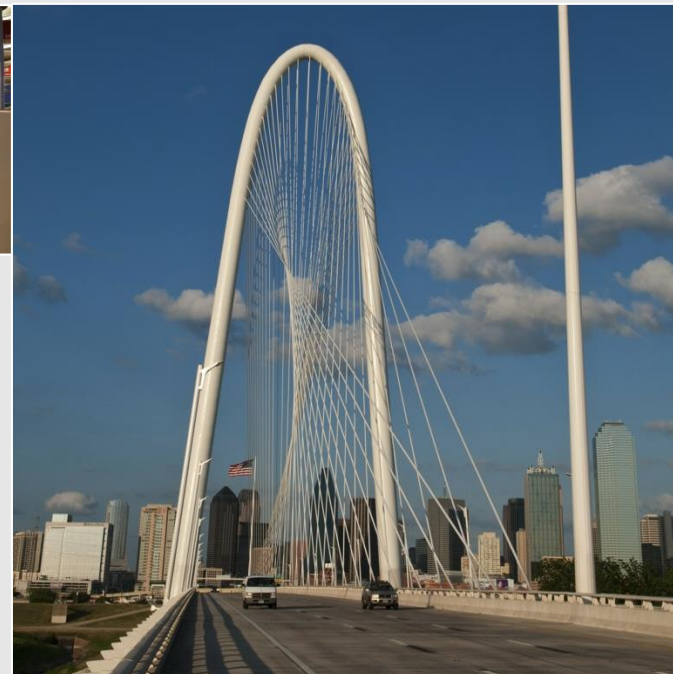




TEXAS DEPARTMENT OF TRANSPORTATION



Power 45 Curve

Travis Patton, P.E.

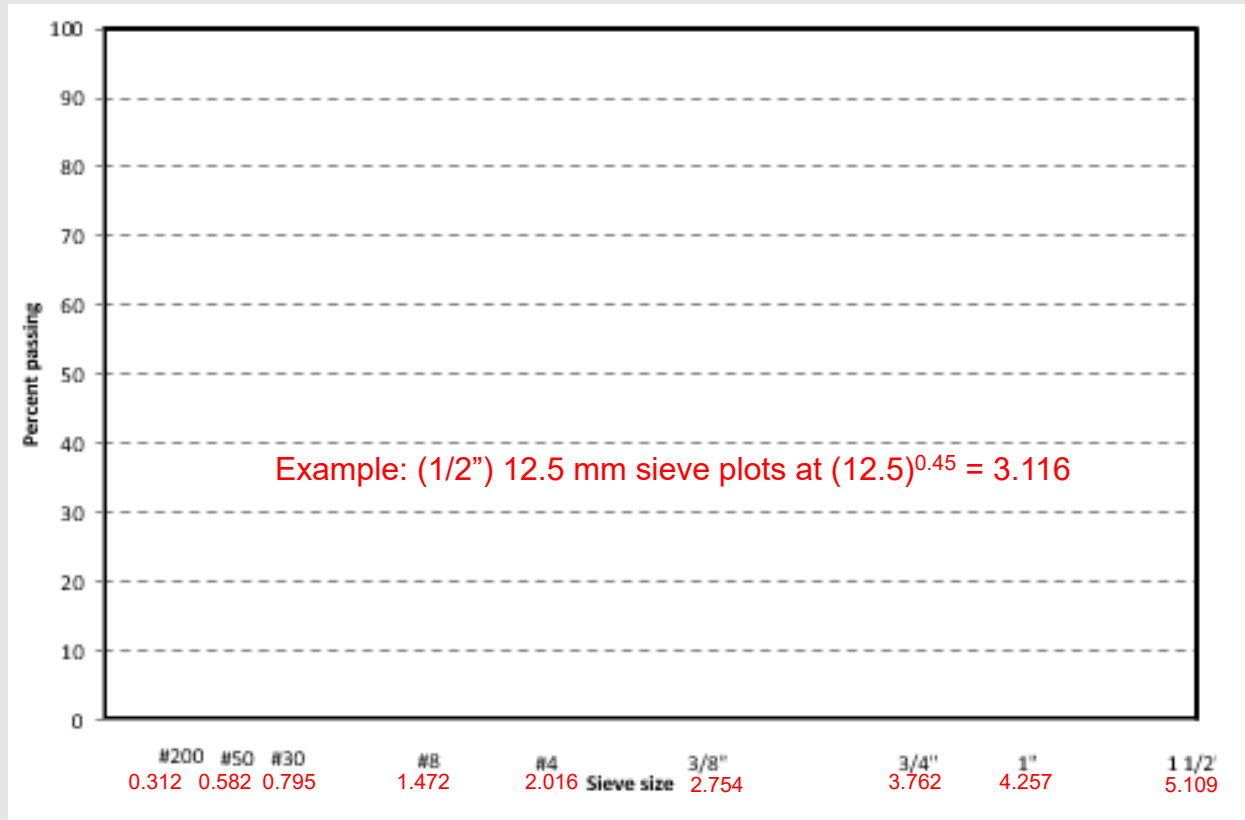
Texas Department of Transportation

Table of Contents

1	Power 45 Basics	3
2	Maximum Density Line	7
3	Lab Design vs. Plant Production	10
4	Item 344 vs SS3077	16
5	Tx2MixSolver Template	20
6	Questions	26

Power 45 Basics

Power 45 Basics



- Sieve Size, mm, Raised to 0.45 Power – allows straight max density line
- Sieve labels with actual sieve size added for clarity

Gradation Limits

Superpave D Specification Limits

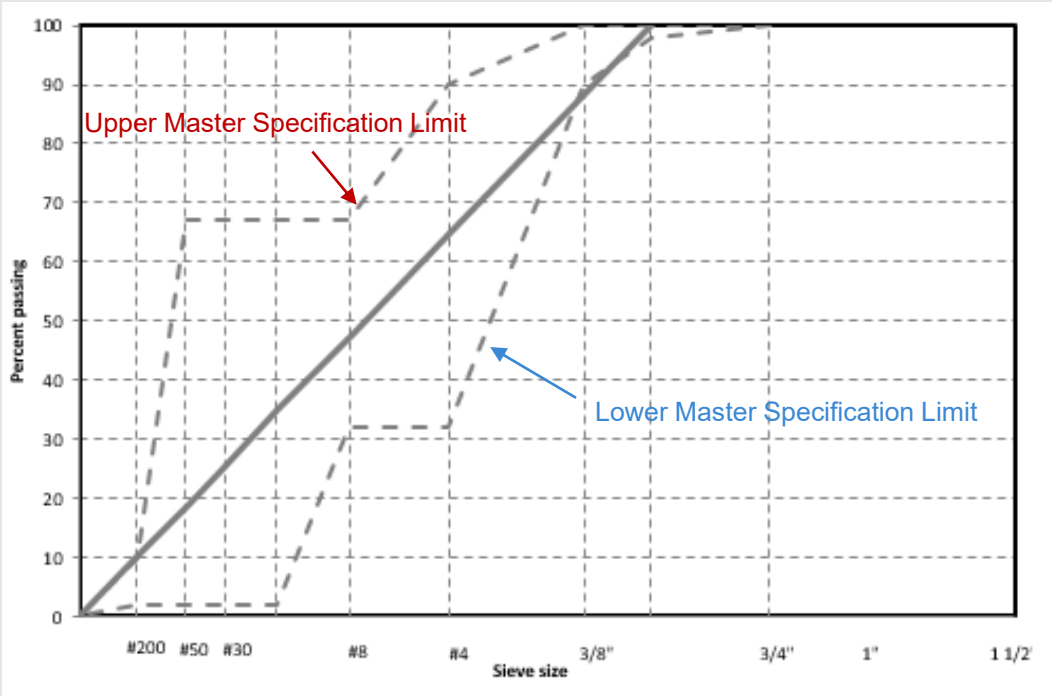


Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	SP-B Intermediate	SP-C Surface	SP-D Fine Mixture
2"	–	–	–
1-1/2"	100.0 ¹	–	–
1"	98.0–100.0	100.0 ¹	–
3/4"	90.0–100.0	98.0–100.0	100.0 ¹
1/2"	Note ²	90.0–100.0	98.0–100.0
3/8"	–	Note ²	90.0–100.0
#4	23.0–90.0	28.0–90.0	32.0–90.0
#8	23.0–34.6	28.0–37.0	32.0–40.0
#16	2.0–28.3	2.0–31.6	2.0–37.6
#30	2.0–20.7	2.0–23.1	2.0–27.5
#50	2.0–13.7	2.0–15.5	2.0–18.7
#200	2.0–8.0	2.0–10.0	2.0–10.0
Design VMA, % Minimum			
–	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum			
–	13.5	14.5	15.5

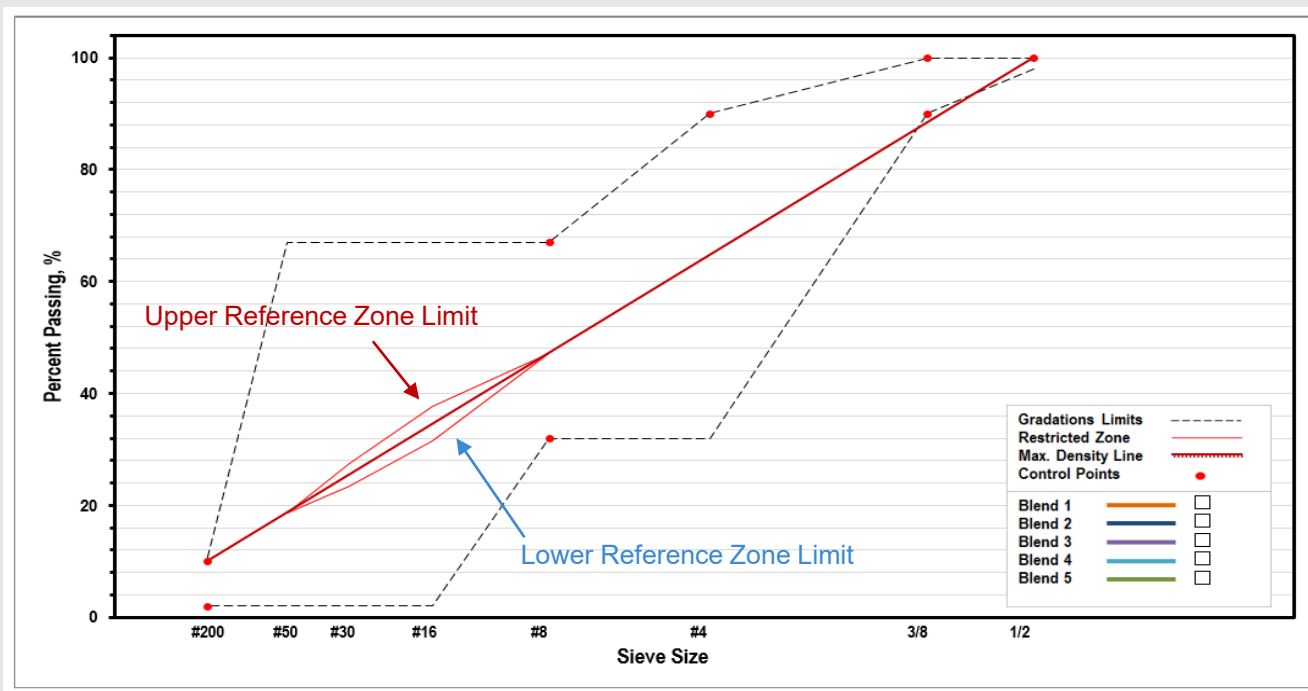
1. Defined as maximum sieve size. No tolerance allowed.
2. Must retain at least 10% cumulative.

Reference Zone

- Formerly known as the “Restricted Zone”
- Max density line passes through middle of reference zone
- Generally recommended that you don't design through
 - May indicate over sanded mixture
 - May indicate too much fine sand in relation to total sand
 - May close mixture and lower VMA
 - May result in “tender” mixtures and low asphalt content

Table 9
Reference Zones (% Passing by Weight or Volume)

Sieve Size	SP-B Intermediate	SP-C Surface	SP-D Fine Mixture	
2"	-	-	-	-
1-1/2"	-	-	-	-
1"	-	-	-	-
3/4"	-	-	-	-
1/2"	-	-	-	-
3/8"	-	-	-	-
#4	-	-	-	-
#8	34.6-34.6	39.1-39.1	47.2	47.2
#16	22.3-28.3	25.6-31.6	31.6	37.6
#30	16.7-20.7	19.1-23.1	23.5	27.5
#50	13.7-13.7	15.5-15.5	18.7	18.7
#200	-	-	-	-



Maximum Density Line

Maximum Density Line

- Nominal maximum aggregate size - one sieve size larger than the first sieve that retains more than 10% of the total aggregate.
- Maximum aggregate size - one sieve size larger than the nominal maximum aggregate size.

Superpave D Max Density Line

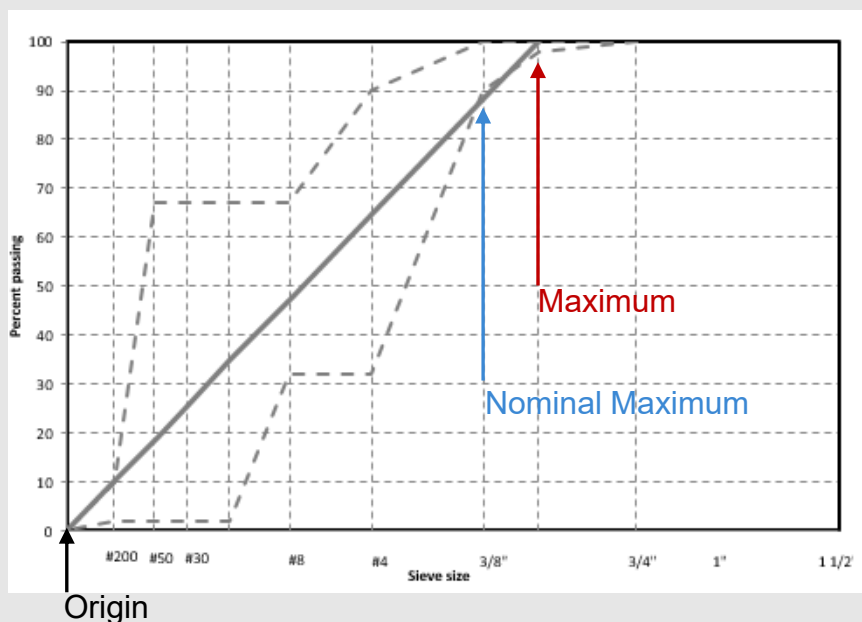


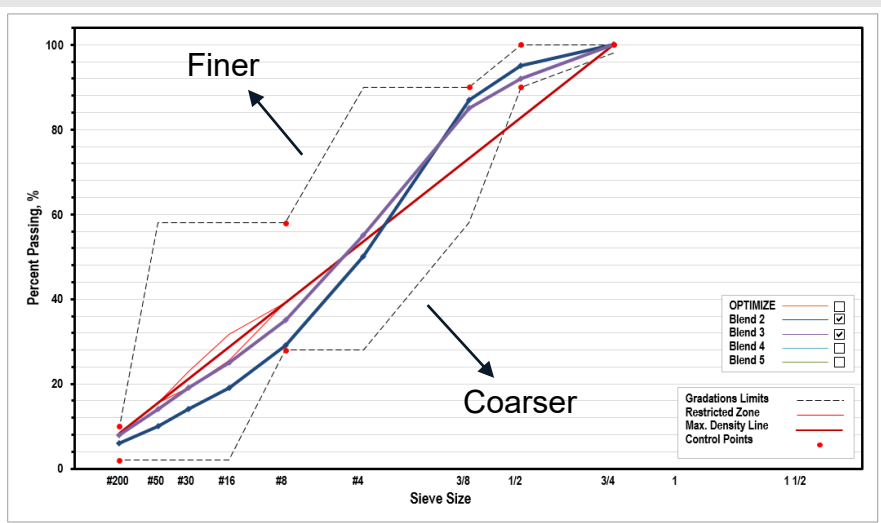
Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

Sieve Size	SP-B Intermediate	SP-C Surface	SP-D Fine Mixture
2"	–	–	–
1-1/2"	100.0 ¹	–	–
1"	98.0–100.0	100.0 ¹	–
3/4"	90.0–100.0	98.0–100.0	100.0 ¹
1/2"	Note ²	90.0–100.0	98.0–100.0
3/8"	–	Note ²	90.0–100.0
#4	23.0–90.0	28.0–90.0	32.0–90.0
#8	23.0–34.6	28.0–37.0	32.0–40.0
#16	2.0–28.3	2.0–31.6	2.0–37.6
#30	2.0–20.7	2.0–23.1	2.0–27.5
#50	2.0–13.7	2.0–15.5	2.0–18.7
#200	2.0–8.0	2.0–10.0	2.0–10.0
Design VMA, % Minimum			
–	14.0	15.0	16.0
Production (Plant-Produced) VMA, % Minimum			
–	13.5	14.5	15.5

- Defined as maximum sieve size. No tolerance allowed.
- Must retain at least 10% cumulative.

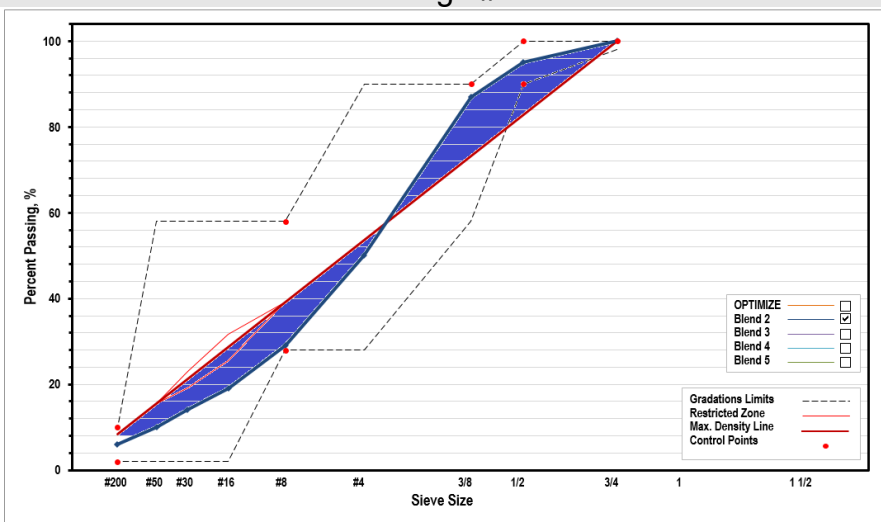
- Maximum density line plots a straight line from the maximum aggregate size to the origin (0,0).

Maximum Density Line

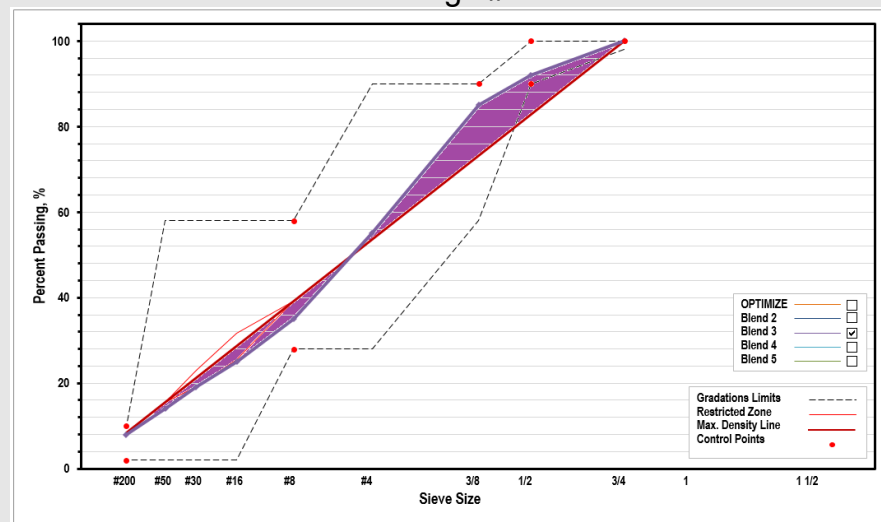


- More linear gradations (closer to max density line) = less VMA and therefore less optimum asphalt content at target density
- Design #1 has more void space built into gradation than Design #2
 - At the same AV%, this will result in more room for AC%
 - Design #1 VMA > Design #2 VMA
 - Design #1 OAC > Design #2 OAC

Design #1

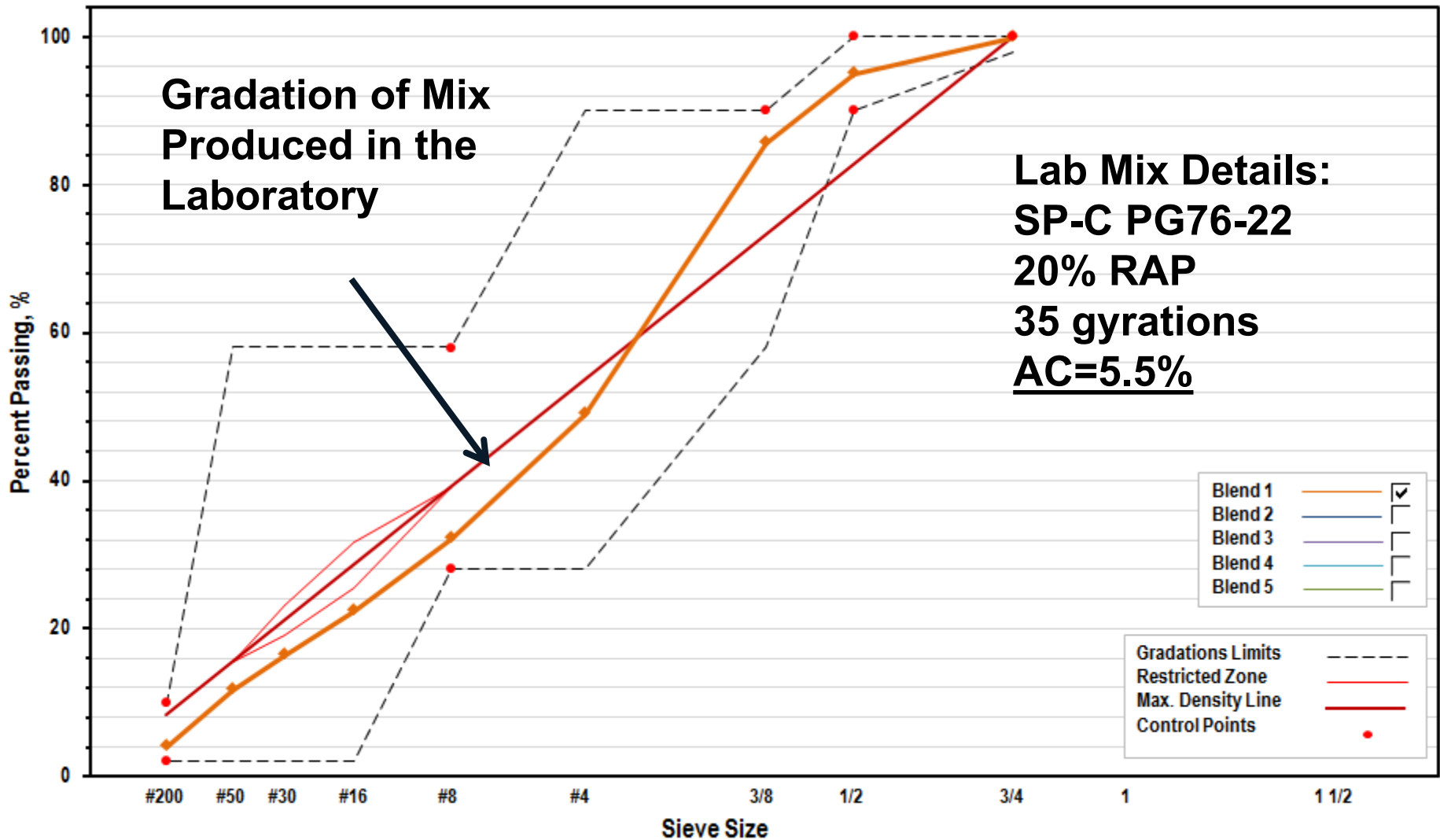


Design #2

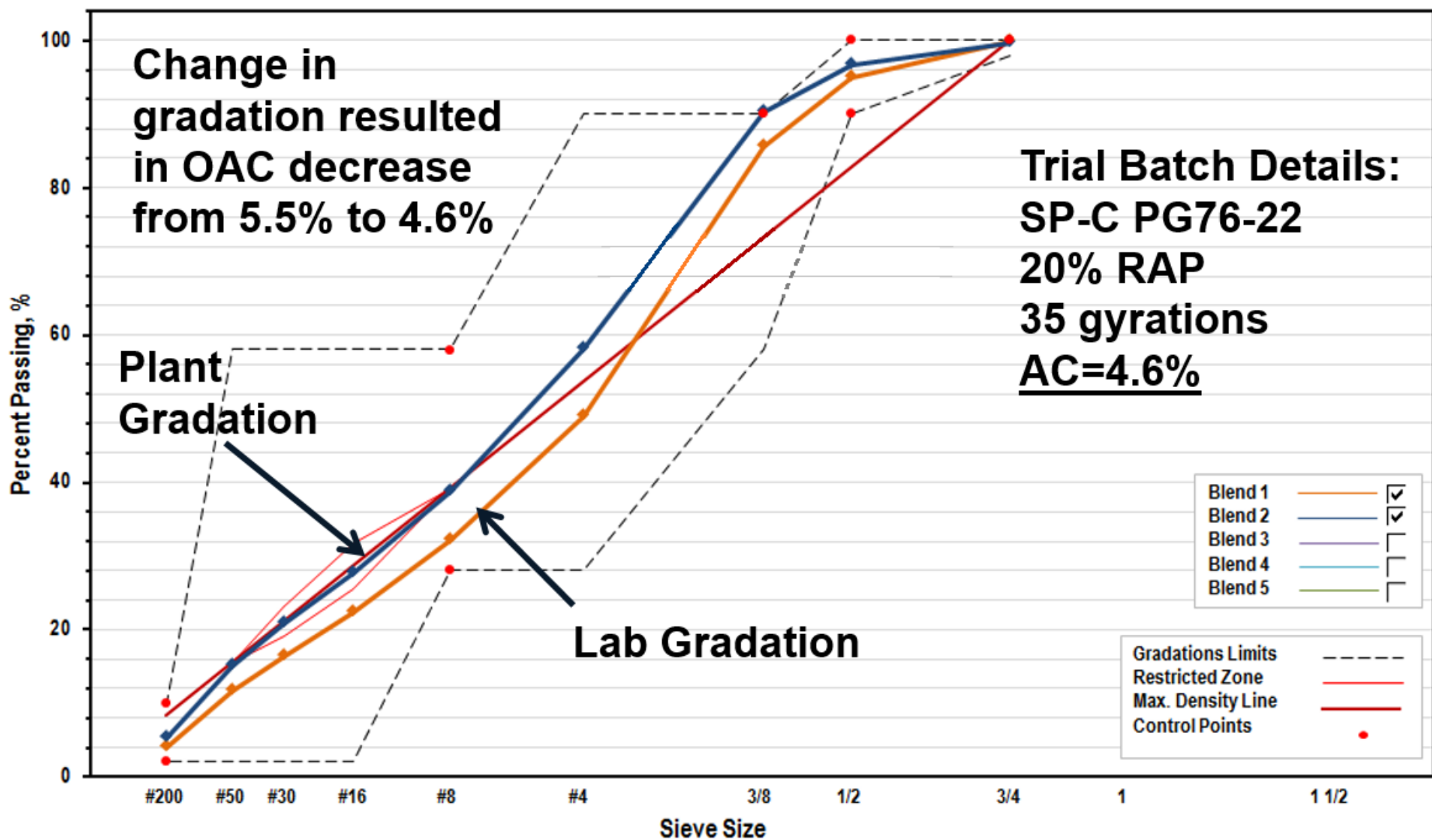


Lab Design vs. Plant Production

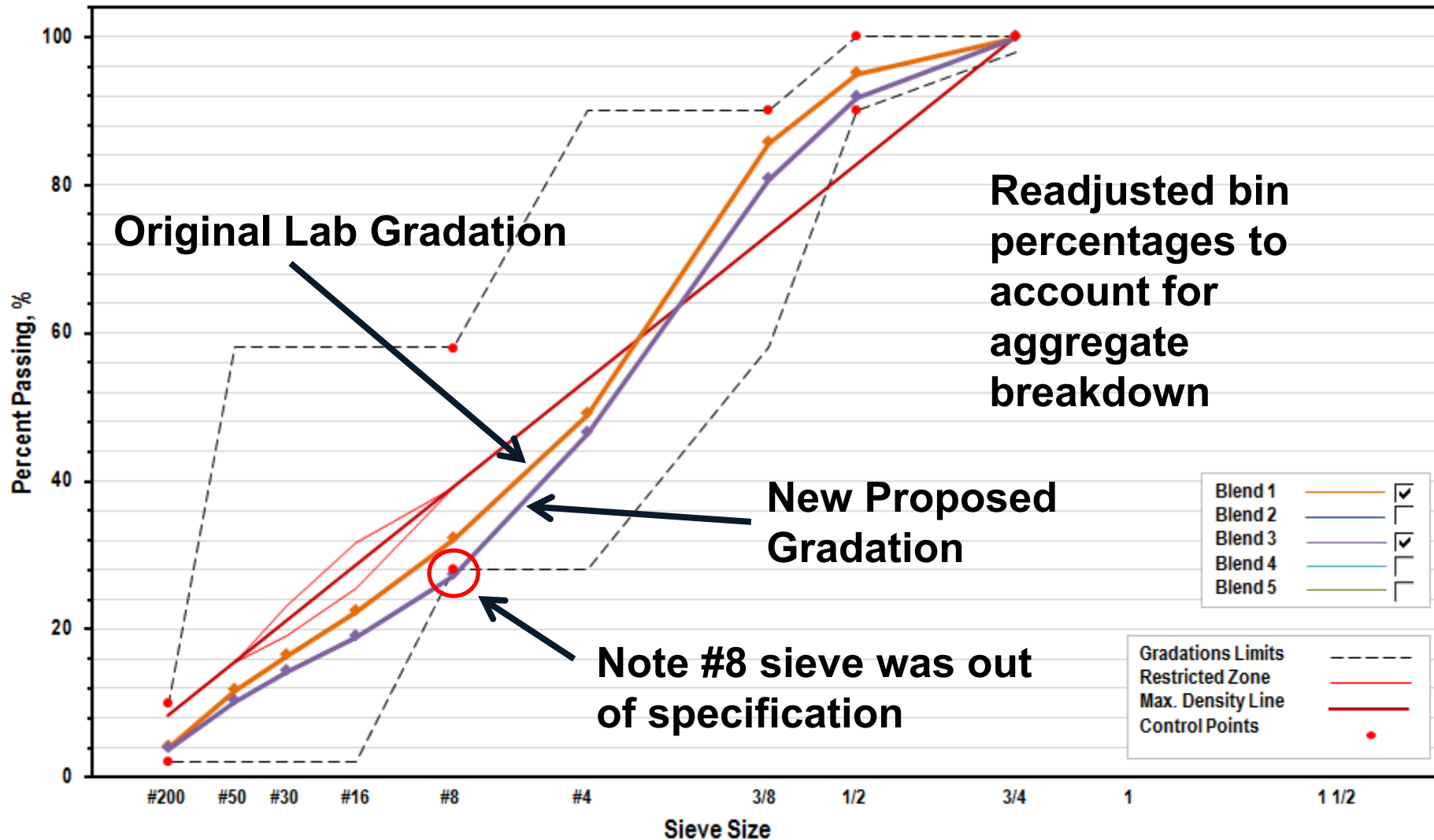
Gradations Fining Up During Production Example



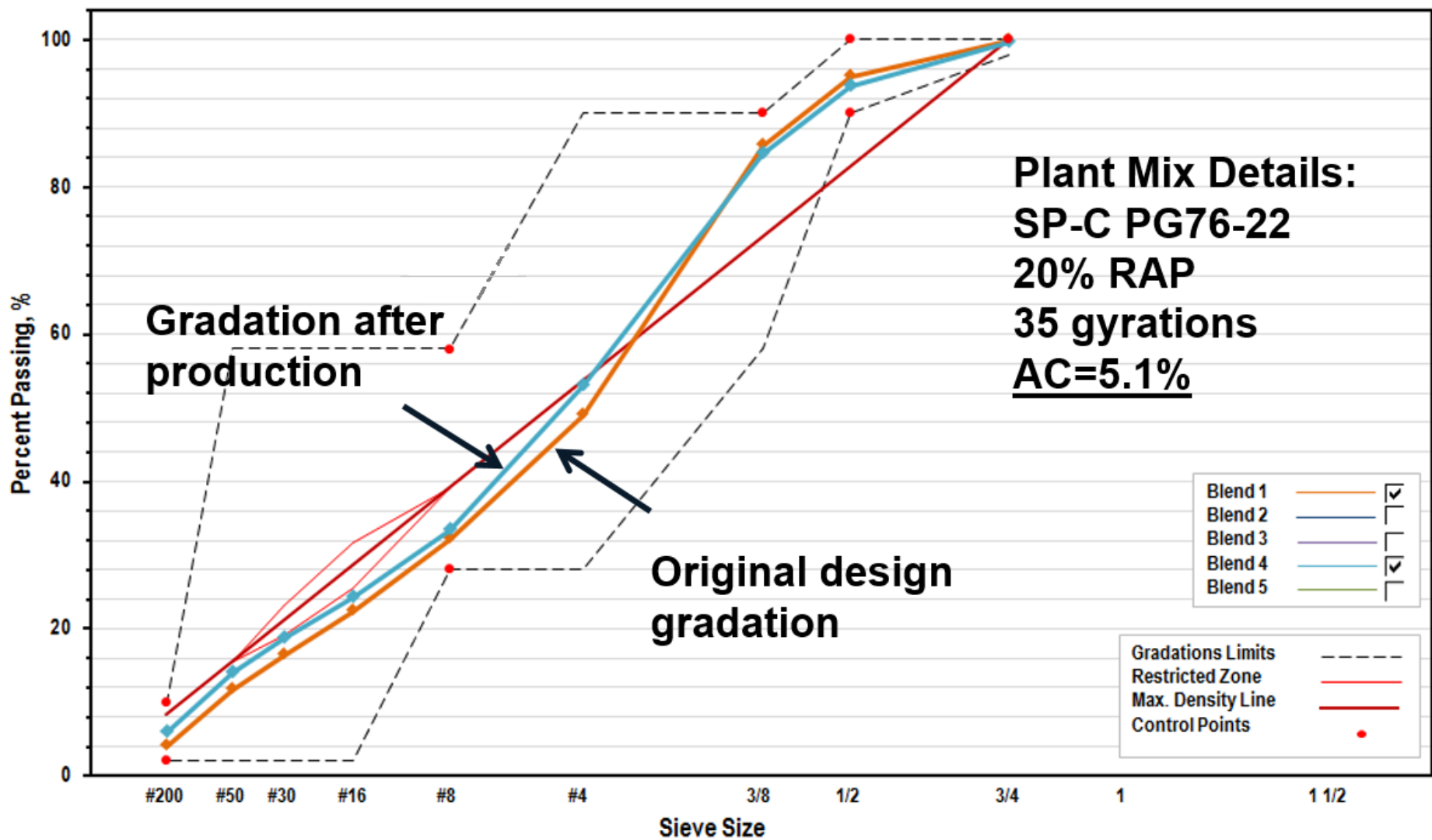
Gradations Fining Up During Production Example



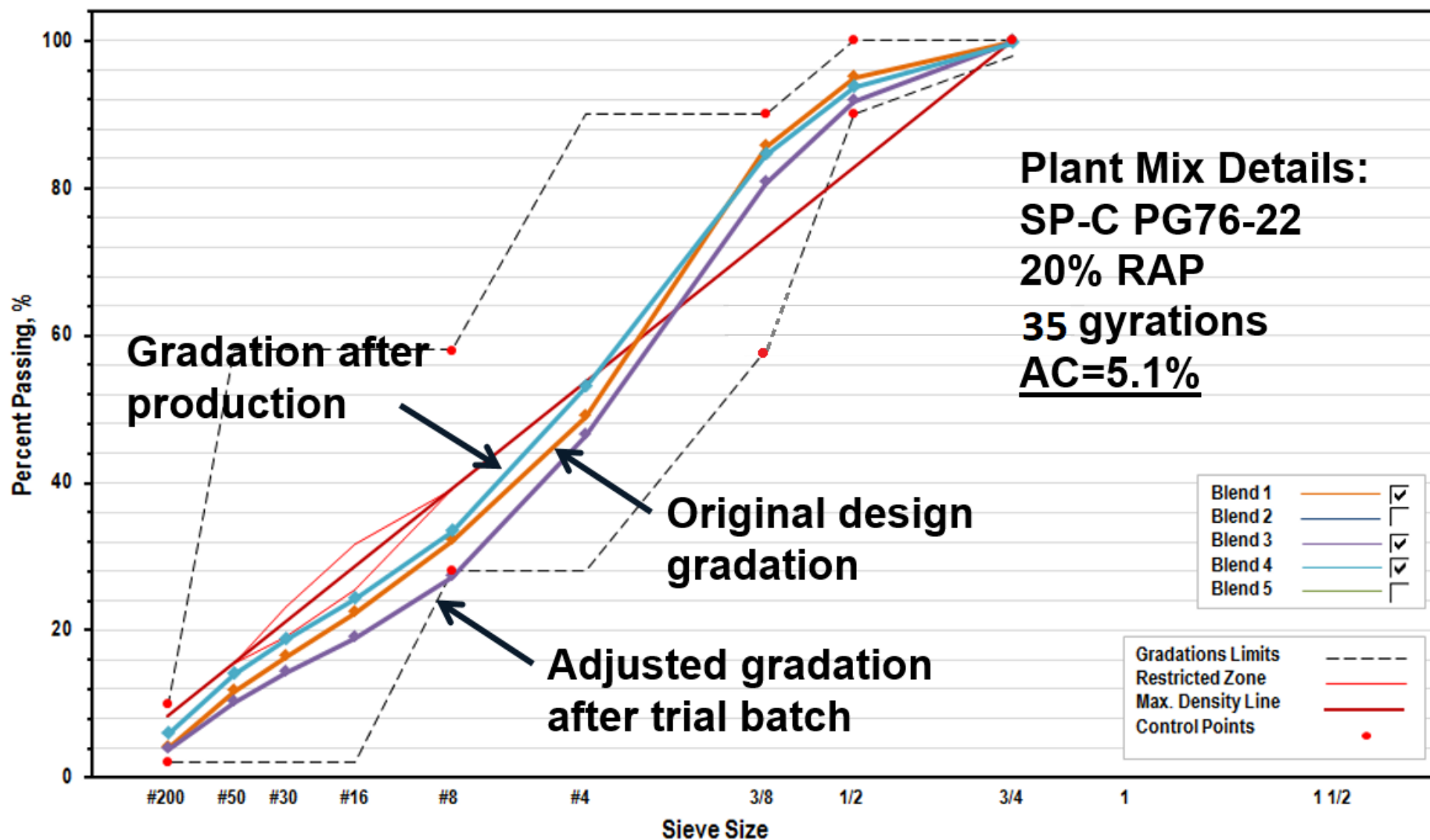
Gradations Fining Up During Production Example



Gradations Fining Up During Production Example



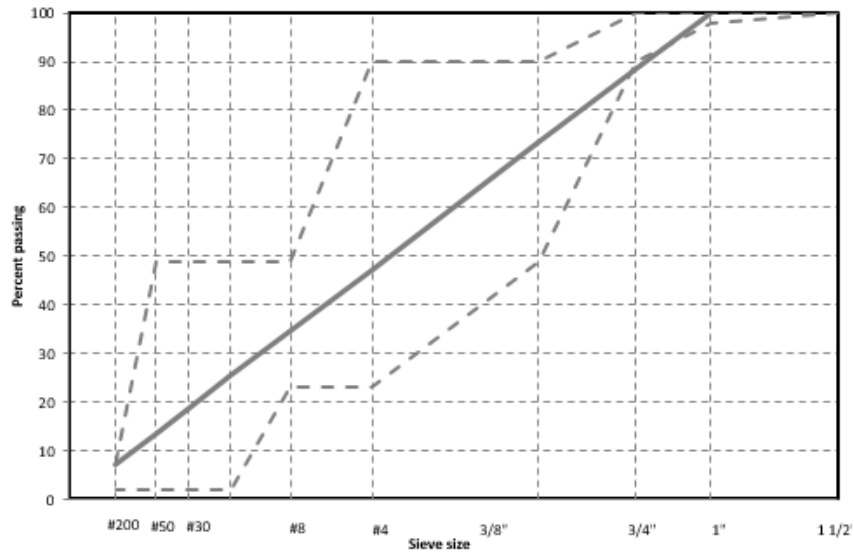
Gradations Fining Up During Production Example



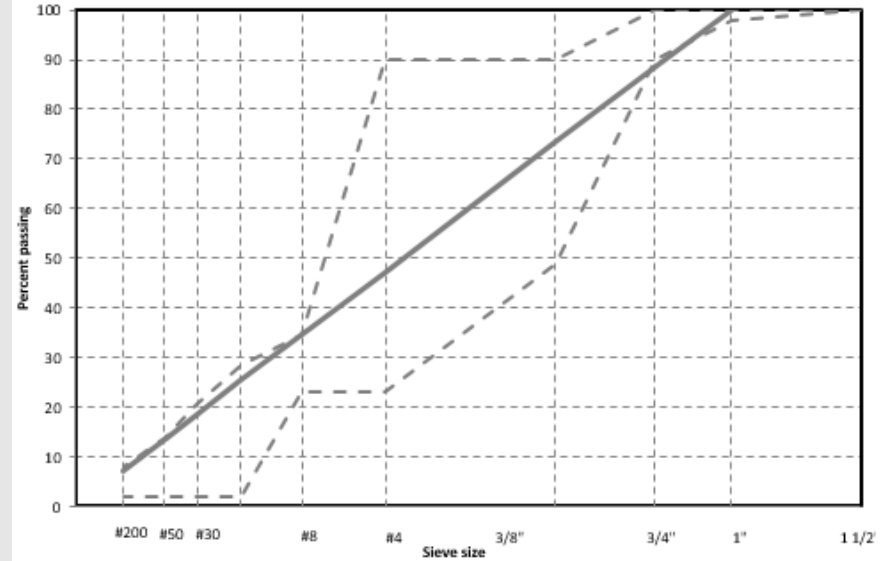
Item 344 vs SS3077

Gradation Limits – Superpave B

Item 344

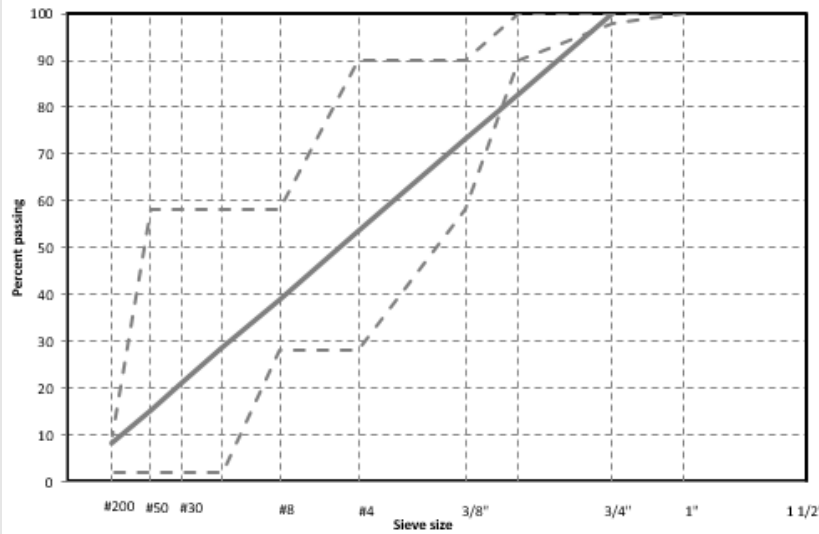


SS3077

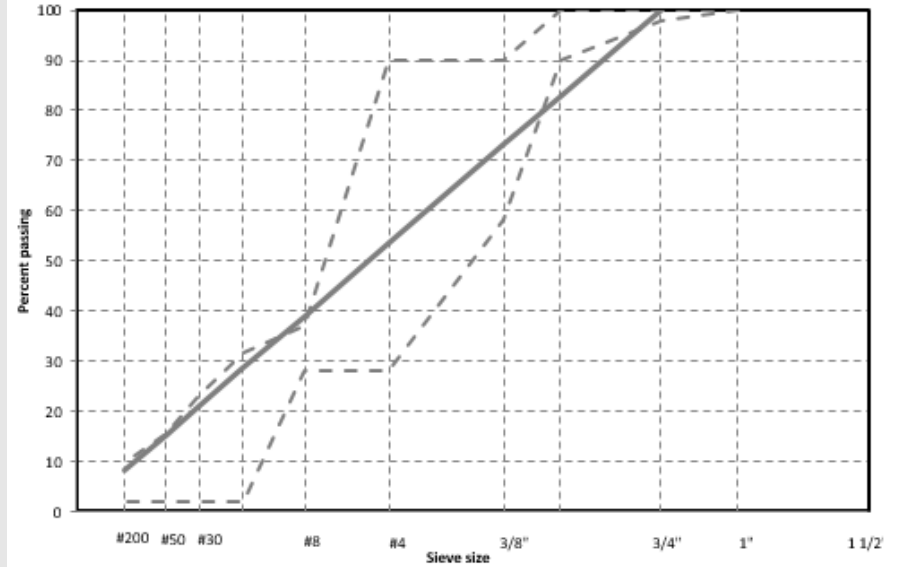


Gradation Limits – Superpave C

Item 344

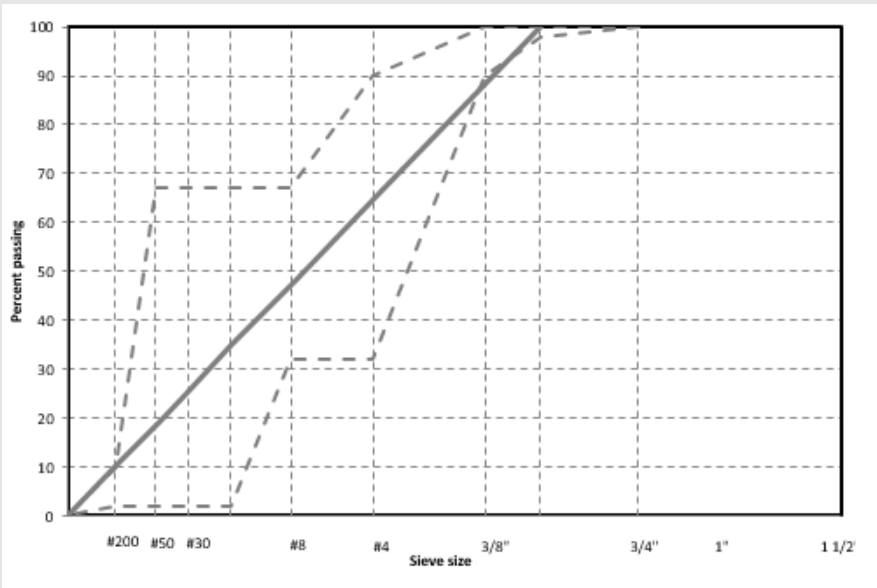


SS3077

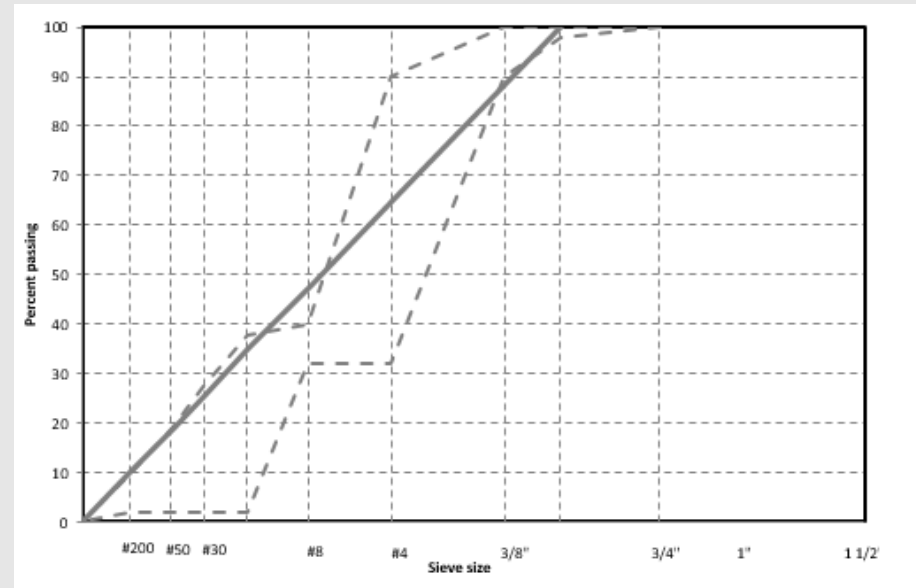


Gradation Limits – Superpave D

Item 344



SS3077



Tx2MixSolver Template

What and Where?

What is it and how does it work?

- Macro enable solver
- Follow the instructions on the *information* tab to add the solver function to your Excel
- Input your mix type and stockpile gradations into the sheet
- It is not set up to optimize lime, recycle, or SAC A
 - You will need to input your lime and recycle bin percentage
- Hit the “OPTIMIZE GRADATION” button
- Use this as a tool to help start a new Superpave design

Step 1: Mix Type:

STOCKPILE GRADATIONS								
Sieve Size	Bin No. 1	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	Bin No. 6	Bin No. 7	Bin No. 8
	Please type-in the aggregate type ↓							
	C-Rock	Grade 5	Man Sand	Field Sand		LIME	RAP	RAS
Class (A) Rock (Y/N)	YES							
1 in	100.0	100.0	100.0	100.0			100.0	
3/4 in	97.1	100.0	100.0	100.0			100.0	
1/2 in	60.4	100.0	100.0	100.0			98.2	
3/8 in	26.5	99.8	100.0	100.0			92.2	
#4	2.6	23.9	96.5	100.0			67.5	
#8	1.8	2.1	62.8	100.0			47.5	
#16	1.7	1.4	36.7	99.7			37.1	
#30	1.6	1.4	22.4	98.1			28.2	
#50	1.6	1.3	15.1	66.4			19.7	
#200	1.1	1.1	9.0	3.1			6.1	

What and Where?

Step 2:

	Aggregate Type	OPTIMIZE Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
Bin No. 1	C-Rock					
Bin No. 2	Grade 5					
Bin No. 3	Man Sand					
Bin No. 4	Field Sand					
Bin No. 5						
Bin No. 6	LIME					
Bin No. 7	RAP	20.0%				
Bin No. 8	RAS					
		20.0%				

If you want to use Lime, RAP, or RAS, it will need to be populated here. The template will not optimize these values. The template will not optimize SAC A either, however, it will calculate the total SAC A.

Step 3:

**OPTIMIZE
GRADATION**

Step 4:

Solver will display a message:

- Found a solution
- Could not find a solution

Either way, hit “OK” to view the proposed gradation.

What and Where?

Output Data

	Aggregate Type	OPTIMIZE Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
Bin No. 1	C-Rock	20.4%				
Bin No. 2	Grade 5	26.9%				
Bin No. 3	Man Sand	31.8%				
Bin No. 4	Field Sand	0.9%				
Bin No. 5		0.0%				
Bin No. 6	LIME					
Bin No. 7	RAP	20.0%				
Bin No. 8	RAS					
		100.0%				

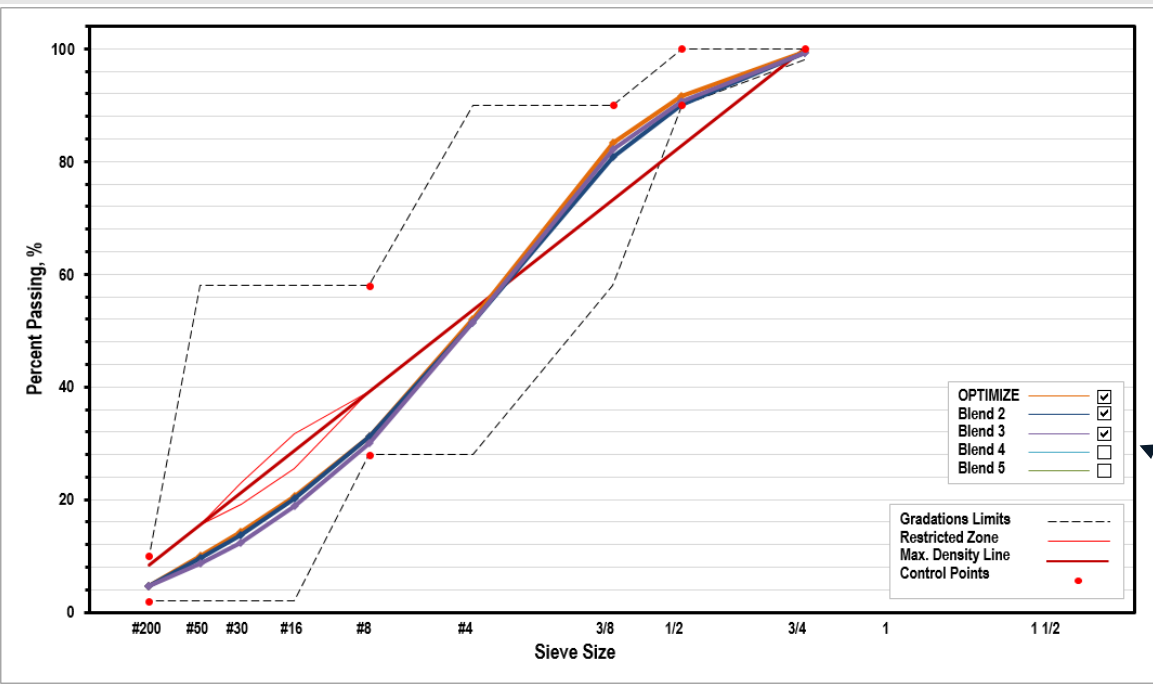
Class A, %
41.4

Sieve Size	Master Gradations				
	OPTIMIZE Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
1 in	100.0 ✓				
3/4 in	99.4 ✓				
1/2 in	91.6 ✓				
3/8 in	83.4 ✓				
#4	52.0 ✓				
#8	31.3 ✓				
#16	20.7 ✓				
#30	14.3 ✓				
#50	10.0 ✓				
#200	4.6 ✓				

Comments:

- You may see red “x” on the table. This is typically due to rounding of the program.
- “Blends 2-5” do not optimize. Use to make modifications.
- Note some recommendations may not be practical (i.e. field sand at 0.9%)
- Keep in mind, during production, some bins may need to be split into 2 bins for better control.

What and Where?



Sieve Size	Master Gradations				
	OPTIMIZE Blend 1	Blend 2	Blend 3	Blend 4	Blend 5
1 in	100.0 ✓	100.0 ✓	100.0 ✓		
3/4 in	99.4 ✓	99.3 ✓	99.3 ✓		
1/2 in	91.6 ✓	90.1 ✓	90.7 ✓		
3/8 in	83.4 ✓	80.8 ✓	82.2 ✓		
#4	52.0 ✓	51.5 ✓	51.4 ✓		
#8	31.3 ✓	31.1 ✓	30.1 ✓		
#16	20.7 ✓	20.3 ✓	18.8 ✓		
#30	14.3 ✓	13.7 ✓	12.4 ✓		
#50	10.0 ✓	9.6 ✓	8.6 ✓		
#200	4.6 ✓	4.7 ✓	4.7 ✓		

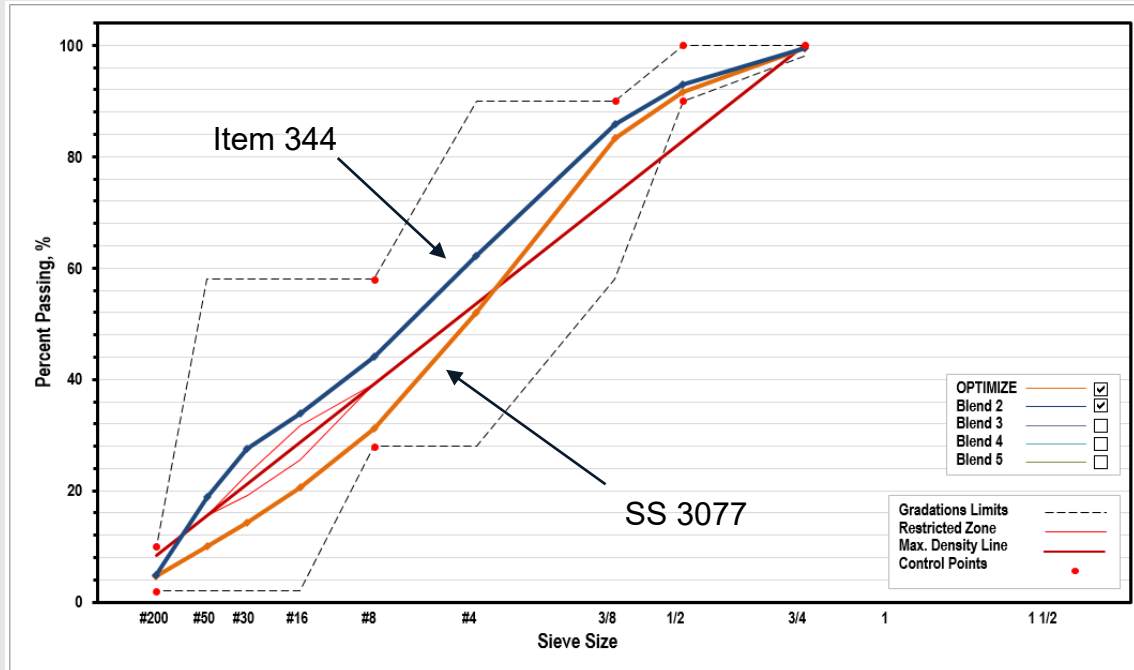
Use the toggle feature to display different gradations

The Tx2MixSolver template can be found on the TxDOT website at:
<https://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/materials.html>

Example

Item 344 Gradation

Aggregate Type	Blend 2
C-Rock	17.0%
Grade 5	18.0%
Man Sand	30.0%
Field Sand	15.0%
LIME	
RAP	20.0%
RAS	
100.0%	



Sieve Size	Blend 2	
	Percent Passing	Check
1 in	100.0	✓
3/4 in	99.5	✓
1/2 in	92.9	✓
3/8 in	85.9	✓
#4	62.2	✓
#8	44.0	✓
#16	33.9	✓
#30	27.6	✓
#50	18.9	✓
#200	4.8	✓

SS3077 Gradation

Aggregate Type	OPTIMIZE Blend 1
C-Rock	20.4%
Grade 5	26.9%
Man Sand	31.8%
Field Sand	0.9%
0.0%	
LIME	
RAP	20.0%
RAS	
100.0%	

Sieve Size	OPTIMIZE Blend 1	
	Percent Passing	Check
1 in	100.0	✓
3/4 in	99.4	✓
1/2 in	91.6	✓
3/8 in	83.4	✓
#4	52.0	✓
#8	31.3	✓
#16	20.7	✓
#30	14.3	✓
#50	10.0	✓
#200	4.6	✓

Questions?

