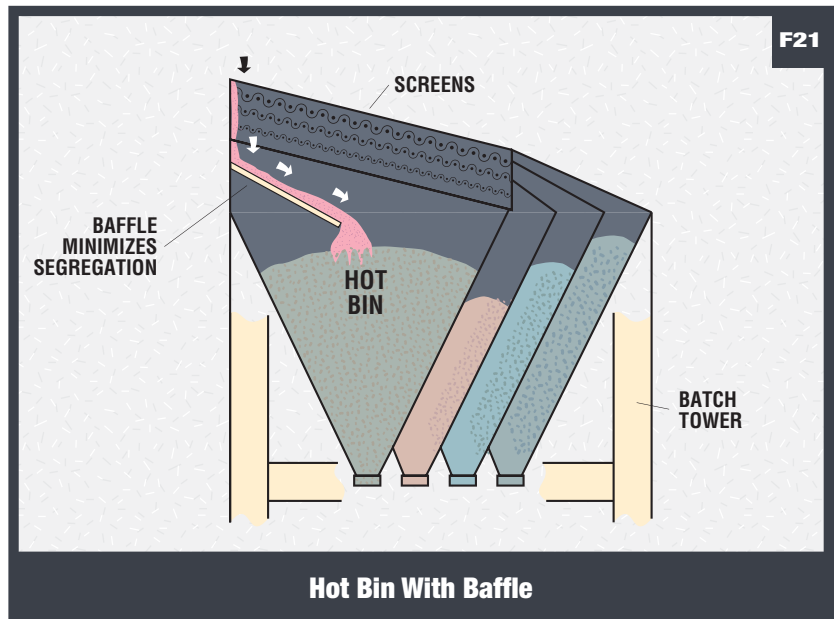
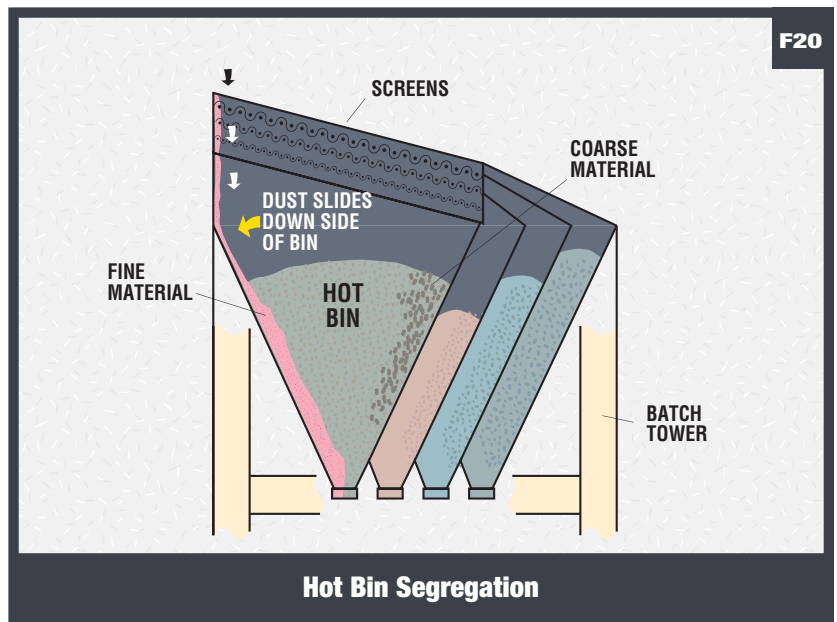
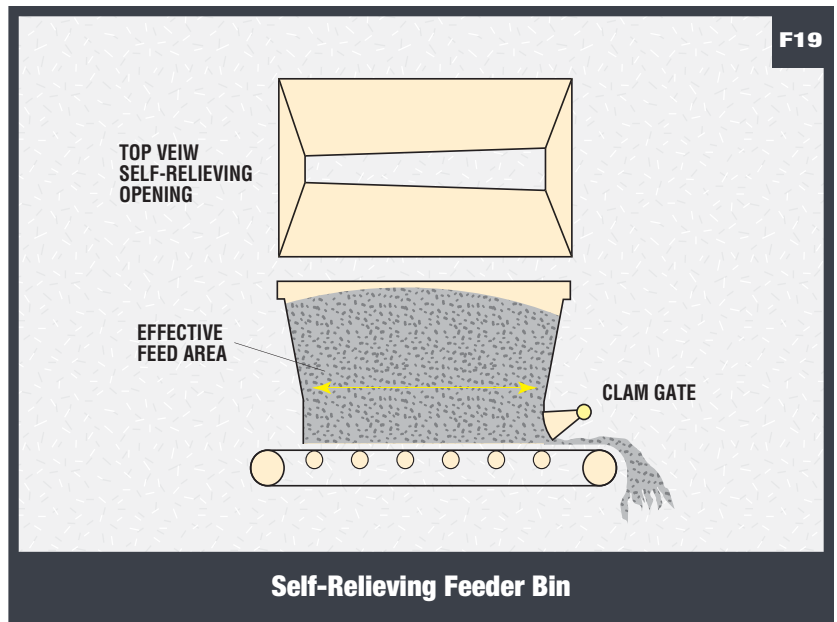
As mentioned, segregation can occur with all sizes of material. Segregation often occurs in the No. 1 hot bin due to the size and shape of the large bin and the wide size range of materials in that bin. The size variation in material in Bin 1 is potentially greater than any other part of the asphalt plant because its material size varies from as large as 3/16-inch all the way down to one micron.

In recent years some have voiced concern about uniform dust return from baghouses to batch plants. Generally, material is uniformly collected in baghouses and is uniformly returned, but the material may actually be segregating in Bin 1. The ultra-fine material discharged from the bucket elevator may fall directly through the screen and lay on a sloping bin wall, **Figure 20**. It may lay there until the bin is about empty. Then a large slug of the dust may break loose and feed into the weigh hopper, producing an ultra-fine batch that is segregated, and uncoated.

In many cases non-uniform feed from the baghouse was incorrectly suspected to be the cause of segregation in the hot bin and resulted in the addition of expensive and unnecessary equipment. There was simply an improper analysis of the problem. The proper solution should be to install a baffle as shown in **Figure 21**. The baffle causes the dust to slide to the center of the bin where it is uniformly mixed with the coarse materials.

The same results can be achieved by using a baffle to force the coarse material back to the sloping bin wall. There, it can be intermixed with the fine material. The method used depends on the head room and space available in the hot bins.

Utilizing a dust blower at the baghouse and a cyclone type dust receiver properly located in Bin 1 has also proved effective in eliminating segregation in this area. However, many prefer to use baffles because of relatively high maintenance costs for airlocks that handle abrasive materials such as granite.



F22

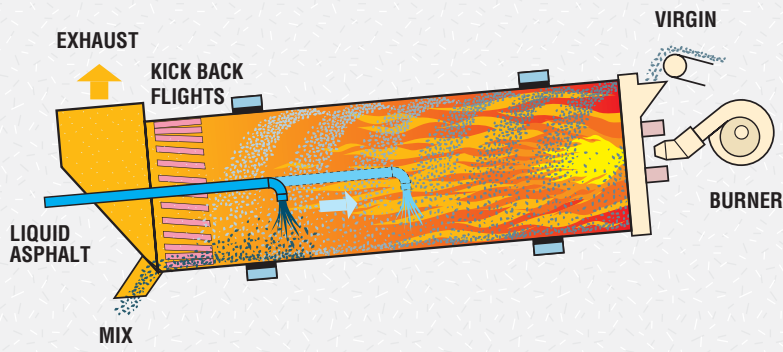
DRUM MIXER

Large particles will generally flow through a drum mixer at a slightly faster rate than small particles during initial start-up and at plant shut down. Negative effects associated with this characteristic can be eliminated by adjusting the start/stop time intervals between the cold feed bins. Due to the continuous flow process that occurs after start-up, this characteristic does not produce segregation. The potential to segregate is also of little significance unless the material is gap-graded.

When gap-graded mixes are processed in a drum mixer, it becomes more difficult to achieve a thorough coating with a uniform thickness. The uncoated or thinly coated coarser materials are more likely to segregate. Such segregation can be reduced or eliminated through better coating. This can be accomplished by increasing the mixing time by extending the asphalt line farther up into the drum mixer as shown in **Figure 22**. For hard-to-coat materials, kick-back flights as shown in **Figure 22** can be used, or a dam (donut) can be installed in the drum to increase the mixing time, **Figure 23**.

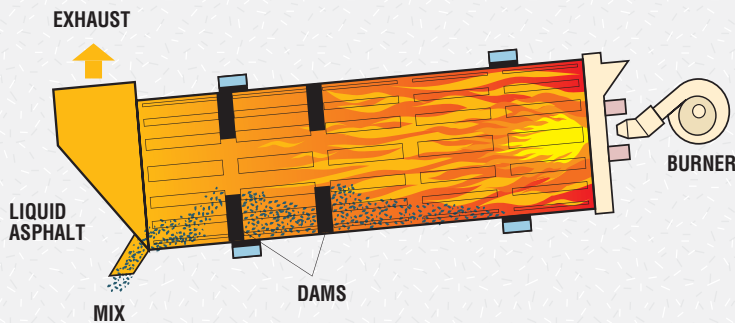
An alternate method is to decrease the drum slope, which increases the dwell time and provides additional mixing. Increased dwell time, whether due to the addition of dams or due to decreasing the drum slope, increases the drum load. This may reduce the production rate if the drum drive motor is a limiting factor.

An often overlooked factor which can significantly affect coating quality and film thickness is the amount of minus 200 material in the mix. Coating quality will be adversely affected if the amount of minus 200 material exceeds specifications or even if it is within specifications, but on the high side of the tolerance allowed. **Figure 24** shows the surface area of one pound of each of the different material sizes. As seen, one pound



Increasing Mixing Time In A Drum Mixer

F23



Drum Mixer Dams Retard Flow

F24

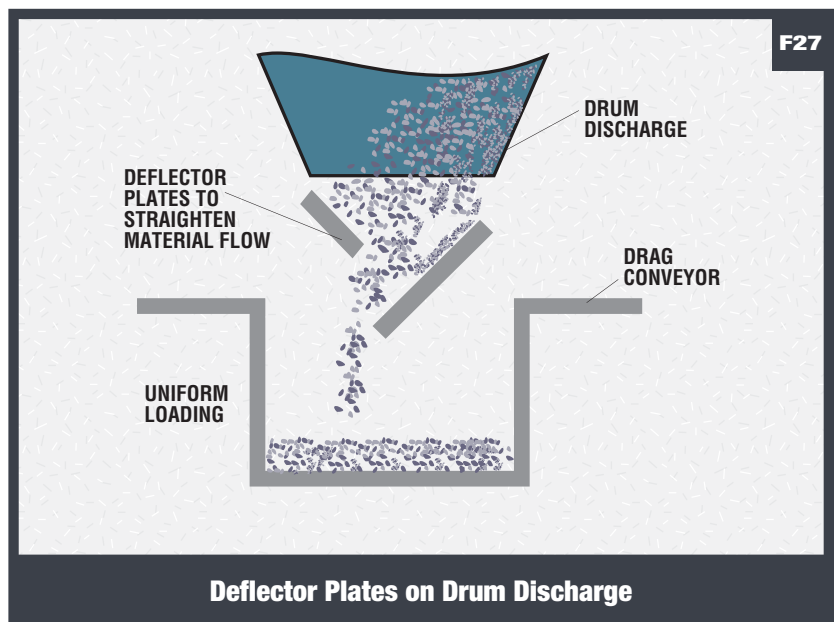
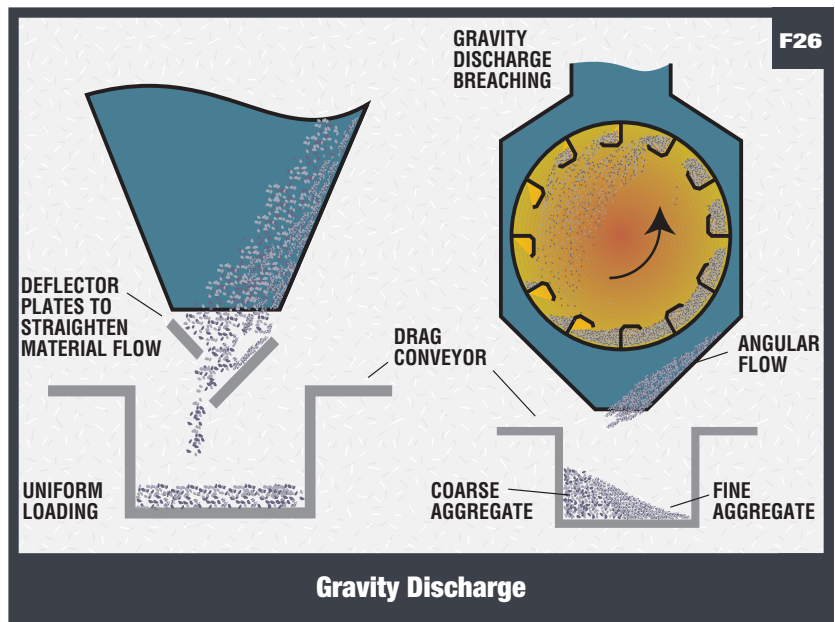
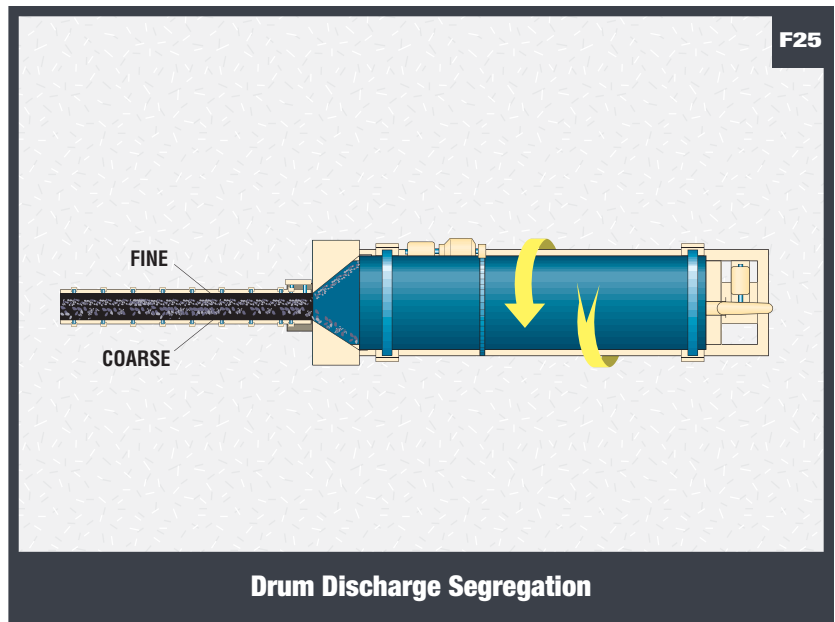
MESH NUMBER AND SIZE	SURFACE AREA SQ. FT/LB
200	150.2
100	73.9
50	37.2
30	18.8
16	9.3
8	4.65
4	2.33
3/8"	1.16
1/2"	0.87
3/4"	0.58
1"	0.43
1-1/2"	0.29
3"	0.145

Surface Area Per Pound

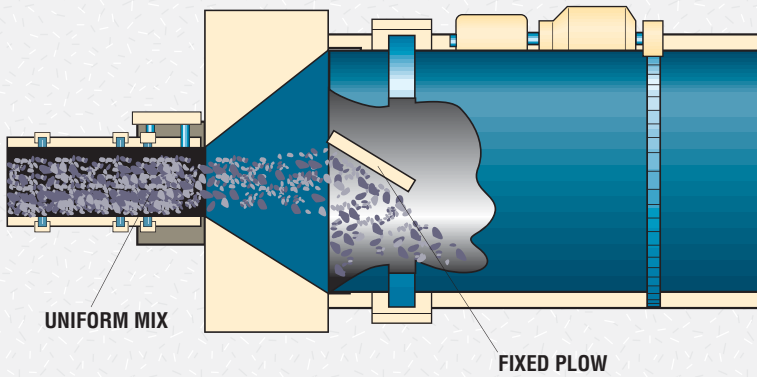
of 3/8 rock has 1.16 ft² of surface area while one pound of 200 mesh material has 150 ft². Because of the large amount of surface area present in fine material and because of its affinity for the liquid asphalt, coarser material in the mix will have a reduced film thickness even though it may appear to be fully coated. Reduced film thickness makes the coarse material less sticky and increases its tendency to segregate. Reducing the amount of minus 200 material to the low side of the allowable tolerance will usually correct this problem. Moreover, it will be easier to produce a uniform mix and easier to handle the mix throughout the trucking and laydown operations.

Mix discharged from drums by gravity is more sensitive than mix discharged from drums with a high lift where the material is required to make a 90 degree turn prior to discharge. With gravity discharge, coarse material often discharges on one side and fine material on the other. **Figure 25** the segregated material drops directly onto a drag conveyor and continues to segregate right on through the batcher and bin as shown in **Figure 26**. The problem can be improved by restricting the discharge chute from the drum to a smaller opening, forcing the mix into the center of the drag conveyor. Adding deflector plates or straightening vanes is also an effective way to make sure the drag conveyor is properly loaded from a gravity type discharge see **Figure 27**.

Another solution is to install a plow or single discharge point in the drum as shown in **Figure 28**, forcing all mix to come out at one point. However, experience shows it is difficult to design and install an effective plow on most drum mixers. When possible it is best to set the drag conveyor at a 90 degree angle to the drum discharge to create a right angle change in material flow. This setting reduces or eliminates drum discharge segregation.

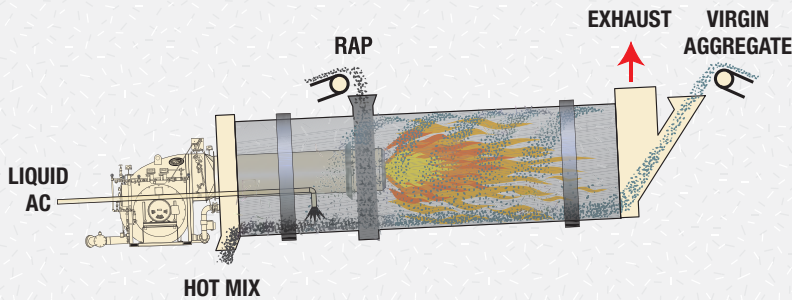


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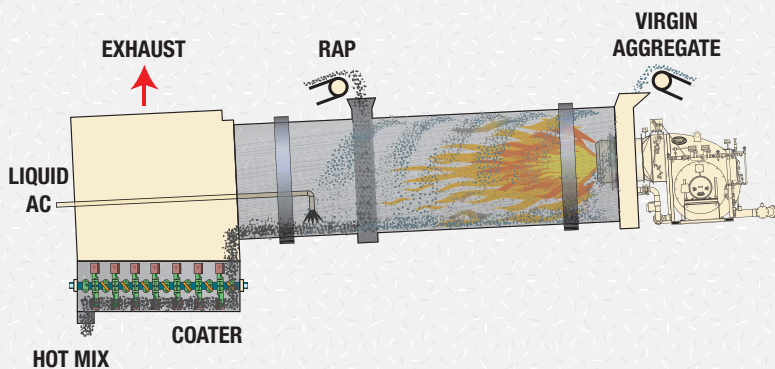
Drum with Fixed Flow

F29



Counterflow Drum Mixer

F30



Parallel Flow Drum Mixer With Coater

INTERNAL MOISTURE

Retained internal moisture is rarely a problem while running RAP since the virgin aggregate containing the internal moisture is superheated above the mix temperature. The degree of superheat depends on the percent RAP, RAP moisture and the mix temperature. For example, with 30% RAP containing 5% moisture, the virgin aggregate is heated to 512°F to produce 300°F mix. If retained internal moisture is a problem while producing a virgin mix, one of the aggregates, not containing internal moisture, can be added into the plant process through the RAP system. This induces the plant to superheat the aggregate containing internal moisture, thus removing the internal moisture before the liquid AC is added. This helps coating and minimizes AC absorption. An Alabama contractor reduced the moisture retained in a slag mix from 0.22% to .06% by adding 15% screenings through the RAP bin.

The coating of large stones can also be affected by internal moisture, causing absorption. In the approximately three minutes that material stays in the dryer or drum mixer, large stone (+1/2) has sufficient time to reach mix temperatures unless internal moisture exists in the rock. To reach the moisture in the center of a large rock, heat must be transferred from the surface to the inside. This often requires between five and ten minutes, depending on the size of the rock. If the rock leaves the drum and gets coated with liquid before the moisture has time to evaporate, as the water evaporates, the aggregate will drop in temperature and as the steam escapes the liquid will be pulled into the crevices of the rock reducing the film thickness. The rock will have a brown appearance if it is gravel and gray if it is limestone. It becomes very prone to segregation. By using the technique mentioned above, this can be eliminated. Internal moisture can be eliminated by increasing drying and mixing times using the methods described above.

Asphalt absorption problems are related to internal moisture problems. This is because the same pores that contain the moisture in the stone will absorb a portion of the available asphalt. This absorption reduces the actual film thickness on the outside surfaces. If absorption is suspected, break open several

larger stones and examine them under a magnifying glass. A dark band ranging from a few thousandths of an inch to 1/32-inch wide from the surface inward indicates that absorption is occurring. The solution to attaining the film thickness originally desired is to increase the asphalt content to make up for the portion being absorbed.

There are a number of other types of dryer/mixer combinations that are being used today. The counterflow drum mixer (**Figure 29**) usually has a rotary type discharge and although the drum tends to segregate somewhat in the mixing zone, the 90° discharge helps to reblend.

Mixers with shanks and tips, as the name implies, are mixers and produce a uniform mix at the discharge. Examples of these are the drum-mix coater (**Figure 30**), the Double Barrel® drum dryer/mixer (**Figure 31**), and the Double RAP dryer (**Figure 32**).

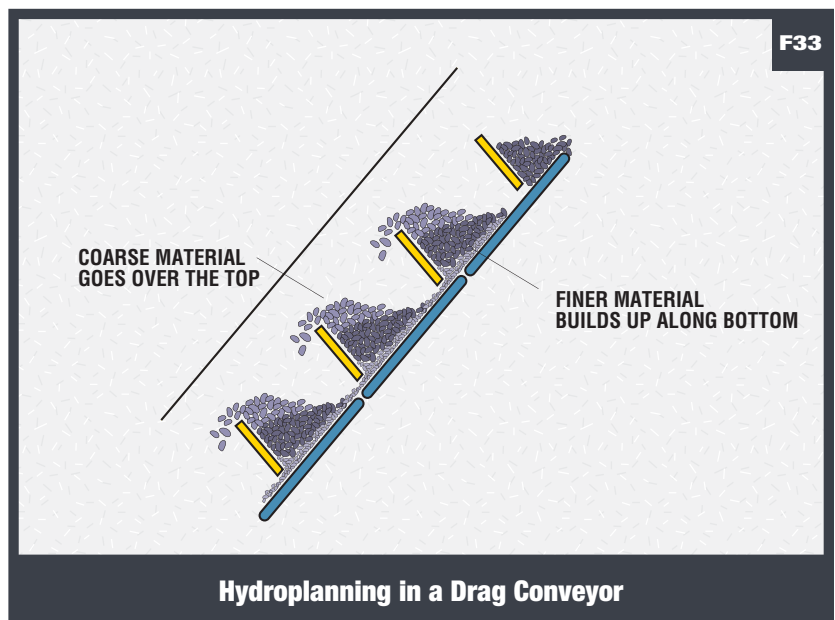
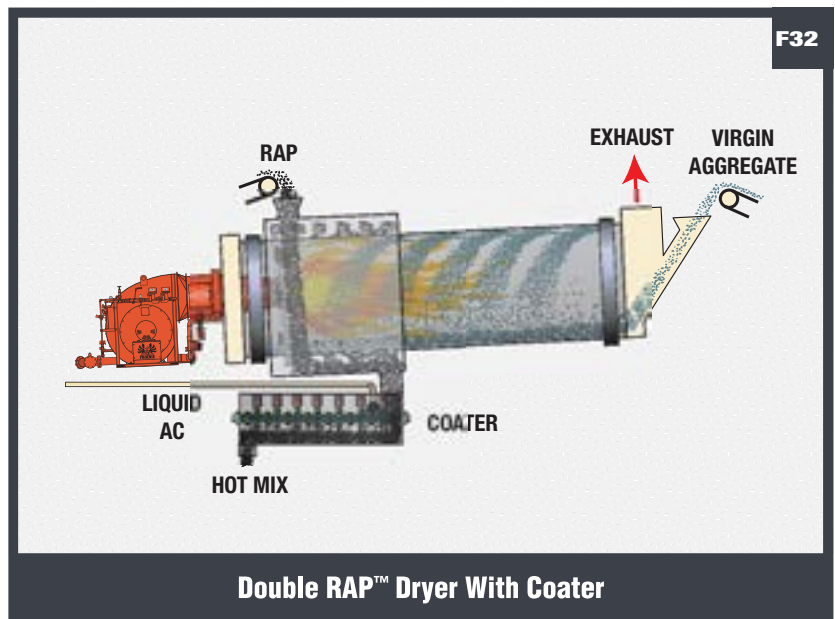
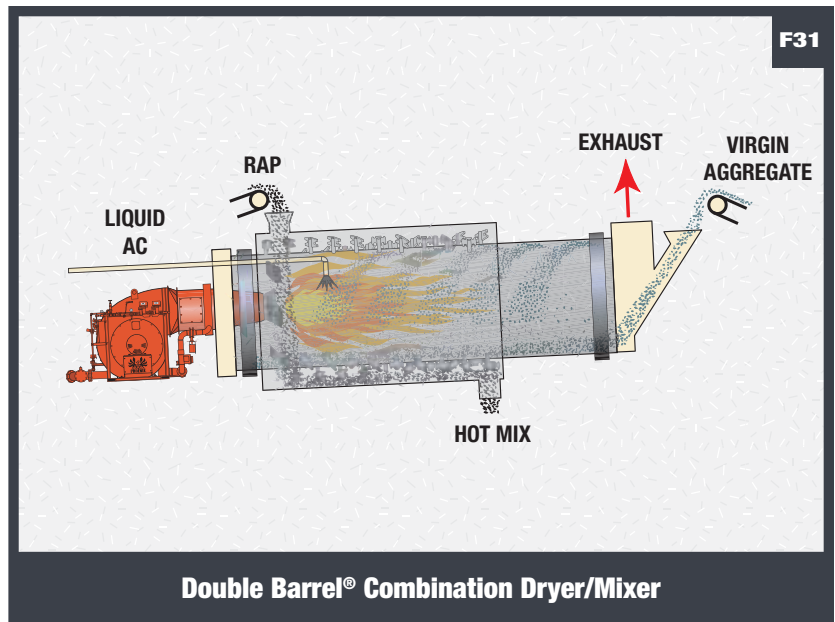
SURGE AND STORAGE BINS

Drag Conveyors

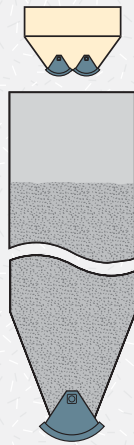
Segregation will usually not occur in a drag conveyor unless it is “hydroplaning.” Hydroplaning occurs as a result of a material buildup in the bottom of the drag conveyor. Cold conveyors that do not have floating hold-downs are prone to buildup on the bottom liners. The buildup creates a high friction drag surface that results in material spilling backwards over the drag flights as shown in **Figure 33**, even at very low production rates. This condition is easily observed. Material falls backwards down the drag conveyor instead of moving uniformly in one mass with full material from flight-to-flight.

When the drag conveyor is hydroplaning, considerable segregation can occur, especially at the beginning and end of each run. Hydroplaning is more prevalent on batch plants where the segregation can be carried from batch to batch. Drag conveyors should be equipped with floating hold downs and heated bottoms for cold start-ups.

Segregation is minimized when the drag conveyor is as full as possible. When the slats are only partially filled, the larger aggregate is apt to roll to each side within the drag

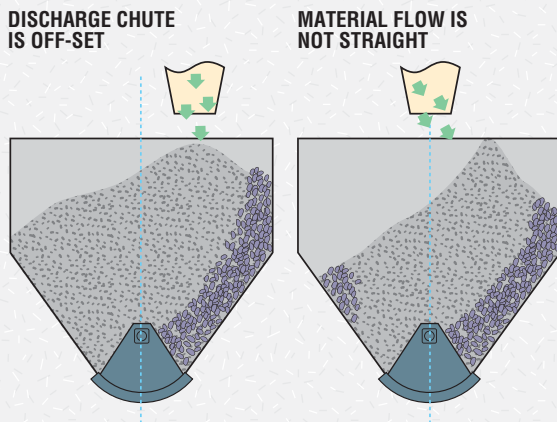


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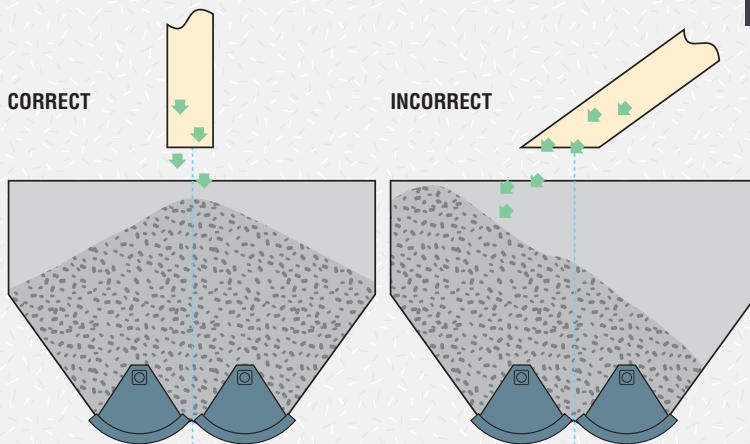
Bin Loading Batcher

F35



Chutes That Cause Unsatisfactory Material Flow

F36



Batcher Discharging

conveyor. So, it's better to run at higher production rates to keep the drag conveyor full. When producing a segregation prone mix at production rates higher than the rate used by paving operations, store the extra mix and shut down production earlier than usual.

Storage Bins

The most sensitive area for segregation on a hot mix plant is in surge and storage bins. The large sizes of the bins contributes to segregation problems. Since the first surge and storage bins were developed many years ago, considerable improvement has been made on bin equipment to prevent segregation. One of the most detailed and complete studies of hot mix surge and storage segregation was conducted by the University of Texas in the early 70's. From their investigation, various techniques were devised for eliminating segregation.

The result of the study revealed that the bin-loading batcher was a good device for eliminating segregation in surge and storage bins, **Figure 34**. The study also addressed various gate openings and showed that if the bin was properly loaded with uniform mix, the gate configuration was not of significant importance. However, the batcher is not an absolute "cure all". It can create problems of its own and it's best to understand how and why.

Bin Loading Batcher

Perhaps the most popular device for eliminating segregation on surge or storage bins is the bin-loading batcher. The following observations and practices should be followed when using a batcher:

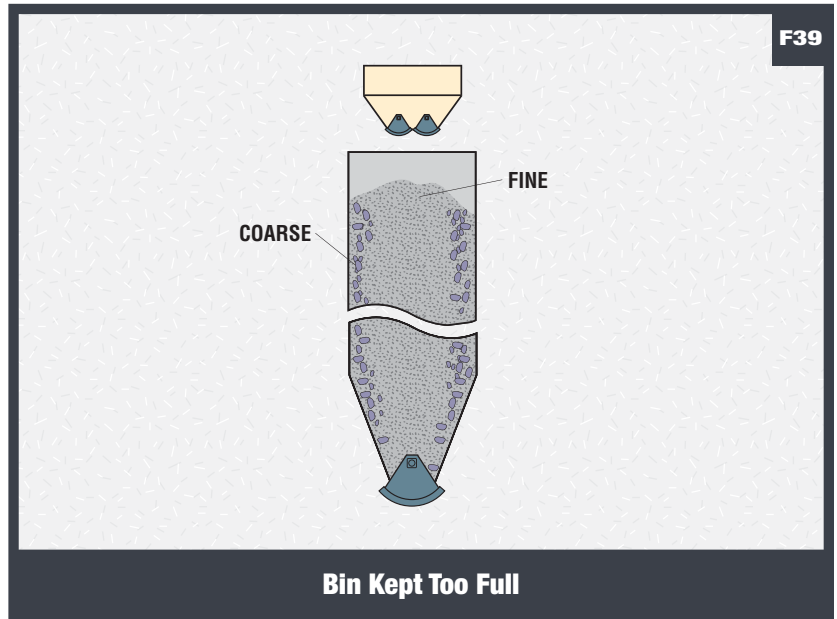
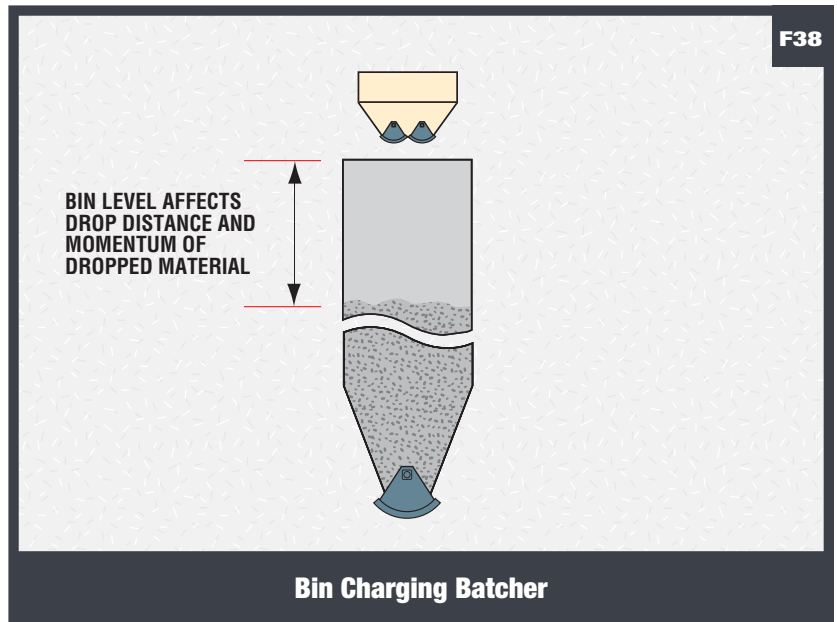
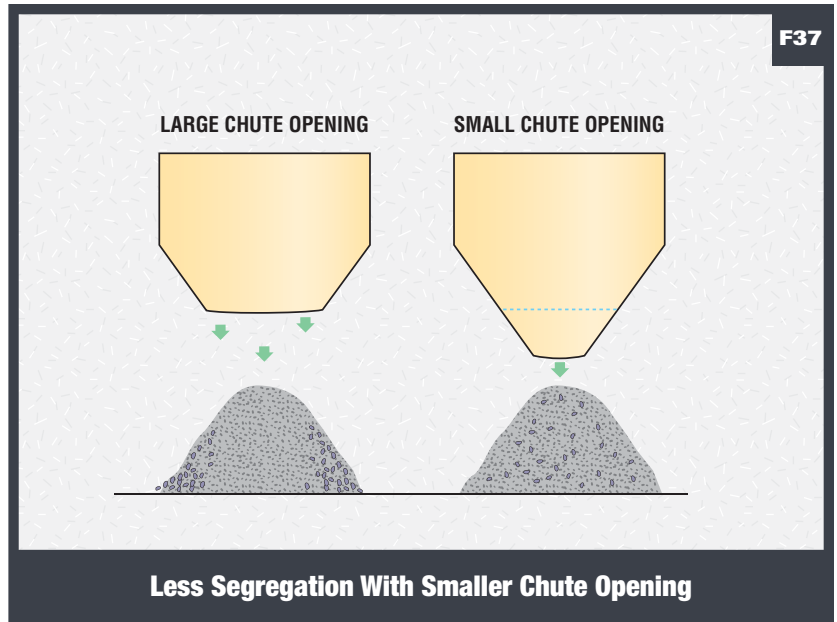
- a. The batcher should be filled to its maximum capacity (at least 5,000 lbs.) and have a relatively large diameter gate opening to insure rapid discharge of material into the storage bin.

b. The batcher must be loaded directly in the center and the material from the chute loading the batcher should have no horizontal trajectory, **Figure 35** and **36**. Also, whenever mix is discharged through a chute, a smaller chute opening minimizes segregation, **Figure 37**. Remember, if the material segregates in the batcher, it will remain segregated throughout the bin.

c. The batcher should be filled completely before each drop. Normally, two high bin indicators are utilized. One dumps the gates and the other insures the gates will dump if the first indicator fails. When the batcher gates fail to open, mix backs up in the drag conveyor all the way into the drum. This possibility makes operators want to leave the gates open, totally defeating the batcher's purpose. If at all possible, timers should not be used on batchers except to control the gate open-time. The production rate of plants will vary, and different times are required to fill the batcher. Remember, it is essential that the batcher be filled each time so that an adequate slug or a single mass drops into the bin.

d. The batcher should never be completely emptied. The gate-open-time should be adjusted so that a small amount of material (approximately 6 inches) remains in the batcher after the discharge cycle is completed. If the gate remains open too long, new material falls straight through the batcher and goes directly into the bin, resulting in random segregation.

e. When utilizing a bin loading batcher, the emptier the bin, the farther the fall of the material and the more likely a level, uniform bin-loading will occur, **Figure 38**. The worst situation when operating a bin loading batcher is to have the bin material level consistently near the top, **Figure 39**. The mix drop then has insufficient momentum and results in peaks of material instead of splattering the material to form a level surface. The rules for correct batcher operation are summarized in **Figure 40**.



1. Batch size should be at least 5,000 lbs. (more is better)
2. Batcher should be loaded in the center.
3. Material should flow straight down into the batcher. (no horizontal trajectory)
4. Batch gate timers should be adjusted so that gates shut with 6-8 inches of material left in the batcher. Do not allow any free flow through the batcher.
5. Batch gate should be maintained so that the mix drops out rapidly as a slug.

F40

Batcher Rules

Loadout From Surge or Storage Bins

If the surge or storage bin is uniformly filled, loadout of hot mix asphalt from the bin is not of great concern. Pulling material below the cone is not as sensitive as with the old type center-loaded bins. This is due in part to improved bin loading with batchers and rotating chutes, but results primarily from utilizing a steep cone angle that produces a mass flow of material from the bin. With most non-gap-graded materials, the bin can be emptied without any appreciable segregation. However, with gap-graded material the bin level should still not be allowed to drop below the cone. Also, constantly running with the cone empty will accelerate cone wear.

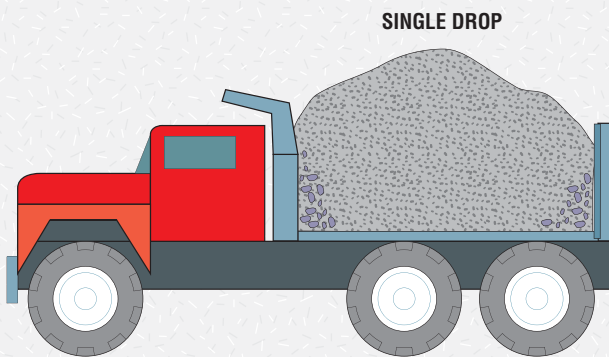
Rapid discharge from the silo gate helps eliminate segregation in trucks. This reduces the chance of segregation in the truck bed by minimizing the rolling action of the mix as it is flowing into the truck bed.

In cold weather, bins should be insulated, at least on the cone. Cold surfaces can cause the mix to stick to the cone and under these conditions the material can plug flow instead of discharging in a uniform mass flow.

V. TRUCK LOADING & UNLOADING

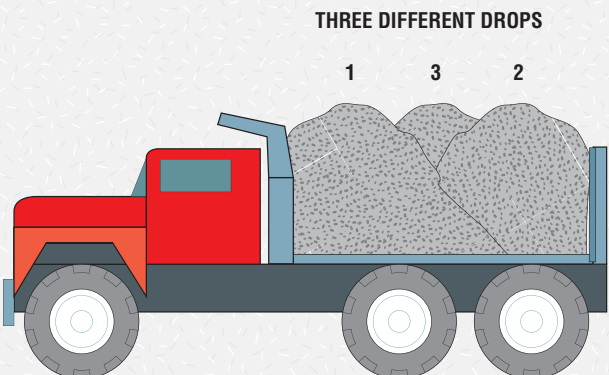
Due to rapid truck loading underneath surge or storage bins, truck drivers often tend to pull the truck under the bin and not move it while loading. If the mix is sensitive to segregation, larger stones will roll to the front of the truck, to the rear, and to the side, resulting in the coarse material being the first and last material to be discharged from the truck bed. The coarse material on each side will then be trapped in the wings of the paver to be discharged between truck loads. This discharging results in coarse areas of pavement between each truck load. This type of loading is shown in **Figure 41**.

By loading the truck in at least three 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 center, segregation caused by incorrect truck loading is eliminated. This type of loading is shown in **Figure 42**.



F41

Improper Truck Loading



F42

Proper Truck Loading

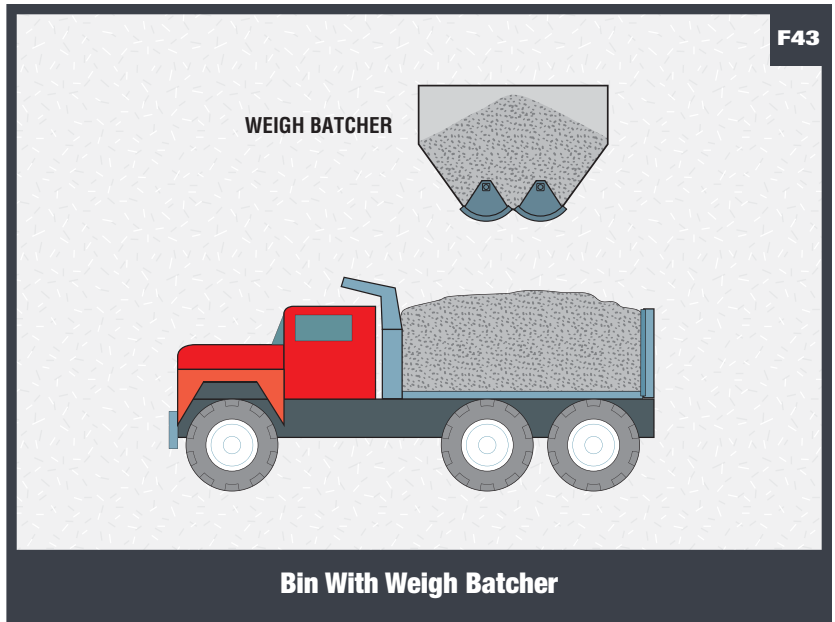
Bins equipped with weigh batchers as shown in **Figure 43** tend to batch material directly into the trucks in a manner similar to the bin loading batcher. The weigh batcher, if designed properly, greatly insures uniform loading of the truck and improves the chance of avoiding segregation with a sensitive mix.

When unloading a truck into a paver hopper it is important to discharge the material as a mass instead of dribbling the material into a paver. To do this, the bottom of the truck bed needs to be in good condition and lubricated so that the entire load will slide rearward. To further assure that the material is discharged as a mass, elevate the truck bed to a large, but safe angle, **Figure 44**. After a mass of mix breaks loose and floods the paver hopper, slightly lower the angle of the truck bed until it is time to re-flood the paver hopper.

Rapid truck discharge floods the paver hopper and minimizes material-run-around that often occurs at the tail gate. Rapid discharge prevents an accumulation of coarse material at the outside portion of the paver wings.

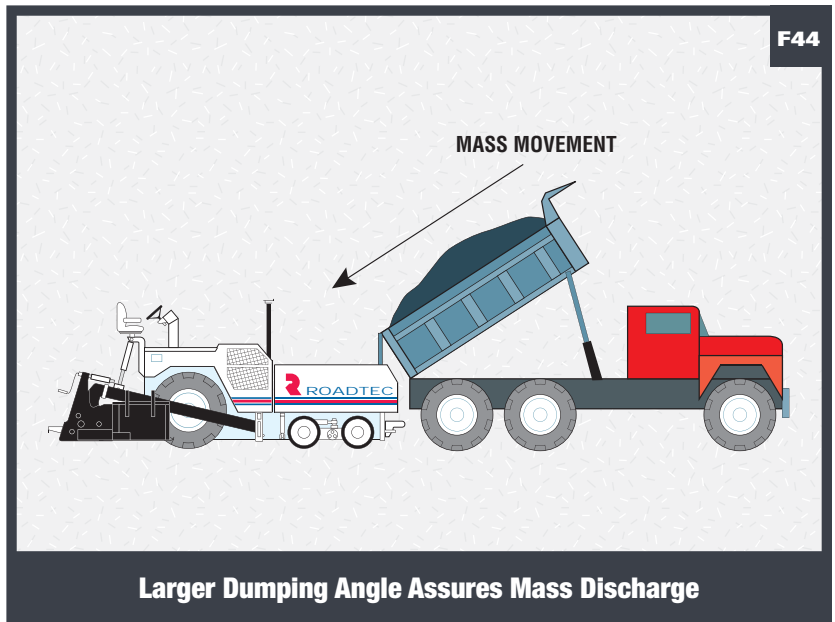
With sensitive mixes it is often necessary to modify the forward portion of the truck bed to eliminate undesirable effects caused by the hydraulic cylinder enclosure. If the mix has a tendency to segregate, a pocket of coarse mix can occur as the mix slides away from the cylinder enclosure. As the load moves rearward, the mix caves in forcing large stones to accumulate in the center of the bed at the front of the truck. Then as the load moves into the paver, “end of the load” segregation occurs, **Figure 45**. Adding a plywood or light gauge metal cover across the entire front of the bed from side-to-side will minimize this problem.

F43



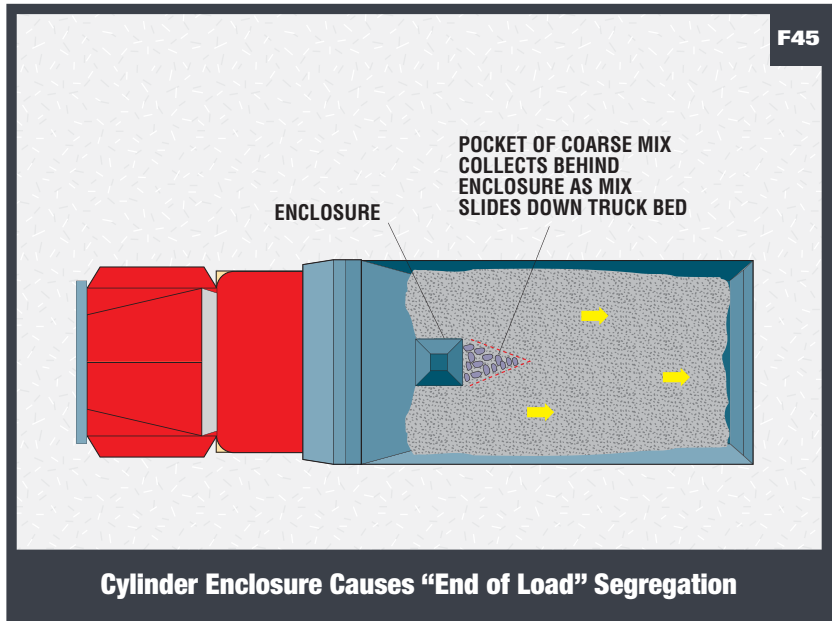
Bin With Weigh Batcher

F44



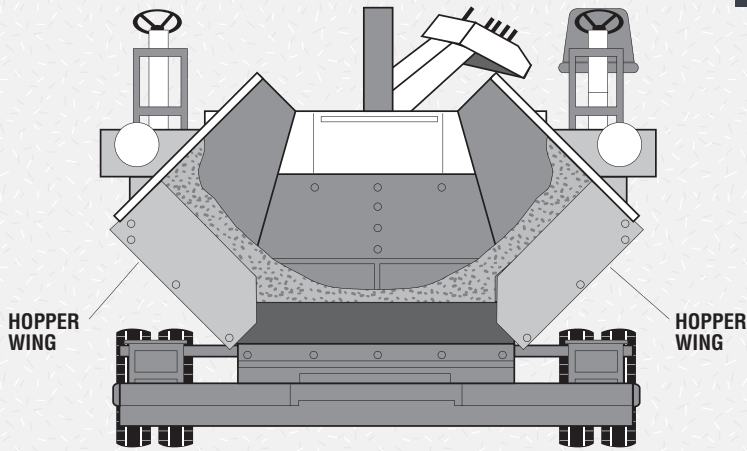
Larger Dumping Angle Assures Mass Discharge

F45



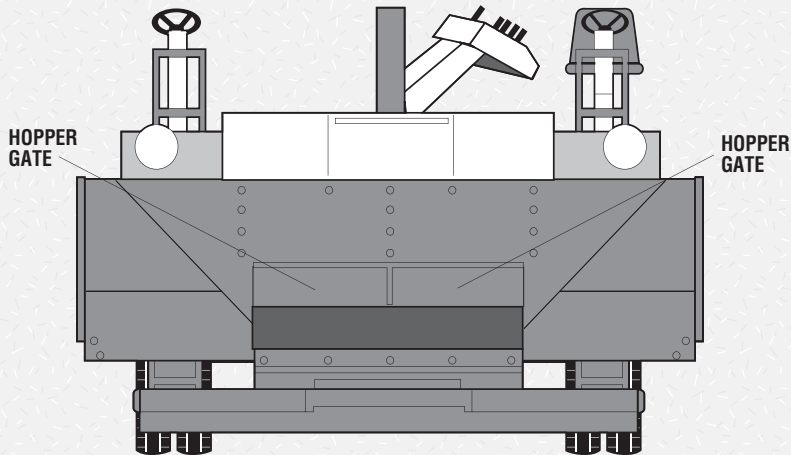
Cylinder Enclosure Causes “End of Load” Segregation

F46



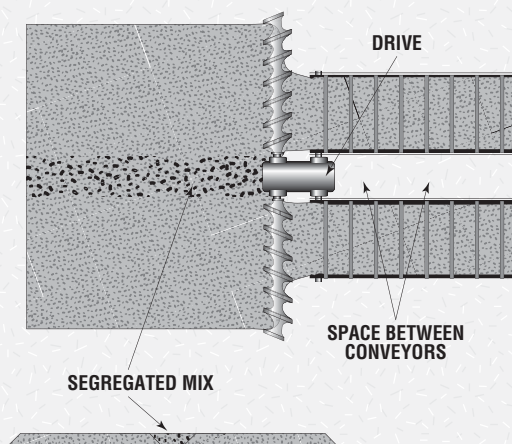
Paver Hopper Wings

F47



Paver Hopper Gates

F48



Conventional Paver Design

VI. PAVER

Even though material has been successfully processed through the cold feed bin, through the plant, through the surge or storage bin, then uniformly loaded on the truck, segregation can still occur in the paver. Improper operation of a paver can cause segregation in varying degrees. Here are suggestions that should be considered when segregation occurs at the paver.

a. Do not completely empty the hopper between each truck load. Coarse material tends to roll to each side of the truck bed and thus roll directly into the wings of the hopper. By leaving material in the hopper the coarse material has a better chance of being mixed with finer material before being placed on the road.

b. Dump hopper wings only as required to level the material load in the hopper. Dumping eliminates the valleys in the material bed, thereby minimizing rolling that occurs when unloading. It allows the truck tailgate to swing open fully to flood the hopper with mix, **Figure 46.**

c. Dump the truck so as to flood the hopper. With the hopper as full as possible, material tends to be conveyed out from under the truck and minimizes the tendency to roll as it is dumped into the hopper.

d. Open hopper gates as wide as possible to insure that the augers are full. By closing the gates and starving the augers for mix, fine material will drop directly on the ground causing coarse material to be augered to each side, **Figure 47.**

e. Run the paver as continuously as possible. Start and stop only as necessary. Adjust the paver speed to balance paver production with plant production.

f. Run augers continuously. Auger speed should be adjusted so that a continuous, slow flow of material occurs. Augers that run at high speeds are cycling on and off continuously and contribute significantly to segregation at the paver.

g. If augers are running too fast, the center of the mat will be deficient of material and this will generally result in a coarse strip, **Figure 48.**

Baffle plates, as shown in **Figure 49**, will also prevent coarse materials from rolling in front of the auger gear box and causing center line segregation.

With the installation of the baffles, the augers then divert material uniformly to the center. **Figure 48** shows a conventional design where space between conveyors causes center line segregation. **Figure 50** shows the Roadtec design with two important changes made on newer Roadtec pavers to minimize segregation and eliminate the need for baffles:

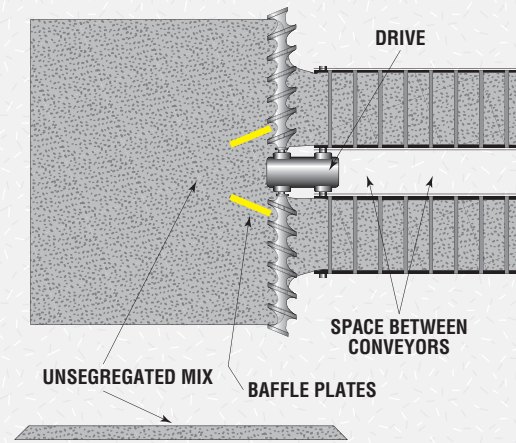
1. Flight chains now have less space between them at the center of the hopper.
2. Head sprockets of the flight chains are now closer to the auger.

Another Roadtec paver design feature which further reduces segregation is a gravity fed auger. Instead of the paver auger being fed by drag chains pulling hot mix from the bottom of the paver hopper, the hot mix in the paver hopper mass flows directly into the paver auger by gravity and is metered by hydraulically activated clam gates. Paver maintenance is also reduced due to elimination of the drag chains, **Figure 51**.

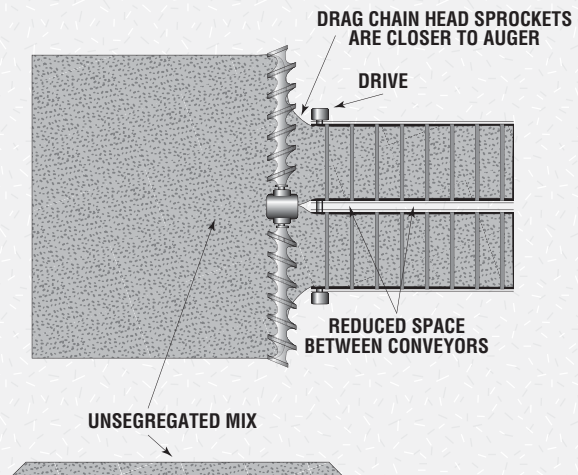
h. If the outer edges of the paver auger are deficient of material, coarse strips along the outsides can occur as the coarse aggregate rolls to the outsides.

i. If possible, adjust paver extensions so that the paver pulls the same amount of material from each side of the hopper. If one side is pulling more material, a valley will form in that side of the paver hopper, causing segregation to occur in sensitive mixes. If correction cannot be made by adjusting the extension, offset the truck slightly towards the side requiring more material to even out the material bed in the hopper.

j. Pavers without auger extensions can cause outside edge segregation. A segregation prone mix can segregate without auger extensions as the mix piles up at the end of the auger and the larger aggregate rolls off toward the outside edge of the road.



Conventional Paver Design With Baffles



Roadtec Paver Design



Shuttle Buggy Material Transfer Vehicle With Gravity Auger

F52



Shuttle Buggy Material Transfer Vehicle

VII. SHUTTLE BUGGY® MATERIAL TRANSFER VEHICLE

The difficulty of dumping mix from the truck into the paver while keeping the paver moving continuously should be apparent from our earlier discussion. **Figure 52** shows a Shuttle Buggy material transfer vehicle that allows the truck to stop at a suitable distance ahead of the paver, then dump its entire load without moving. The Shuttle Buggy carries 30 to 35 tons of mix.

The drag conveyor on the front of the Shuttle Buggy is sufficiently wide to accept the full width of the mix load from the truck (uninterrupted) and convey it up and into the holding hopper of the Shuttle Buggy. Two variable pitch augers in the bottom of the holding hopper re-mix the material as it moves into the rear swivel discharge conveyor.

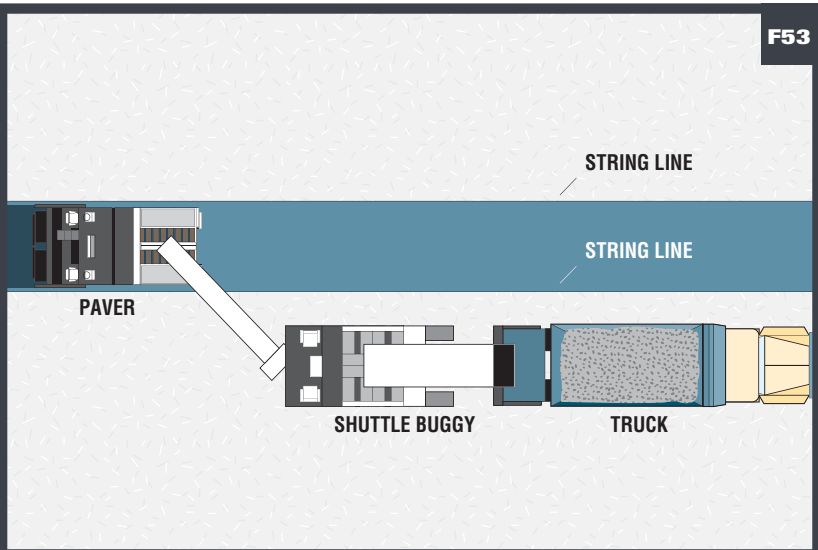
A holding hopper is installed on the paver, allowing storage of approximately 7.5 to 15 tons of material. The swivel conveyor from the Shuttle Buggy fills the hopper from the top. **Figure 53** shows loading from an adjacent line. This new concept allows continuous operation of the paver, re-blends the material and allows the use of large, long trailers. **Figure 54** shows how the material blended from six different points transfers to the material flow. Remixing material from the sides with material at the center.

Moreover, the holding hopper on the paver eliminates the accumulation of coarse material in the wings. Accumulation of coarse material and dumping of the wings is a major cause of end-of-the-load segregation.

Figure 55 shows a transfer device that does not have storage. It blends the material as it is discharged from the unloading conveyor to the rear loading conveyor (**Figure 56**).

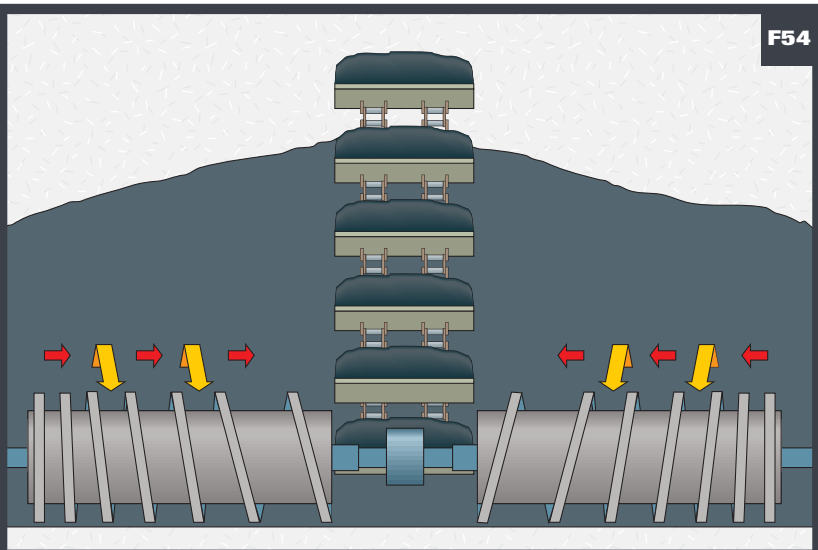
These units have proven to completely eliminate end-of-load and random segregation due to reblending of material by the mixing augers. The resulting pavement smoothness exceeds anything previously accomplished on a consistent basis.

F53



Shuttle Buggy Operating in Adjacent Lane

F54



Shuttle Buggy Mixing Augers

VIII. DIAGNOSTIC SYSTEM

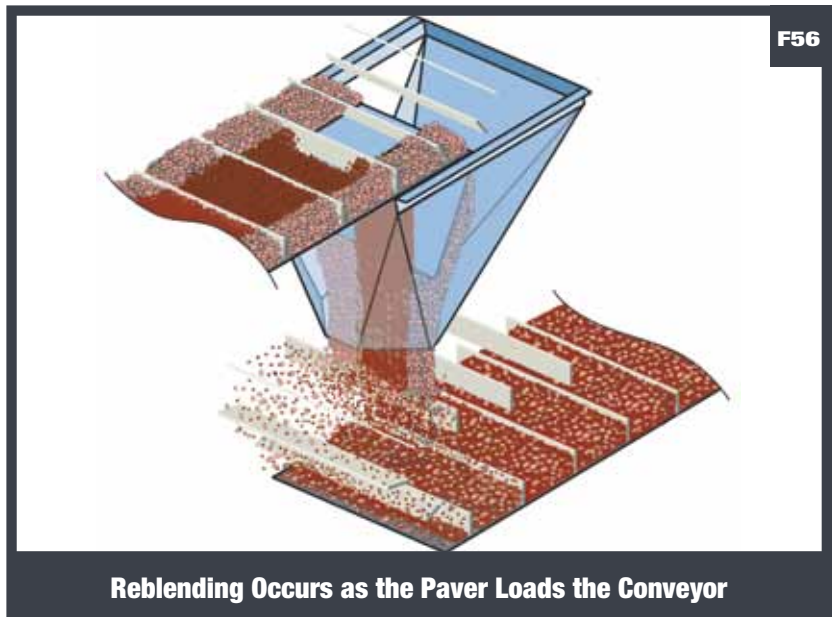
The Segregation Diagnostic Chart accompanying this technical paper shows five different kinds of segregation. It provides a diagnostic system for analyzing the potential causes of segregation based on these types of segregation as they occur on the road. This, the most likely causes of segregation, can be quickly identified in the chart. Then this paper can be consulted for more detailed information regarding causes and remedies.

IX. TESTING

Segregation and asphalt content go hand-in-hand. If mix is uniformly produced and uniformly coated and the material segregates after mixing, a sample of coarse material will reveal low asphalt content while a sample of fine material will show high asphalt content. NAPA Publication QIP109 shows methods of analyzing asphalt content and extraction problems. Refer to this publication if segregation is occurring in the sampling or in the splitting of the material prior to running extraction tests.

A second type of segregation is temperature segregation. Even if the mixed asphalt is uniform, premature failure can occur if the temperature of the mix is not uniform. Uneven temperature leads to uneven viscosity which leads to uneven compaction/density.

In summation, segregation in hot mix bituminous mixtures is a common and persistent problem. However, the problem can be controlled and even eliminated through proper mix design and through proper maintenance and operation of plants, trucks, and paving equipment. It is hoped this paper will assist in analyzing the problems and will be helpful in the selection of an effective cure.



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