Percent Within Limits (PWL)

Industry Perspective

WHAT DOES PWL MEAN TO AN ASPHALT CONTRACTOR

- First of all, we must have a basic understanding of Statistics.
- As an asphalt Producer / Contractor, we must be able to accurately measure our variances.
- We must learn how to minimize the variability of our product both in production at the plant and during the paving operation of the roadway.

Basics of Production at the Asphalt Plant to effectively control variation

Step 1 Aggregates
- Good Quality Aggregates
- Consistency
- Stockpiling

Step 2 Calibration
- Cold Feed Bins
- Scales and Meters
- Asphalt Pumps

Step 3 Mix Design
- Methods
- Lab vs Plant

Step 4 Daily Testing
- Proper Sampling
- Proper Testing Procedures

Basics of Production on the Roadway to effectively control variation

Step 1 Silos / Haul Trucks
- Silo Operations / Segregation
- Loading Trucks Properly

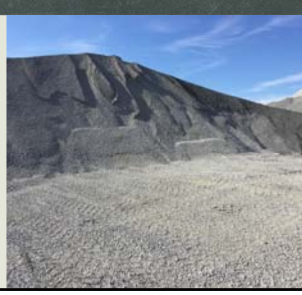
Step 2 Distance to Project
- Ambient Temperature
- Mix Temperature

Step 3 Laydown
- Dumping into paver
- Worn equipment

Step 4 Compaction
- Paving Plan
- Proper type and number of rollers
- Time available for compaction

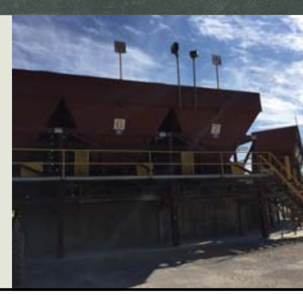
Step 1 - Aggregates

- We must have good quality materials
- We must stockpile properly
- Sampling must be representative of "what is actually inside the stockpile"
- Best to sample stockpile as it is being built



Step 2 - Calibration

- We must calibrate constantly
- Cold Feed Bins
- Belt Scales
- Asphalt Meters
- Batchers



Step 3 – Mix Design

- Aggregates
- Gradation
- Consensus Properties
- Statistics

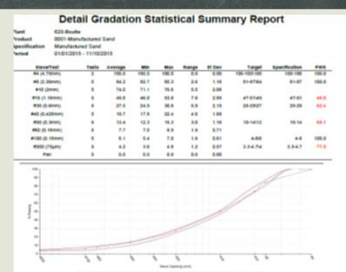
Step 4 – Daily Testing

- Proper Sampling of the Asphalt
- Always the same way
- Follow procedures
- QC Samples for control

Meeting PWL – Mix Design

Step 1 – Aggregate (From Stockpile to Lab)

- Aggregate test results must be "selected from the average" results for each material.
- Use the average of at least 5 gradations to determine the value to use.



Step 1 – Aggregate Preparation for Lab Design

- We sieve our aggregates in the lab to each size fraction all the way down to the # 8 Sieve.
- We combine all the minus # 8 material as on size fraction for each material
- We proportion our mixes by each size fraction proportionately

Use of Bailey Method

Aggregate Proportioning

- We utilize the Bailey Method to proportion our mixes. This way, we can optimize the combined aggregate gradation to achieve the proper aggregate packing for volumetrics and AC Content.
- This is only a "TOOL" for help determine the aggregate proportions.

Benefits from Bailey Method

- Optimize aggregate packing to get the most out of the volumetrics.
- Prediction models to help with design, once one blend is completed. Saves Trials in Lab.
- Cost Effective
- We see increased field compaction on mixes designed using the Bailey Method.
- We see less movement of the mix under the rollers on the roadway.

Problems with Lab Mixes vs Plant Mixes

- The primary cause for the problems with lab designs matching plant mix is the “aggregate breakdown” through the plant.
- Coarser Aggregates have the “edges” knocked off in the drum causing degradation and the aggregate to have “rounded” shapes as compared to lab design.
- Additional fines are created during the drying and mixing process.
- Fines are usually returned to the mix at most plants
- All this results in Volumetrics changing, usually lower VMA and lower Voids.

How to fix this problem (Lab Mix vs Plant Mix)

- YOU MUST make the laboratory design match the Plant Run Tests. This cannot work in reverse.
- Plant gradations are “Finer” than Lab Gradations causing the difference.
- Use of “Bag House Fines” can offset this effect.
- Obtain samples of Bag House Fines (BHF)from the plant during production.
- Simply add some into the lab designs by making it a separate material. Usually 0.5% to 2.0% will do it.
- VMA is the best indicator on volumetrics of Lab vs Plant
- Adjust the amount of BHF depending on the Lab VMA vs Plant VMA for a given mixture. Also monitor the # 200 sieve in lab vs plant.

A look at our Lab vs Plant VMA for some of our designs

Mix Number	Mix Type	Nominal Size	Specification Minimum	Lab VMA	Plant VMA	Difference
M113	1 - Binder	1"	11	12.1	12.2	0.1
M146	2 - Binder	1"	11	11.5	11.7	0.2
M114	1 - Binder	3/4"	12	12.6	12.7	0.1
MM140	2 - Binder	3/4"	12	12.5	12.5	0
M145	2 - Binder	3/4"	12	12.4	12.3	-0.1
M122	1F - Wearing	1/2"	13	13.3	13.3	0
M125	1 - Wearing	1/2"	13	13.1	13.4	0.3
MM128	1 - Wearing	1/2"	13	13.3	13.9	0.6
MM129	1F - Wearing	1/2"	13	13.2	13.1	-0.1
MM150	2F - Wearing	1/2"	13	13.5	13.7	0.2
M157	2F - Wearing	1/2"	13	13	13.1	0.1
M160	2 - Wearing	1/2"	13	13.3	13.8	0.5
M180	SMA Wearing	1/2"	13	17.4	17.3	-0.1
				Average Difference:		0.1

A look at our Gradations - # 200 Sieve – Lab vs Plant

Lab 200 vs Plant 200

Mix Number	Mix Type	Nominal Size	Specification	Composite Gradation	Lab 200	Plant 200
M113	1 - Binder	1"	2.0 - 7.0	5.0	5.0	5.5
M146	2 - Binder	1"	2.0 - 7.0	5.0	5.0	5.5
M114	1 - Binder	3/4"	3.0 - 8.0	5.6	6.0	6.2
MM140	2 - Binder	3/4"	3.0 - 8.0	4.9	5.0	5.5
M145	2 - Binder	3/4"	3.0 - 8.0	5.4	6.0	6.0
M122	1F - Wearing	1/2"	4.0 - 10.0	6.2	6.7	6.2
M125	1 - Wearing	1/2"	4.0 - 10.0	6.4	6.7	6.2
MM128	1 - Wearing	1/2"	4.0 - 10.0	5.5	6.5	6.1
MM129	1F - Wearing	1/2"	4.0 - 10.0	5.8	6.3	6.4
MM150	2F - Wearing	1/2"	4.0 - 10.0	5.2	5.4	6.1
M157*	2F - Wearing	1/2"	4.0 - 10.0	4.8	6.4	5.8
M160	2 - Wearing	1/2"	4.0 - 10.0	6.2	6.6	6.9
M180	SMA Wearing	1/2"	4.0 - 10.0	7.5	7.4	7.7
		Averages:		**5.7**	**6.1**	**6.2**

*Does not include Bag House Fines in the design

Standard Deviation

- Standard Deviation – A measure of variance among values.
- Standard Deviation must be considered on Critical items such as VMA, Air Voids, and Roadway Compaction.
- Normally, designers must allow for the standard deviation times 1.2 as a minimum above the specification minimum.
- Example: VMA – Normal Standard Deviation of 0.4%, then:
  - 0.4 times 1.2 = 0.5%
  - Minimum VMA = 13.0%
  - New Minimum design value for VMA is 13.5% to all for variance.
  - Any Trial design lower than this value will not meet PWL consistently.

Design Guidelines for PWL

- The design technician must know all the design parameters. This is a critical Step for success of the job.
- We must consider past history for lab vs plant values.
- Volumetrics can change depending on design method, design technician and plant factors.
- The design technician must know the variability of all materials and test procedures.
- **VARIABILITY must be “Built into the Design”**

Standard Deviation

- From above, the designer has already allowed for Normal Variation of Daily tests.
- Now, the designer must also compensate for the variation of “LAB vs PLANT” results.
- Now the minimum “Design” Value is at 14.3%
- Using the same parameter – VMA
  - Lab VMA vs Plant VMA = 0.8%
  - Now, Add the 0.8% to the 13.5% = 14.3%
  - Now the minimum “Design” Value is at 14.3%
  - This means the laboratory design must yield a minimum of 14.3%, so that when run through the plant and tested, it will fully meet all PWL requirements.

Roadway Compaction and PWL

- Same theory applies
- The Field Quality Control Technician must know the normal standard deviation of their compaction process from past history.
- Normally, we use a standard deviation of 1.0% as a measure of consistency.
- Same theory applies – Ex. – Minimum 92% Required
- Take 1.0% times 1.2 = 1.2%
- Now add this to the Minimum – 92.0% + 1.2% = 93.2%
- This means that the new minimum target density is 93.2%.

Roadway Compaction – Quality Control

- The Field Technician will also correlate the Nuclear Gauge or Non-Nuclear Gauge to the actual core density.
- Then apply that difference to the compaction process.
- Key thing here is that we allow for these differences during the compaction process, while it can still be changed.

PWL is now “EASY”

- The PWL Specification actually scares a lot of people. However, with a good understanding of how it works, designing the mix properly, Consistency, and allowing for variation into compaction, it is not that difficult of a task.
- With all the statistical calculations, production actually means – “BACK TO THE BASICS”.
- If we pick up the “Best Practices” books from 30 – 40 years ago, you would notice all the simple steps to “GOOD QUALITY CONSTRUCTION” that most of us in the industry have overlooked.
- To Meet PWL Specifications, going back to these basics are essential.

Back to the Basics

- One of the Most important part of a successful job is the Paving Plan.
- The plan shall be laid out for each day’s paving. The Plan shall include the following:
  - The area to be paved - Thickness of the mat
  - Mix Type - Plant Location
  - Trucking - Distance of the haul
  - Equipment needed - Tons per hour
  - Paver Speed - Roller efficiency
  - Compaction Plan - Weather
  - **The Plan will also tell managers of the day is going to be successful before paving starts.**

Back to the Basics - Communication

- Begins with the paving plan – after the project management has established the paving plan, the plan must be communicated to all involved.
- Communication is a key to success.
- The success of a job with PWL Specifications is dependent on a smooth flow of operations.
- Interrupted flow at jobsite causes interruptions at the plant, which causes inconsistent flow through the plant.
- The Plant starts and stops must be planned as carefully as possible.

Back to the Basics – Everyone Knows Their Job

- Everyone on the paving crew, plant operation and management know their role in the job.
- In order for smooth operations, the delays must be kept to a minimum.
- Make sure all equipment is operating properly at the plant and roadway prior to "Firing up" the plant.
- Follow the predetermined paving plan.
- Have a plan of action in the event of equipment breakdown.

Back to the Basics – Constant Communication between the Plant, Roadway and Management.

- Constant communication here is critical.
- All parties must know where the other stands at all times.
- The **PAVER SPEED** dictates the **FLOW OF OPERATIONS** on any paving job.
- Paving speed is set, then tons per hour calculated, haul trucks ordered, number of rollers determined, etc. Not the other way around.
- Keep the paver moving at a constant rate as dictated by the paving plan.
- DO NOT speed up the paver to "empty the line of trucks".
- Loading trucks at the plant shall be on an incremental basis to not cause "Stacking of the trucks" on the job.
- The plant and roadway must communicate this important link constantly during paving operations.

Back to the Basics – Plant Materials

- Consistent materials at the plant are crucial. Know your aggregate sources and their variations by constantly testing.
- Keep moisture contents as consistent as possible. Have the loader hit the stockpiles properly.
- Consistent moisture contents results in consistent air flow through the plant and consistent temperatures of the mix.
- Inconsistent air flow can also cause the bag house fines to be returned to the plant at an inconsistent rate, which affects the minus 200 in the mix.
- This is one of the most critical factors in determining VMA and Air Voids at the plant and on the roadway.

Back to the Basics – Sampling and Testing

- A sampling and Testing Plan is always a good idea.
- Have the Sampling Plan prepared based on the Paving Plan. Know the frequency of testing that is required.
- Lay out the whole day's sampling prior to starting work.
- Sampling the mix from the trucks must be done in the same way every time.
- Reducing the sample size is another critical area. Make sure the sample is reduced properly and is representative of the entire truck.
- Poor Sampling and testing techniques can cause a pay cut even when the mix is of good quality.

Conclusion

PWL not that Difficult, after all.

Now the next challenge ??