Trouble-Shooting Plant Operations:
(Gradation, Asphalt Content, and Voids)

A key thing to remember and focus on when trouble-shooting plant operations is to remember that the asphalt plant (HMA/WMA Facility) is simply a drying, heating, and blending machine.

"Problems" associated with mix production are typically being relayed from the lab; and since we are measuring plant produced mixes in terms of gradation, asphalt content, and voids, "problems" that do develop are likely to be communicated to us in terms of gradations being out of tolerance, asphalt content being out of tolerance, or voids being out of tolerance.

Since gradation and asphalt content both affect voids in the final mix, these items interrelate. Except for specific gravity change or drastic particle shape change in the aggregate materials the likely cause of voids being out of tolerance is either then a gradation change in the aggregate materials or an asphalt content that is too high or too low.

Since the plant is basically a blending machine, gradation changes can either be the cause of the gradation in the feed materials changing or the "blending machine" malfunctioning; that is either the wrong recipe being run, the loader operator putting the wrong material in the feed bins, or the plant falling out of calibration.

Since the asphalt content is "slaved" to follow aggregate and RAP scale readings, when it comes to asphalt content inaccuracy, typically either the virgin aggregate scale, recycled materials scales, or the asphalt meter is malfunctioning. With some mixes, however, asphalt content will track gradation changes; so a coarse gradation will often result in lower asphalt content while a finer gradation will result in higher asphalt content.

And since voids follow both gradation and asphalt content, expect voids to track deviations in both asphalt content and gradation.

- Coarse gradations typically result in lower voids in the mix,
- Fine gradations typically result in higher voids in the mix,
- Low asphalt content typically results in higher voids in the mix, and
- Higher asphalt content typically results in lower voids in the mix.

An exception to this can be dust content (-200 mesh material) in the final mix. Dust can increase voids at first, then "collapse" (lower) voids when it becomes excessive, but generally excess "dust" is considered to lower voids in the final mix.

Segregation will also cause gradation, asphalt content and voids to change. Segregation can occur at any point in the process. Do not rule out segregation as the cause of mix problems.

That is the short version of the information presented below. What follows is a more detailed explanation of how these factors interrelate and trouble shooting guides of where to look to find the root cause of mix deficiencies.

Trouble Shooting Gradation Problems:

When gradations in the final mix do not match design targets, we need to determine whether there has been a gradation change in the feed materials or there is a (plant) blending problem.

Your easiest Trouble-Shooting approach in making this determination is comparing these three gradations:

1. Extracted gradations in the tested and final mix (which has already determined your problem in all likelihood),

2. The combined / blended aggregate gradations being fed into the dryer, and

3. The individual aggregate gradations in the stockpiles / being loaded into the feed bins

The "<u>extracted gradations</u>" are the gradations of the final mix after the asphalt cement has been removed. They are established / identified as part of the routine testing procedures and have been set during the design process. If the "extracted gradations" do not match design requirements, perform the additional sampling recommended below. Comparing this data against "extracted grades" will help you to determine the probable cause of the gradation deficiency.

"Combined aggregate" samples are typically taken from the aggregate conveyor as it enters the drying drum or drum-mixer. RAP samples can be taken similarly. There are two common ways this is accomplished.

1. A combined sample can be taken with an "automatic sampler" as it enters the drum or travels up the belt, or

2. The plant can be "hot stopped" or "mid-streamed" and a combined aggregate sample taken directly off the belt entering the drying drum (typically referred to as a "belt cut"),

"Individual aggregate" gradation samples are the gradations of the individual materials being used to make up the mix. These can be taken very simply with one of the techniques below.

1. The plant can be "hot stopped" or "mid-streamed", the feeders and collector belt locked out, and material samples collected right out of the "mouth" or "throat" of the feeder, or

2. Two or three loader buckets of material can be extracted from the feeding face of the individual aggregate, and sampled. (Avoid sampling around the entire pile – sample only out of the feeding face – as this is the material being fed to the plant)

Each of these techniques allows you to obtain a representative sample of the material that is being fed into the plant to produce the mix.

If stockpile face sampling is selected, it is important that material is taken from the face where the materials are being extracted by the loading equipment. If there is variability in the stockpile, it can be masked by sampling around the entire stockpile and averaging the results. The goal is to sample the actual material that is being fed into the plant or was being fed into the plant when the mix was made.

Note that when using this diagnostic technique, it is advisable during the design phase to execute both a "washed" gradation and a "dry" gradation of the individual materials. This allows faster checks by comparing "dry" material gradations when determining whether individual materials are still to design tolerances. If "dry gradations" are found to be inconsistent, then washed gradations can be accomplished later to fine-tune the analysis.

By comparing these three sets of gradations, one can determine where the probable gradation errors are occurring, as noted in the table below.

There are, however, complications. One set exists with baghouse fines return. Another relates to segregation. And a unique set of complications exist with batch plant type mixing. All of these can affect the gradation of the final mix.

Baghouse Fines Return

Baghouse fines return complications fall into two categories; when 100% fines are returned to the mix, and when none or only part of the fines are returned to the mix.

These same complications exist for both drum mix plants and batch type plants.

<u>When 100% of the baghouse fines are returned to the mix (without an intermediate storage silo):</u>

- It can take a considerable amount of time for the fines to be collected in the baghouse and returned to the mix. This delay can be as long as 30 minutes.

  Therefore, significant changes in production rate can cause the mix to be deficient in fines (production rate rose rapidly, but the baghouse fines were being returned at the previous lower production rate) or have an excess quantity of fines (production rate dropped rapidly, but the baghouse fines were being returned at the previous higher production rate).

  The operational solution to this potential problem is to make less dramatic production rate changes.

- It is also advisable to lower production rates back down to start up rates at the end of the day. This ensures that the dust level in the baghouse is consistent with the start up rate the next day.

- It is advisable to not clean out the baghouse at the end of the day. This causes the mix to be short of fines on startup the next day. Fines can typically be safely left in the bottom of the baghouse. When the plant is pre-heated the next day the fines are typically dried of any overnight condensation that might occur in the baghouse hopper. Fines return equipment, however, is always emptied as there is no possibility of heating the fines return equipment to eliminate any condensation problems in the fines in the return equipment.

- Controls should be configured to clean the baghouse continuously. This ensures that baghouse fines are always being returned to the mix. Controls that clean the baghouse only when the baghouse pressure drop rises to a certain level are to be avoided when 100% of the baghouse fines are being returned to the mix.

- Dust return augers that are extremely steep can also cause variable fines in the final mix immediately after “mid-stream stops” or “hot stops”. When the auger stops the fines run down to the bottom of the auger. When the plant restarts these fines are immediately absent in the startup mix then become excessive as the auger clears itself and returns to steady state operation.

- Note that these rules do not apply when wasting baghouse fines, using an intermediate storage silo for dust return, and/or using an intermediate storage silo to return only part of the baghouse fines. This equipment configuration has another set of “best practices” that affects fines in the final mix, but the extremely steep incline auger phenomenon mentioned above will still apply.

<u>When using an intermediate storage silo, wasting baghouse fines, and/or returning only part of the baghouse fines:</u>

- The “draft” level in the drying drum or drum-mixer needs to be monitored and held to a consistent number at all production rates. There is a gauge for this in the control house adjacent to the burner control panel.

Not all the “dust” or -200 mesh / 75 micron fractions in the aggregate mixture goes to the dust control equipment. The “draft” in the drying drum will affect the percentage of “dust” that stays on the aggregate and the percentage that is evacuated to the dust control equipment during the drying process.

By monitoring this draft level against mix results you can determine where to properly run the dryer draft and where to properly run the dust return equipment.

- If you are wasting 100% of the baghouse fines, increasing the draft will reduce the quantity of -200 mesh / 75 micron “dust” in the mix. Decreasing the draft will increase the quantity of -200 mesh / 75 micron “dust” in the mix.

- If you are putting back only part of the baghouse fines from an intermediate storage device, or are even using an intermediate storage device to return all the fines, managing the draft is also important.

  Increasing the draft will result in less “dust” in the total mix, since the return rate from the intermediate storage device has probably not changed.

  Decreasing the draft will result in more “dust” in the final mix, as the return rate from the intermediate storage device has probably not changed.

- Note that when using an intermediate storage device or wasting baghouse fines, running the plant to maximum capacity or “puff point” typically results in “voids collapse” or too much “dust” in the final mix, as the draft is eliminated when the dryer is “puffing” (the dryer is actually pressurized and under positive pressure).

- One should be able to see readily, therefore, that when using an intermediate storage device or wasting baghouse fines, draft is critical and fluctuations in draft can be a primary cause of -200 mesh / 75 micron “dust” variability, even when the cold feed bin gradations and combined material gradation going to the dryer is on design target.

<u>Segregation at the Plant</u>

Segregation can affect the gradation in the tested mix.

Segregation can occur at several places in the mixing process; in truck load out from a silo, when charging a silo from a batcher or “gob hopper”, in the batcher or “gob hopper” itself, as material is discharged from a slat conveyor or bucket elevator into a transfer conveyor or batcher, as material discharges from the mixing area of a drum mixer, as material discharges from a batch plant pugmill, in the batch plant pugmill itself, in the mixing area of the drum-mixer itself, or in the drying drum itself.

If gradations of the extracted mix do not match design targets, but the combined aggregate gradation going into the drying drum does, we cannot rule out segregation as a possible cause of mix gradation deficiencies.

Segregation can be tested using the following techniques, sampling "backwards" in the plant process to where it stops. The transition point immediately after it stops is typically the cause of the segregation.

- Sample the left side and right side of the truck and compare results.
- Sample the front and back of the truck and compare results.
- Sample mix from two different locations in the batcher or "gob hopper" and compare results. (The plant should be stopped and "locked out" to do this)
- Sample mix from the left side and right side of the slat conveyor(s) or bucket elevator and compare results. (The plant must be stopped and "locked out" to do this.)
- Stop the plant and view the homogeneity of the mix in the mixing area if a drum-plant. (This is typically a visual analysis. The plant must be stopped and "locked out". Sampling can be dangerous, and may not be possible. Visual inspection might not be possible and might have to be deduced.)
- Sample the left / right or front / back side of a batch discharged directly from the batch tower into a truck. (This determines if the pugmill is producing a homogenous mix during the dry and wet cycle times.)

With all this information as background, the following diagnostic tables can now be useful when "Trouble-Shooting" Gradation Problems.

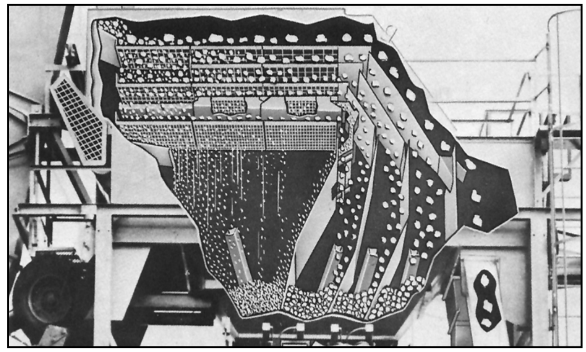
Drum-Mix Plant Gradation Issues (gradations larger than the -200 mesh / 75 micron sieve)

Extracted Gradation	Combined Gradation	Individual Gradations	Investigate
Incorrect	Incorrect	Incorrect	Gradation change in individual material Segregation of stockpiled material
Incorrect	Incorrect	Correct	Feed bin out of calibration Plugged feed bin Wrong mix recipe
Incorrect	Correct	Correct	Mix segregation

Drum-Mix Plant Gradation Issues (for material passing the -200 mesh / 75 micron sieve)

Extracted Gradation	Combined Gradation	Individual Gradations	Investigate
Incorrect	Incorrect	Incorrect	Gradation change in individual material Segregation of stockpiled material
Incorrect	Incorrect	Correct	Feed bin out of calibration Plugged feed bin Wrong mix recipe
Incorrect	Correct	Correct	Production rate changes if 100% baghouse dust return Draft level at time if dust wasted, partial return, or silo return Return equip out of calibration if partial return or silo return Inclined dust screw with start & stop Mix segregation

Batch Plant Mixing Gradation Control Issues:



With a batch type plant, the gradation of the final mix is controlled by the individual materials from the hot bins. However, the gradations of the hot bins will be affected by what is being fed from the cold feed bins. For instance, two sands" that are being blended at the feed bins are both most likely to end up together in the "No. 1" or "Fines" bin. Also, some "chips" in the "manufactured sand" are likely to be screened into the "No. 2" or "3/8 inch or 9.5mm" bin.

Also with a batch type plant, certain operational considerations affect hot bin sizing.

Hot bin walls are sloped. This can lead to segregation issues. The gradation of the material can actually change depending on the quantity of material in the hot bin and how the material flows from the hot bin down through the hot bin gate into the aggregate weigh hopper.

High feed rates of the combined material flow over the screen deck can cause "carryover" when the flow rate exceeds the screens capability, causing the hot bins to become "finer" in gradation.

Screens that "blind" either from material that is not dried or from "near size" rock wedging in the screen openings can also cause hot bins to become "finer" in gradation.

Vibration in the batch tower can cause vertical separation or segregation over time if the batch tower is allowed to "idle" with "inventory" in the hot bins when there are no trucks to be loaded and the plant is not making mix. This condition primarily shows up in the No. 1 ("Fines") and No. 2 (3/8" or 9.5mm) bin.

Very fine dust particles can accumulate in the corners of the No. 1 bin or "fines" bin, then "slough off" (the "street term" for this) unexpectedly when they get too heavy, negatively affecting No. 1 bin or "fines" bin gradations when the material is "drawn" into the aggregate weigh hopper.

<u>For these reasons, most operators of batch plants, when running QC/QA or End Product Specification mixes follow these rules to reduce the chance of these complications from arising</u>.

– <u>The batch plant is scheduled to run continuously</u> either into silos or trucks (if no silos are on the batch plant then sufficient trucks must be scheduled for the projected production rate).

– <u>The cold feed flow and drying rate is carefully monitored so that there is very low inventory in the hot bins</u>. The rate is typically controlled so that each "draw" of a hot bin takes one or two additional seconds waiting on material. Whatever is screened for that hot bin now passes through that hot bin and there is little chance of "fines" building up on the bin walls or any segregation that might occur in the hot bin affecting the final mix. (This is often referred to as "running on the gates".)

– The cold feed flow and drying rate is carefully monitored so that no "carryover" occurs at the screen deck, either with the total flow or the flow of an individual material. (This last point often reduces the throughput capability of batch type plants. Modern mixes typically have more aggregate than older mixes and the quantity of square feet of screen and hot bin capacity for larger aggregates is often less than desired for the rate being run. This results in "de-rating" the plant.)

– Vibrators are attached to the No. 1 or "fines" bin and are activated when this material is being "drawn". (This reduces the likelihood of fines building up in the corner of the hot bin.)

– The plant is "hot stopped" and the motors on the tower are shut down if the silos are full or there are no trucks to load. (This eliminates the chance for vertical segregation to occur in the bins as there is no appreciable inventory in the hot bins and there is no vibration to the tower.)

– Some batch plants are configured to run "screen-less". With this type of configuration, the screens are by-passed and all aggregate material goes into the "No. 1" or "fines" bin. Gradation is set at the cold feed like a drum-mix plant. Producers running "screen-less" will not be affected by "carryover" problems, but will still manage flow rates so that hot bin inventory is minimized and will shut off the tower and plant if the silos are full or there are no trucks to load.

Batch Plant Gradation Issues (gradations larger than the -200 mesh / 75 micron sieve)

Extracted Gradation	Combined Gradation	Individual Gradations	Investigate
Incorrect	Incorrect	Incorrect	Gradation change in individual material Segregation of stockpiled material
Incorrect	Incorrect	Correct	Feed bin out of calibration Plugged feed bin Wrong cold feed recipe
Incorrect	Correct	Correct	Carryover on screens Blinding on screens Hot bin segregation Wrong hot bin pulls Inadequate mixing in pugmill Mix segregation downstream of mixer

Batch Type Plants Gradation Issues (for material passing the -200 mesh / 75 micron sieve)

Extracted Gradation	Combined Gradation	Individual Gradations	Investigate
Incorrect	Incorrect	Incorrect	Gradation change in individual material Segregation of stockpiled material
Incorrect	Incorrect	Correct	Feed bin out of calibration Plugged feed bin Wrong cold feed recipe
Incorrect	Correct	Correct	Carryover on screens Blinding on screens “Vertical” segregation in No. 1 / “fines” bin from idling plant “Dust slide” in No. 1 / “fines” bin Production rate changes if 100% baghouse dust return to elevator Draft level if dust wasted, partial return, or silo return Return equip out of calibration if partial return or silo return Inclined dust screw with start & stop Inadequate mixing in pugmill Mix segregation downstream of mixer

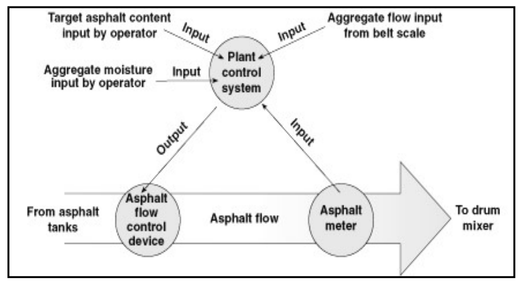
Trouble-Shooting Asphalt Content Problems

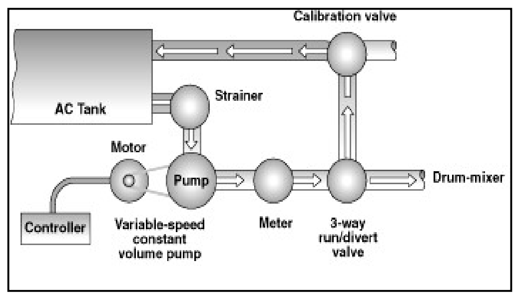
Asphalt content is controlled differently in a drum-mix type plant and a batch type plant. Therefore, trouble-shooting asphalt content issues requires a completely different approach with each style facility.

To understand where to look to correct asphalt content variations with each of these facilities, it is first advisable to review how asphalt content is controlled in each of them, and discuss best practices and issues that can complicate asphalt content control in each facility.

Drum-Mix Plants and Asphalt Content:

With a drum-mixer style plant, the asphalt flow is ratio-controlled by the automation based on the plant's belt scale signals.





Belt scales measure the virgin aggregate and reclaimed aggregate flow continuously. The mix formula entered by the operator determines the asphalt flow requirements. The material moistures entered by the operator allow the control system to adjust the wet belt scale signals to dry rates. The control automation thus determines the proper flow of the asphalt cement and sends a signal to the asphalt flow control device for the proper amount of AC. Watching the belt scales and watching the asphalt flow meter, the control system will automatically adjust the asphalt cement flow to maintain the proper quantity of asphalt against the belt scale signals.

Obviously, for the asphalt content to be correct, the belt scales need to be properly calibrated so they represent accurate flow over all the production rates the plant will run, and the asphalt meter needs to be properly calibrated over the rate which the plant will run. Calibrating over these different speed ranges is a very important point.

<u>In addition, we know the following factors can affect asphalt content accuracy</u>.

- Mechanical items like multiple splices, screen vibration, roller buildup, the lack of wind guards, or the lack of belt tensioning assemblies can affect scale accuracy.

- Some belt scales are affected by climates that have extreme ambient temperature swings during the day (40°F or more). This needs to be checked and monitored. This condition is frequently associated with a scale that cannot "maintain zero", has to be "re-zeroed" during the day, or does not return to "zero" at the end of a run.

- Material moistures must be properly entered in the automation.

- When using ignition ovens to determine AC content, it is important to first ascertain that there is no moisture in the mix prior to run an AC content test.

- Asphalts of different viscosities or performance grades can have different meter calibration factors. This should be checked prior to using different asphalt cements and applies to all types of meters. Sometimes the mix formula allows you to store the calibration factor or specific gravity for the asphalt being run. Frequently it does not, and must be entered by the operator.

- These different calibration factors can be affected by the temperature of the liquid asphalt cement flowing through the meter. This is different than the automatic adjustments in weight per gallon or specific gravity based on material temperature. This relates to the flow characteristics through the metering head. This needs to be checked prior to using different asphalt cements. Liquid asphalt temperature needs to be monitored during production. Control systems do not adjust for this, so the operator must watch this, and if this proves to be a factor for the asphalt cement being run, adjustments in the set point for the asphalt content or a change to the calibration factor must be made to compensate for this during production.

- Some asphalt cements of the same grade, but from different suppliers, also have different meter calibration factors. This needs to be checked prior to production.

- The asphalt content of the RAP or RAS is often not part of the mix formula. This input is often made elsewhere in the control system. The correct AC content in the RAP or RAS needs to be entered for the material being run, and needs to be adjusted by the operator when changing material stockpiles prior to the mix change.

- Segregation that might occur in the drum, in the mixing area, in the bucket elevator or slat conveyors, in the batchers or “gob hoppers”, in the silos, or in the truck loading process, can affect not only gradation of the mix sampled, but also the asphalt content of the mix sampled.

- Baghouse dust return irregularities can affect dust to binder ratios, gradation, and may also affect asphalt content percentages in the final mix.

<u>Note that when diagnosing asphalt content issues, it is wise to first determine if the error is consistent.</u>

- <u>Consistent AC content errors</u>, either high or low, typically point to calibration issues or improper data entered into the control system (like the wrong meter calibration factor for the asphalt cement being run, or the incorrect specific gravity of the asphalt cement being run, or the incorrect asphalt content in the RAP or shingles being run).

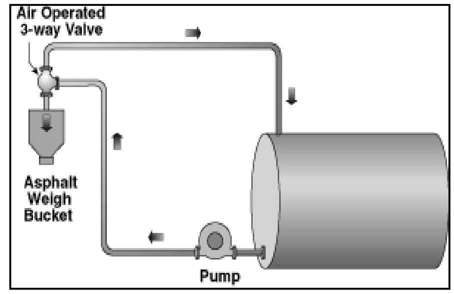
- <u>Inconsistent asphalt content</u> typically points to segregation problems or problems with the asphalt flow control mechanism (belt scales and asphalt meters are reading correctly, but the control system cannot control the quantity of the asphalt cement correctly if the flow control device is worn or damaged),

With this as background information, the following diagnostic tables can now be useful when “Trouble-Shooting” Asphalt Content Problems.

Trouble-Shooting Asphalt Content Problems in Drum-Mix Plants

AC Content High	Belt scale is reading artificially high due to calibration problem, rock in pivot point, accumulated fines on belt, wind effect on belt, or drastic ambient temperature variations. Asphalt meter reading artificially low, due to incorrect specific gravity of the asphalt cement, incorrect calibration factor with the liquid asphalt cement being run, temperature swings to the liquid asphalt cement that impact metering accuracy. AC% in reclaimed materials higher than entered. Incorrect moisture setting in automation (too low). Ignition oven used for testing & moisture in mix. Mix segregation – also check extracted gradations.
AC Content Low	Belt scale is reading artificially low due to calibration problem, rock in pivot point, wind effect on belt, or drastic ambient temperature changes. Asphalt meter reading artificially high, due to incorrect specific gravity of the asphalt cement, incorrect calibration factor with the liquid asphalt cement being run, temperature swings to the liquid asphalt cement that impact metering accuracy. AC% in reclaimed materials lower than entered. Incorrect moisture setting in automation (too high). Mix segregation – also check extracted gradations.
AC Content Varies	Unstable asphalt flow control device – automation cannot control. Erratic belt scale signals causing AC flow to vary. Temperature fluctuations in metered asphalt cement with ACs that are temperature sensitive. Ambient temperature fluctuations affecting belt scale accuracy. Fluctuations in AC content in reclaimed materials. Changing material moistures not being entered. Ignition oven testing & moisture sometimes in mix. Mix segregation – also check extracted gradations.

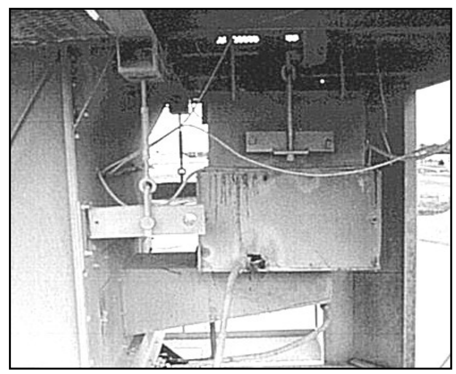
Batch Type Plants and Asphalt Content:



Batch type plants control asphalt content completely different than drum-mix style plants.

With a batch type plant, the asphalt quantity is weighed in a scale device designed to weigh the asphalt cement. This is typically referred to as the asphalt "weigh scale" or "weigh bucket", which is a term left over from the original batch type plants from the early 1900's that actually used a "bucket" to measure asphalt cement.

Asphalt scales or "weigh buckets" need to be calibrated to make sure they weigh accurately. This typically involves hanging known weights on the device to make sure the scale instrument is recording the correct weight.



A complication that exists with batch type plants is that calibrating with static weights can sometimes be different than weighing dynamically under production. If the lever arms or load cells attached to the scale are worn or not tight, an inaccurate weight reading can occur during mix production. The automation will recognize the signal, but this signal may not actually represent the true weight. The same can apply to the aggregate weigh hopper. This can be diagnosed by weighing several "batches" into a truck, and then comparing the batch weights from the automation against actual weights in the truck measured with a truck scale. By weighing aggregate only first, then weighing aggregate with asphalt, one can determine if both scales are working correctly or if only one is a problem. Remember, the accuracy of the aggregate weigh scale and the asphalt weigh scale both affect AC content accuracy.

Also, with a batch plant the asphalt cement is introduced into the pugmill down an asphalt injection pipe, either with the aid of a separate asphalt injection pump or by gravity. This pipe spans the breadth of the pugmill and has multiple holes in it with the goal of distributing the asphalt evenly into the pugmill. If some of these holes become plugged, asphalt may be deposited mostly on one side of the mixer. Depending on the effectiveness of the pugmill during the wet-mix cycle time, the asphalt may or may not be distributed evenly through the batch. The condition of the tips and arms in the pugmill also affect this. This can be diagnosed by depositing one full size batch directly into a truck (only one), sampling from multiple points and comparing the asphalt content from these different samples. By checking extracted gradations at the same time you can also determine whether or not the pugmill is creating a homogenous aggregate mixture in addition to homogenous asphalt content.

Like a drum-mixer, segregation downstream of the mixing process can also result in tested mix that is inaccurate in asphalt content or gradation. If this problem is suspected, the same type of segregation diagnostic practices used for drum type plants can be employed for batch type plants.

With this as background information, the following diagnostic tables can now be useful when "Trouble-Shooting" Asphalt Content Problems.

Trouble-Shooting Asphalt Content Problems in Batch Type Plants

AC Content High	Lack of consistent and accurate weighing in either aggregate weigh hopper or AC weigh hopper. Lack of homogenous mixing due to flow characteristics from AC pipe into mixer. Lack of homogenous mixing due to condition of pugmill tips and shanks. Inaccurate AC content in reclaimed materials entered into plant automation (actual higher than entered). Mix segregation "downstream" of mixing – check extracted gradations as well as AC content.
AC Content Low	Lack of consistent and accurate weighing in either aggregate weigh hopper or AC weigh hopper. Lack of homogenous mixing due to flow characteristics from AC pipe into mixer. Lack of homogenous mixing due to condition of pugmill tips and shanks. Inaccurate AC content in reclaimed materials entered into plant automation (actual lower than entered). Mix segregation "downstream" of mixing – check extracted gradations as well as AC content.
AC Content Varies	Lack of consistent and accurate weighing in either aggregate weigh hopper or AC weigh hopper. Lack of homogenous mixing due to flow characteristics from AC pipe into mixer. Lack of homogenous mixing due to condition of pugmill tips and shanks. AC content in reclaimed materials varying. Mix segregation "downstream" of mixing – check extracted gradations as well as AC content.

Trouble-Shooting Segregation Problems

The easiest way to find the source of your segregation problems is to "chase the problem backwards" in the operation – If you encounter segregation in the final mat, start looking backwards until the segregation stops – the cause of your problem will exist in the transition between where it is occurring and where it is not. As simple as this sounds, it works. Below is a list of some common causes of segregation at various stages of the operation – listed in a backwards direction. They can serve as a simple "punch list" for locating your problem.

At the Paver:

- **Failure to "fold the hopper wings" in frequently during the paving operation** – this can cause both gradation problems and "temperature segregation".
- **Failure to keep the ends of the cross screws full during paving** – this causes large rock to roll to the longitudinal edges of the mat
- **Failure to keep the depth of material high enough in the cross screw** – maintain the level of mix +/- 1" from the center of the shaft on the cross screw
- **Allowing the hopper to run empty between truck loads** – keep the paver hopper or paver insert between 1/3 and 2/3 full at all times.

During Truck Loading:

- **Load in multiple drops** – do not load in one continuous drop – load against the bulk head, tail gate, then "socket load" the middle in three drops
- **Do not allow the truck to creep forward during loading** – which can cause "running segregation" in the truck bed
- **Loading below the cone line should be avoided** - always keep a cone of material in the silo – emptying the cone typically results in coarse mix
- **"Lose the cone" on startup** – strongly consider wasting the first load from the silo to eliminate the first load into the silo being too coarse

At the Batcher:

- **Holes in the batcher gates or batcher walls -** allow mix to trickle feed into the silo
- **Make sure batcher gates close all the way** - so mix is not allowed to trickle feed into the silo
- **Make sure each batch is as large as possible** – timed batchers should be adjusted so that the batcher fulls up completely regardless of production rate – volumetric batchers should have paddles adjusted to collect as large of a mass of material as possible
- **Make sure batchers are fed in the middle** – too fast of feed from a slat is sometimes a problem with this – AND split batchers (batchers with a middle splitter and two gates) should be fed in-line with the splitter so material collects evenly on both sides.

At the Slat Conveyors:

- **Make sure feed is at 90 degrees at transfer points** – sometimes "oblique feed" causes large material to "roll to the outside" at transfer points
- **Make sure slats are tall enough and moving fast enough for the production rat**e – material should not roll over the top of the slat
- **Slats that run too fast** – can cause segregation by "flipping" the large stone to the outside of the transfer point at discharge

<u>In the Drum-Mixer or Mixing Drum</u>:

- **Mixing flights with buildup on them** – can create dams in the drum, causing segregation behind the dam
- **Missing mixing flights or mixing tips** – can also create dams and spots where segregation can occur
- **Buildup on mixing flights** – can eliminate the "tumbling action" in the mixing area, which can cause large stone to constantly roll to one side in the mixing chamber
- **Feed from the drum to the slat should be at 90 degrees** – "in line" feed can cause the mix to be coarser or finer on the left or right depending on the effectiveness of the mixing chamber – see above – 90 degree feed from drum to slat pretty much eliminates this problem by remixing the material

<u>At the Feed Bins</u>:

- **Loader person should "blend or mix the face" before filling the loader bucket** – any minor amount of stockpile segregation is typically eliminated with this approach
- **Care should be taken to make sure the right material is fed into the right bin** – with a repetitive movement like this it is easy to accidently put the wrong material in the bin

<u>In the Stockpiles</u>:

- **Outside edges can be coarser and inside finer with "stacker built" material** – it is imperative to "blend the outside edges with the inside middles" prior to filling the loader bucket
- **Stacking material too high with the loader** – can cause the outside edges to become coarser as material constantly rolls down the outside edges – re-mix the outside edges
- **Building ramps** – can cause material to "ribbon segregate" as it is pushed off the end of the ramp and tumbles down to the ground – extreme outside edges become coarser

<u>At the Quarry</u>:

- **Outside edges can be coarser and inside finer with "stacker built" material** – it is imperative to "blend the outside edges with the inside middles" prior to loading trucks
- **Stacking material too high with the loader** – can cause the outside edges to become coarser as material constantly rolls down the outside edges – re-mix before loading
- **Building ramps** – can cause material to "ribbon segregate" as it is pushed off the end of the ramp and tumbles down to the ground – extreme outside edges become coarser
- **Storage silos can segregate** – depending on the silo diameter or width – outside edges can become coarser as the silo is filled like a hot mix silo - when the silo is then emptied gradations become coarser

The 7 Habits of Highly Effective Producers
(7 Best Practices for Mix Success)

Field experience, and that is the field experience primarily associated with comparing the habits of successful producers against those that have problems, shows that if producers follow the following best practices and they end up becoming the "habits" of the organization, mix success dramatically improves and is assured. It is my firm conviction that anyone can produce consistent high-quality mix if they follow these steps.

1. Know Your Stockpiles …

- **Gradation <u>Will</u> Vary from the Quarry …** so check material gradations as they enter the yard. Gradation changes when screens are changed, when crushers are adjusted, when different veins of rock are encountered. Know if your stockpiles are changing prior to production.
- **"Map" Your Stockpiles**. Know what is in each pile. Know if the back of the pile is different than the front of the pile. Know if the left side of the pile is different than the right side of the pile. White boards come in very handy for this so everyone has a visual picture of the differences in the stockpiles. I refer to this process as "mapping your stockpiles".
- **"LIFO" vs "FIFO" is the Best Approach.** Using the last material that comes into the yard does not give you a chance to test the material and know the gradation. It is better to use older material where you know what the gradations are.
- **Separate Material Into "Cells".** Stockpile material "left" and "right", or "front" and "back", or into completely separate piles (they can touch – you just need to be able to visually see the difference), so that you can know the gradation of the material you are feeding into the plant.
- **Use "Blend Sheets" to Adjust "Bin Pulls".** Each owner/agency group allows for minor adjustments in "cold feed bin pulls" of "cold feed percentages" to maintain the final desired composite mix formula. Use spread sheets so you can enter new gradations of the individual material and see the impact on the final mix gradation. This will allow you to determine which cold feed bin adjustments will keep you on your final mix target. Relay this information to the plant prior to production. Do this proactively, not after you have mix problems.

2. Keep Your Plant Calibrated …

- **Calibrations Do Shift and Will shift.** Plant calibrations do shift and will shift. Accept this fact. Some plants "drift" more than others.
- **Routinely Check Plant Calibrations.** The best idea is to proactively check plant calibrations. A proactive approach is better than a reactive approach.
- **Don't Wait Until "Mix is Bad".** Calibrations often "drift" their way into being out of spec. If you run calibration checks prior to mix going completely out of spec you can stay ahead of the curve financially.
- **Electrical / Mechanical Problems are Typically at Fault.** The reason for calibration "drift" is typically a worn part or electrical connection. Worn parts can be mechanical or electrical.

- **Calibration Checks Typically Only Take 30-45 Minutes per Test.** It does not take a long time to run a calibration check on any individual item. A good time to do this is when you are “on hold” in the afternoon, the plant is not running, and you waiting to ship the final loads. Early morning hours can also be a convenient time for this. You don’t have to check every calibration item on the plant. You can just do one at a time.

3. Produce in Long Runs …

- **Don’t Bounce Between Mixes Rapidly.** There is a certain amount of “magic mix” made between mix changes, and depending on how well your plant is adjusted / calibrated and depending on the automation algorithm this amount will be more or less. Obviously, the minimal number of changes you make, the less of this potentially out of tolerance mix you will have.
- **Takes Time for Plants to “Level Out”.** See the note above. Realize it takes time for plants to “level out” so short tonnage runs between mix changes jeopardizes mix quality for both mixes.
- **PID Loops in Automation Affect This.** The control system PID loop that affects the proportion or rate of the change, and the interval of the time between the next change, affects this amount of “magic mix” between mix changes. This control algorithm is typically not adjustable by the operator but is embedded in the control logic, so it is important to realize the amount of “crossover” mix between mix changes is not always under the control of the plant operator. Adjusting this is available to the control maker.
- **Stagger Your Start Times on Different Mixes.** By “staggering” the start times between jobs you create an opportunity for the plant to be able to make a protracted amount of material for each project and avoid “bouncing back and forth” between different mixes in short runs, which again, protects mix quality.
- **Try to Produce a “Silo at a Time”.** So … this should be the goal. Try to “stagger” project start times so you can produce a silo at a time as you change back and forth between mixes. You have a chance to stay “ahead of the trucks”. If you can store mixes overnight, consider producing a silo the day before to get a head start on the next day. You must take care, however, and balance paving speed to plant production. If you have more than one crew all trying to pave at a rate equal with the plant rate, they are going to “catch the plant” mid to late morning. Balancing start times and paving speeds to plant production and storage capability helps create a condition whereby you can meet the goal of producing a “silo at a time”.
- **100 Ton Minimums per Run.** If you can’t produce a silo at a time, set a goal of producing at least 100 tons with each run. You have a better chance of producing a consistent mix. Mixes can “overlap” on “switchovers” so minimize the quantity of “switchover mix” in the silo by producing in at least 100 tons runs.

4. Produce in Steady Runs …

- **Don’t Raise & Lower TPH Rapidly.** Consistent mix is best produced if production rate changes occur slowly.
- **Takes Time for Controls to Adjust.** It takes time for the controls to adjust to new production rate changes. See the comments above about PID loops in controls. The same issue that occurs with mix changes occurs with production rate changes. Small incremental changes to production rates ensure the mix stays within specification.
- **Takes Time for BH Fines to Stabilize.** It takes time for the baghouse fines to “catch up” to the cold feed and asphalt changes, which is another reason for small incremental

changes to production rates. Baghouse fines delay times can be as long as 30-40 minutes, so small changes in production rate allow the fines delay to not drastically affect the mix.

- **Steady Running Produces Steady Mix.** Steady runs produce consistent mix. It is best to slowly ramp up to your running rate on startup and then try to stay at the rate rather than changing production rates up and down. If rate changes are required, small tph rate changes (incremental changes) are better than large increases and decreases for all the reasons stated above. The goal should be steady production rates "once you get into the run".

5. Control Mix Temperature +/- 10° …

- **Production Temperature is the First Step in Achieving Consistent Field Density.** Controlling mix temperature is the first step in achieving field density.
- **Mix Temperature Influences the Rolling Pattern.** Mix temperature on the road affects the ideal rolling pattern. Rolling patterns change for different mix temperatures.
- **Holding Mix Temperature Consistent Helps Achieve Consistent Density…** **t**herefore, holding mix temperature consistent at the plant and in the truck dramatically helps the paving operation control field density as this ensures that the rolling pattern they establish will not have to be changed and consistent field compaction will result.

6. Load in Multiple Drops …

- **"Socket Load" the Trucks (Front / Back / Middle).** It is universally recognized that loading trucks in multiple drops, and furthermore loading in the front, then in the back, and then finally in the middle is the best practice for loading square bodied dump trucks. The term "socket loading" explains this sequence, as the last load into the truck body gets deposited in the "socket" created from the first two drops.
- **Test Consistency & Mix Trends Frequently Improve with Properly Loaded Trucks (1/2" Greater Mixes Typically).** My own experience has shown in multiple states or provinces is that test result consistency improves on large stone mixes with this approach. If you are chasing bonus, strongly consider multiple-drop and a front / back / middle load out sequence as part of your best practice regimen.
- **"Chatter Loads" Should Not be Tested.** "Chatter loads" are loads that get "topped off" with small amounts at the end of the load sequence to maximize net tonnage in the truck. Because small quantities are "batched" onto the truck at the very end, this can affect the mix samples being taken from the truck if the technician does not dig down deeply into the mass of material in the truck. If you are sampling from the truck to test mix quality, strongly consider not "chatter feeding" the truck being sampled and just live with a smaller quantity of mix in the sampled load.

7. Make Calculated Mix Changes …

- **Wait and Look for a Trend.** It is best to wait for a trend in mix results before making a mix change at the plant.
- **Don't Make Mix Changes Based on One Test Result (except "test batches").** Making mix changes based on only one test result is a dangerous practice. The exception, of course, is when you are running test batches or trial batches and are trying to "dial in" a mix.

- **Wait for 2-3 Samples Before Making Changes & Change Only if Trending.** It is best to wait for a consistent mix trend before making a change to plant settings. Mixes that keep changing coarse to fine / fine to coarse typically indicate segregation in the mix process not a calibration "shift" and small changes to cold feed percentages will not "fix" the problem. "Trending" changes usually indicate you can "fix" the problem rapidly in the short term. You can explore the cause of the required change later, as it may apply to all mixes.