MoDOT BMD Update

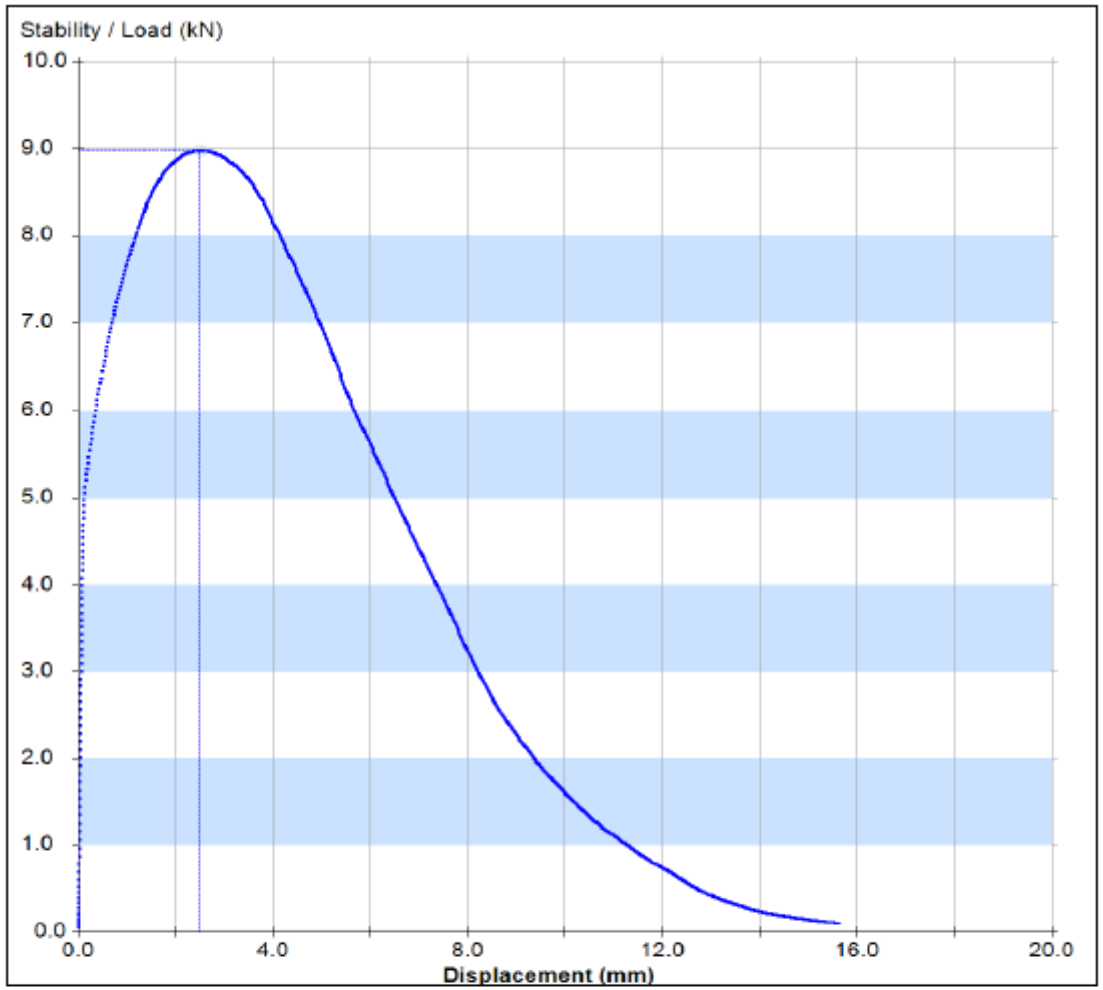
Balanced Mix Design (BMD)

- **Using performance test to predict the flexibility, stability, and durability of an asphalt mixture.**
  - **Flexibility measured by CT_{Index}**
  - **Stability measured by the RT_{Index} and Hamburg Wheel Track Test**
  - **Durability measured by Tensile Strength Ratio (TSR) and Hamburg Wheel Track Test**

BMD Goal: Asphalt Mixtures that are crack free, rut free, and distress free over the service life and beyond.

ASTM D822 Index of As Crackin g Tolerance ect Tensile erature

- Procedure – In v +/- 1 ° C.
- Test within 4 mi
- Use CT_{Index} Jig ar

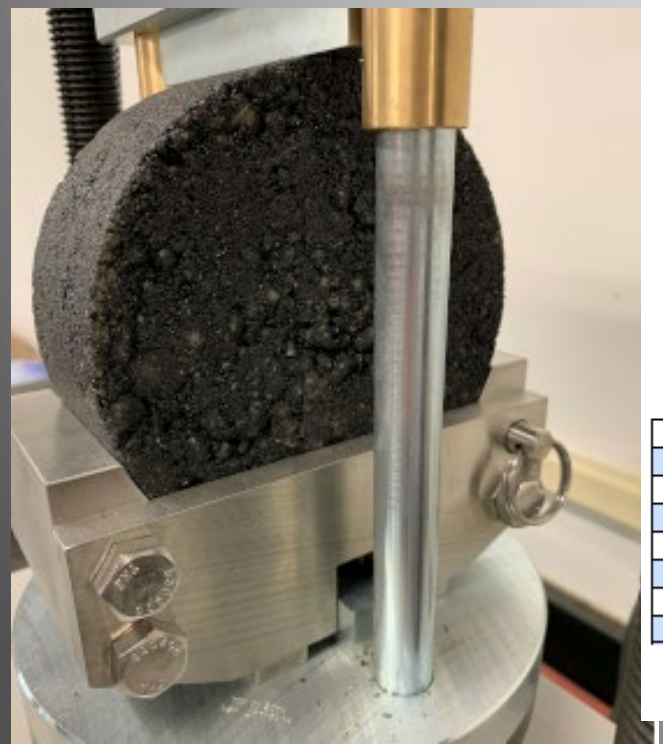


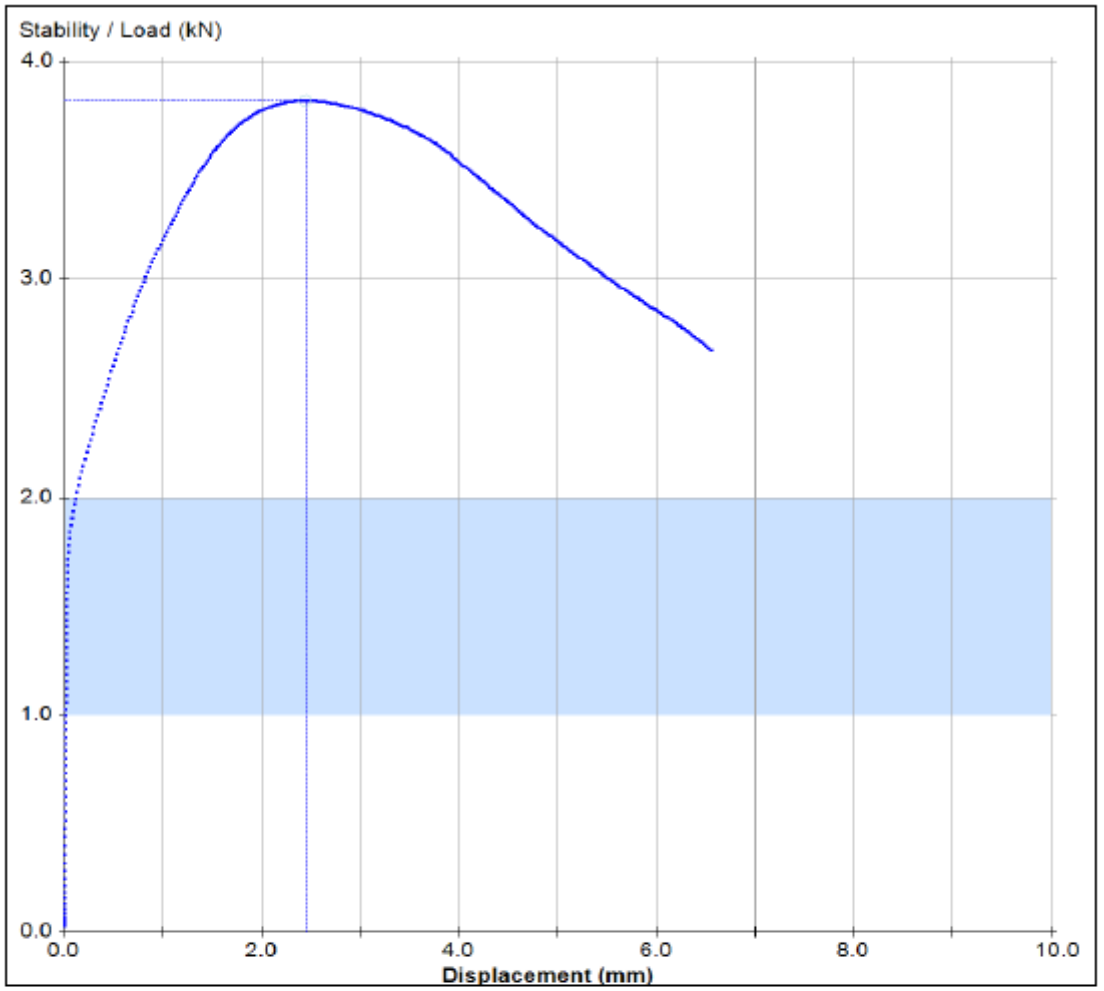
Project ID: JNW0024		Specimen ID: 240621-A017.29CT2	
Date / Time: 08/11/25 10:49 AM		Stability (Peak Load): 9.0 kN	2019 lbf
Specimen Diameter: 150.0 mm	5.9 in.	IDT Strength: 614.7 kPa	89.2 PSI
Specimen Thickness: 62.0 mm	2.44 in.	Peak Displacement: 2.5 mm	0.10 in.
Starting Load: 0.06 kN	12 lbf	Flow (0.254 mm units): 9.9	
Stopping Load: 0.10 kN	22 lbf	Work of Failure: 62.8 Joules	
Max Specific Gravity: 2.420		Strain Energy to Peak: 19.03 Joules	
% Voids: 7.1		Failure Energy: 6749.0 Joules / m²	
% AC: 5.3		Temperature: 25 °C	77 °F
Preparation Method:		Aging Condition:	
Mixture Type:			
Displacement at 75%: 5.1 mm		Average Speed: 48.8 mm/Min	
Post-Peak Slope (75%): 1312598 N/m		IDEAL-CT Index: 175.7	

ASTM D 8360 ... mination of Rutting

Tolerance Inc ... al Rutting Test.

- Procedure – ... s; 50° C +/- 1 ° C.
- Test within 2 ...
- Use RT_{Index} J ...





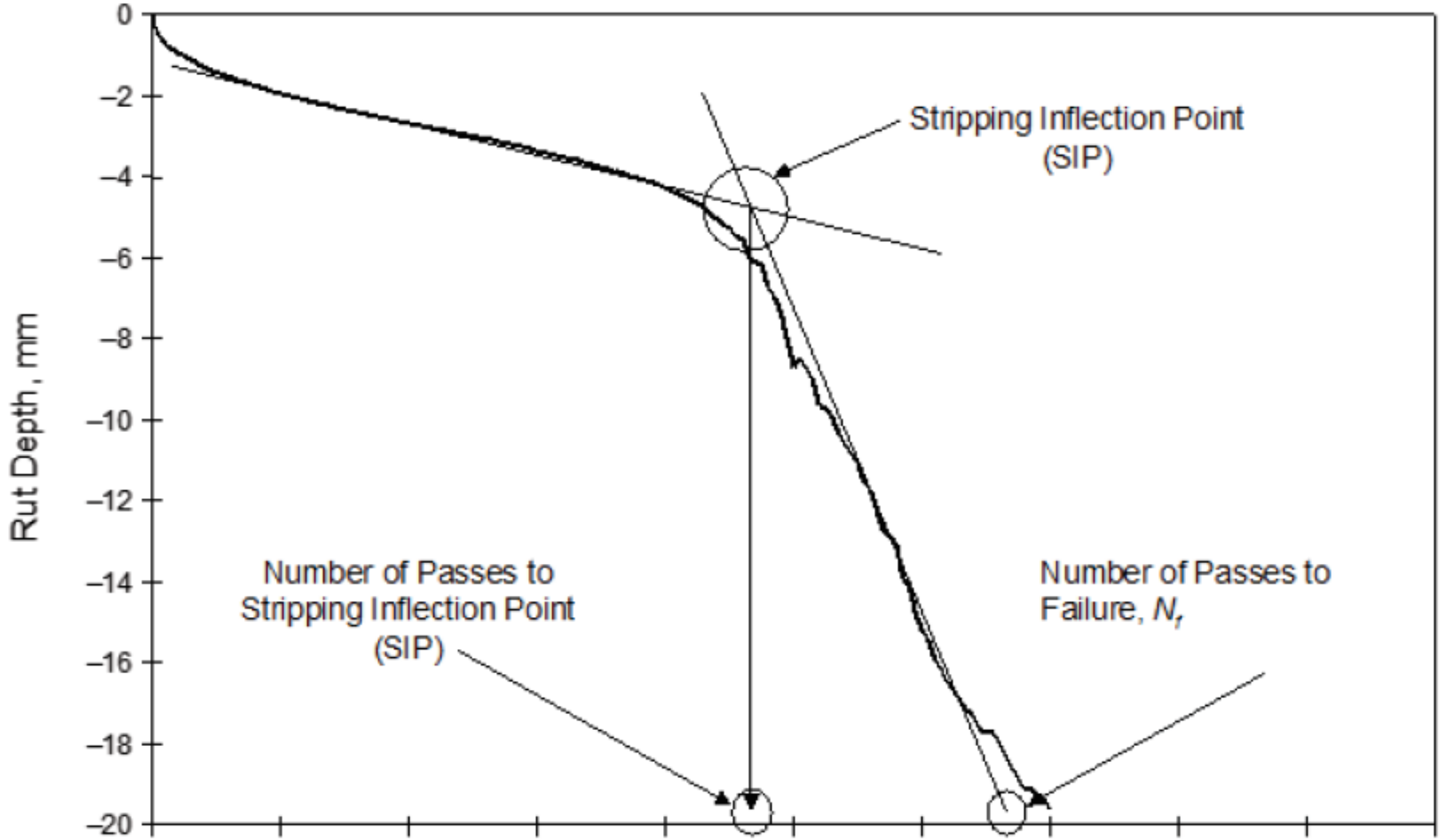
Project ID: JNW0024		Specimen ID: 240621-A017.29RT9	
Date / Time: 08/11/25 10:04 AM		Temperature: 50.0 °C	122 °F
Diameter: 0.1500 m	5.9 in.	Thickness (Height): 0.0620 m	2.44 in.
% Voids: 6.8		% AC: 5.3	
Preparation Method:		Aging Condition:	
Mixture Type:		Max Specific Gravity: 2.420	
Loading Strip Width: 0.01905 m	0.75 in.	Peak Load: 3824.2 N	860 lbf
Shear Strength: 1152667 Pa	167 PSI	Rutting Tolerance Index: 76.3	

A typical IDEAL-RT set-up for rutting evaluation of asphalt mixtures and a typical load versus displacement curve

Hamburg Wheel Track Test (HWTT) – AASHTO T 324

- In water bath for 45 minutes prior to starting the test.
- 50 +/- 1 °C at 7.0 +/- 1 % air voids
- 62 mm specimen height

- Measures average rut depth and the number of wheel passes
- Also can measure stripping potential.


Rut Depth, mm
0
–2
–4
–6
–8
–10
–12
–14
–16
–18
–20
0
2
4
6
8
10
12
14
16
18
20
Number of Passes × 1000
Stripping Inflection Point (SIP)
Number of Passes to Stripping Inflection Point (SIP)
Number of Passes to Failure, N,

Tensile Strength Ratio (TSR) – AASHTO T 283 – Resistance of Compacted Asphalt Mistures to Moisture-Induced Damage

- Six gyratory compacted specimens needed @ 7.0 +/- 0.5 % air voids
- Conditioning
  - Three specimens tested dry condition at 25◦C water bath.
  - Three specimens are conditioned by vacuum saturated to 70 – 80%, then placed in a freezer (-18 ◦C) for 16 hours, then placed in water bath 60 ◦ C for 24 hours, then placed in a 25 ◦C water bath for 2 hours.
- Run Indirect Tensile Strength on the dry set and the conditioned set; TSR = Tensile Strength (Conditioned) / Tensile Strength (Dry)

Back to the Basics - Importance of Mix Sampling, Handling, Fabricating, and Storgage

- From shoveling mix to placing in the gyratory compactor, special care is needed to avoid segregation.
- READ AASHTO R 97 and R47 Carefully!
  - R 97 -Sampling from Trucks, Windrows, Stockpiles, Conveyor Belts, Hopper, or asphalt chute.
  - R 47 - Splitting the sample without segregation.
    - Mechanical Splitter
    - Coning or Quartering Methods

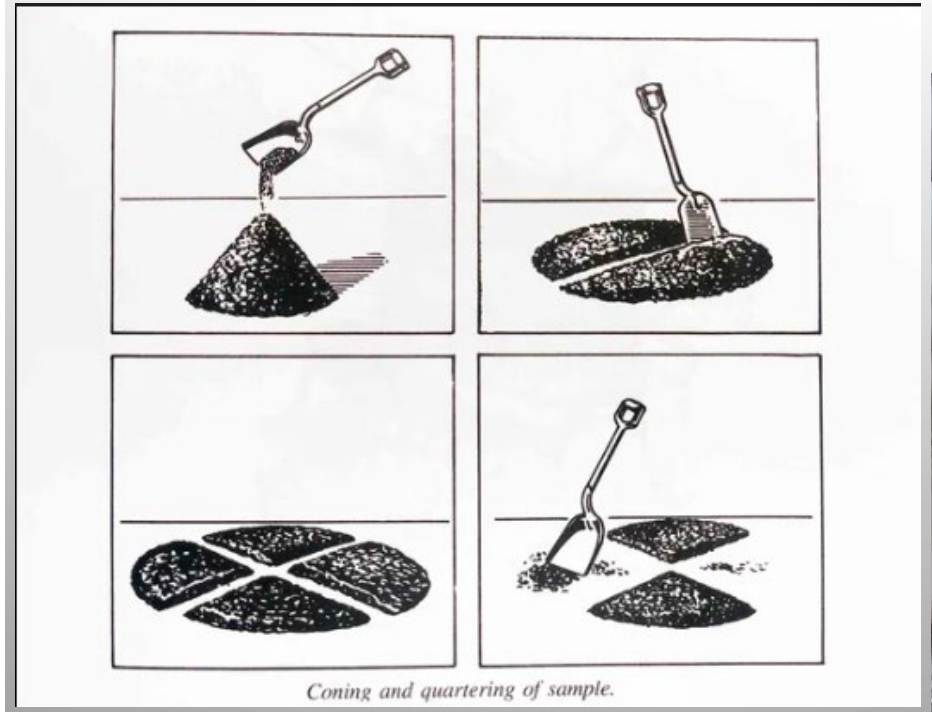
Back to the Basics - Importance of Mix Sampling, Handling, Fabricating, and Storgage

- From shoveling mix to placing in the gyratory compactor, special care is needed to avoid segregation.
- READ AASHTO R 97 and R47 Carefully!
  - R 97 -Sampling from Trucks, Windrows, Stockpiles, Conveyor Belts, Hopper, or asphalt chute.
  - R 47 - Splitting the sample without segregation.
    - Mechanical Splitter
    - Coning or Quartering Methods

PAVEMENT TECHNOLOGY INC.

Asphalt Splitting – Reducing Sample Size (AASHTO R 47)

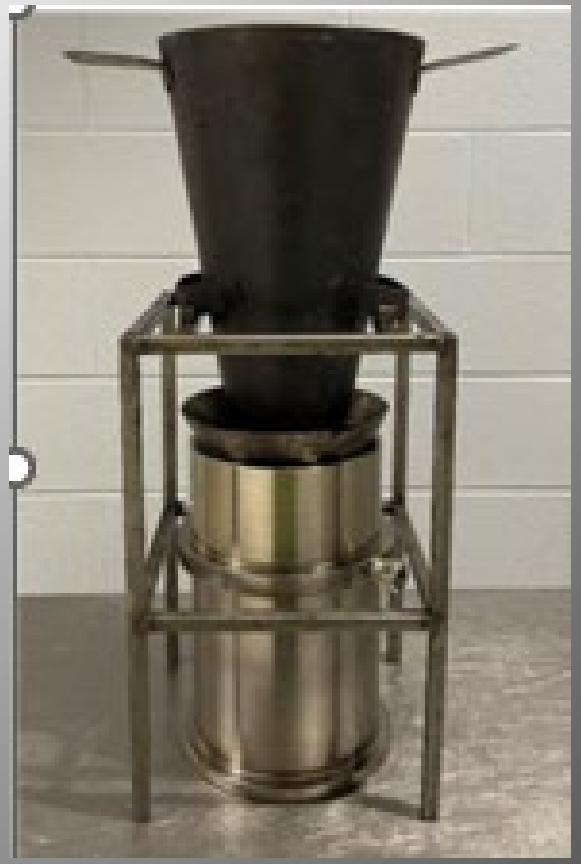
Figure 17. Asphalt Mechanical Quartering Device (Mechanical Splitter Type A)



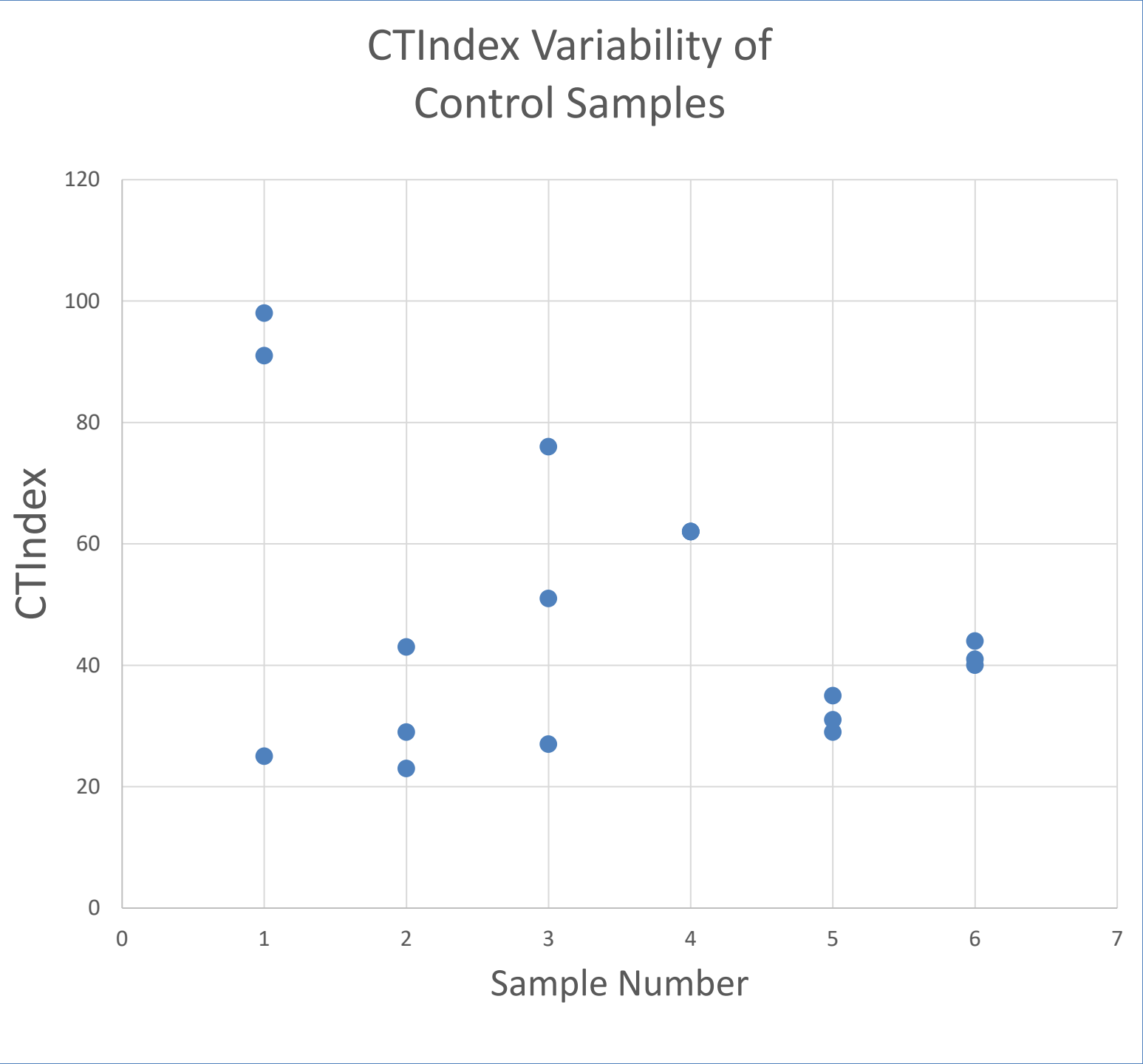
Coning and quartering of sample.

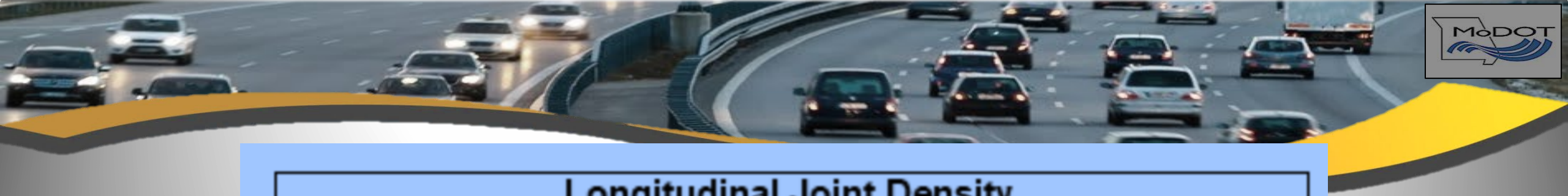
Getting the asphalt into the gyratory molds without segregation!

Figure 2—Another Mixture Transfer Funnel Option



CT_{Index} Variability on 6 Samples from 1 Project





2025 rs

403.23.2 Pay eighted sum
of the pay fac lows:

$PF_T = + (0.5)$

Longitudinal Joint Density	
Field Density (Percent of Laboratory Max. Theoretical Specific Gravity)	Percent of Contract Unit Price
SuperPave Mixtures	
≥ 90.5	PF_{Total} not changed by longitudinal joint density
89.5 – 90.4	Maximum PF_{Total} = 100%; Correction Required[(a)]
< 89.5	Remove and Replace
SMA Mixtures	
≥ 92.0	PF_{Total} not changed by longitudinal joint density
90.0 – 91.9	Maximum PF_{Total} = 100%; Correction Required[(a)]
< 90.0	Remove and Replace

2025 BMD Performance Pay Factors

403.4.11.2 Rutting Tolerance Index (RT_{Index}) Testing. The RT_{Index} testing shall be completed in accordance with ASTM D8360 and at a test temperature of 50 ± 1 C.

PG Grade High Temperature*	Minimum RT_{Index}
58-28H / 64-22	50
64-22H / 70-22	65
64-22V / 76-22	80

*Determined by the binder grade specified in the contract.

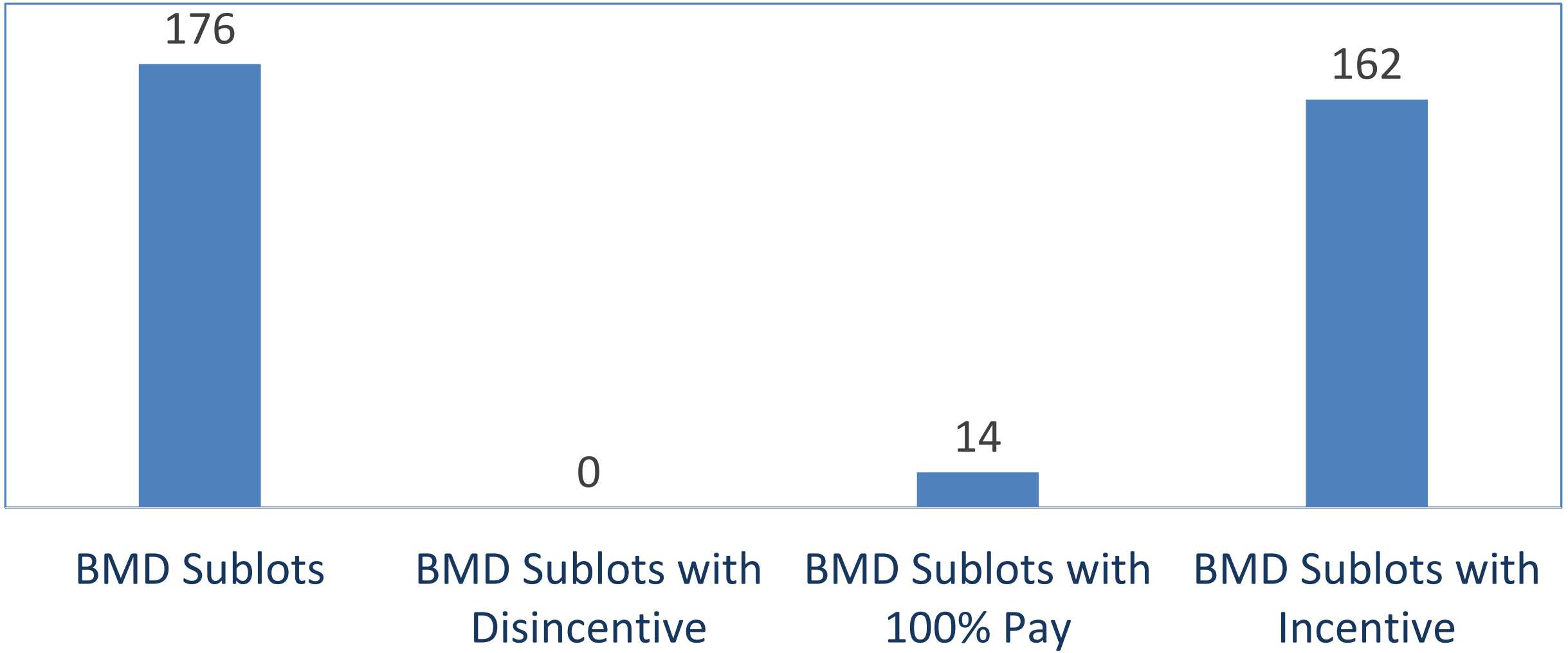
HAMBURG WHEEL TRACK TEST

PG Grade High Temperature *	Minimum Wheel Passes	Maximum Rut Depth (in.)
58-28H / 64-22	7,500	12.5 mm of Rutting
64-22H / 70-22	15,000	
64-22V / 76-22	20,000	

*Determined by the binder grade specified in the contract.

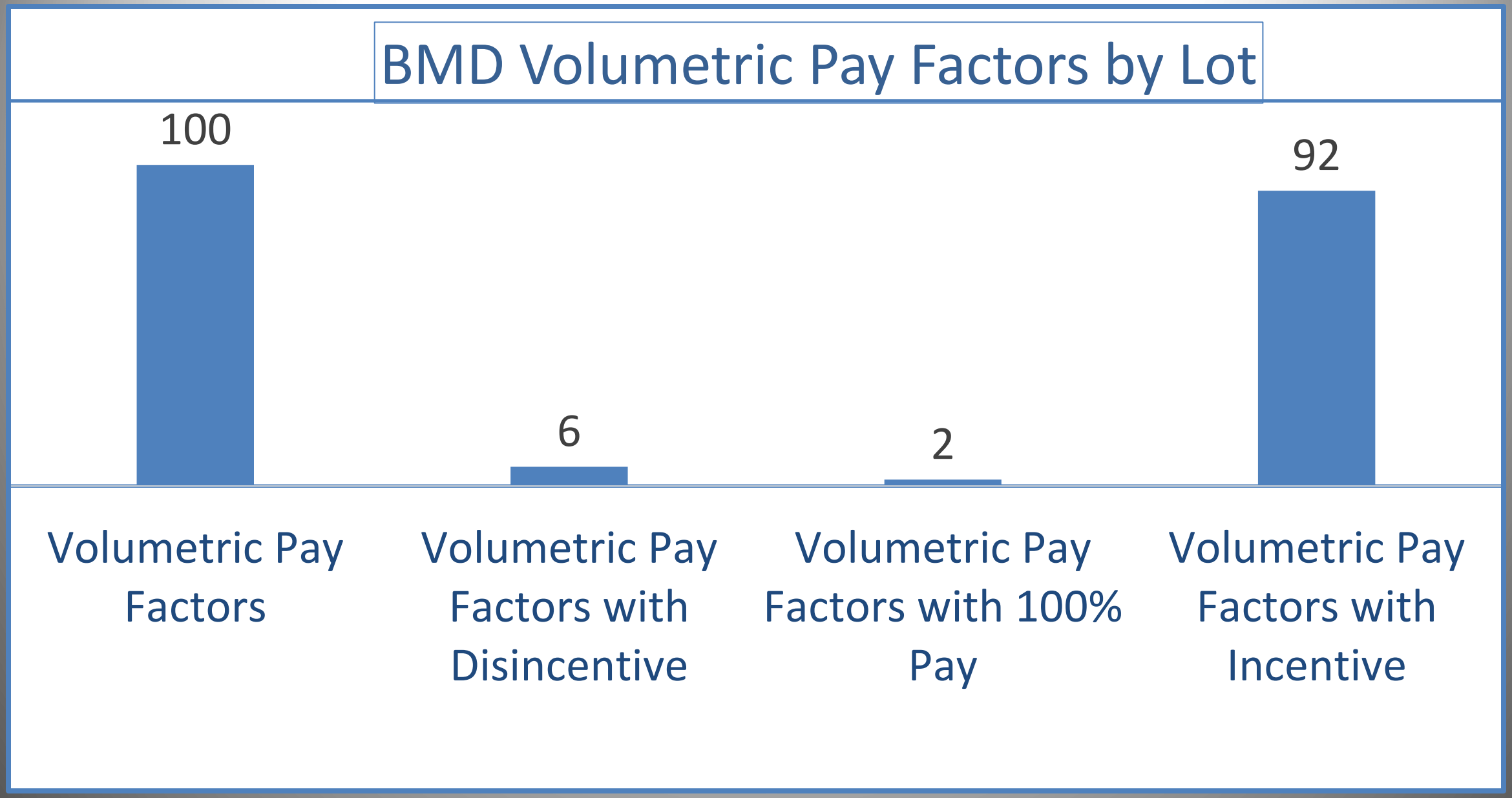
(a) If an approved … entive is 80 percent.

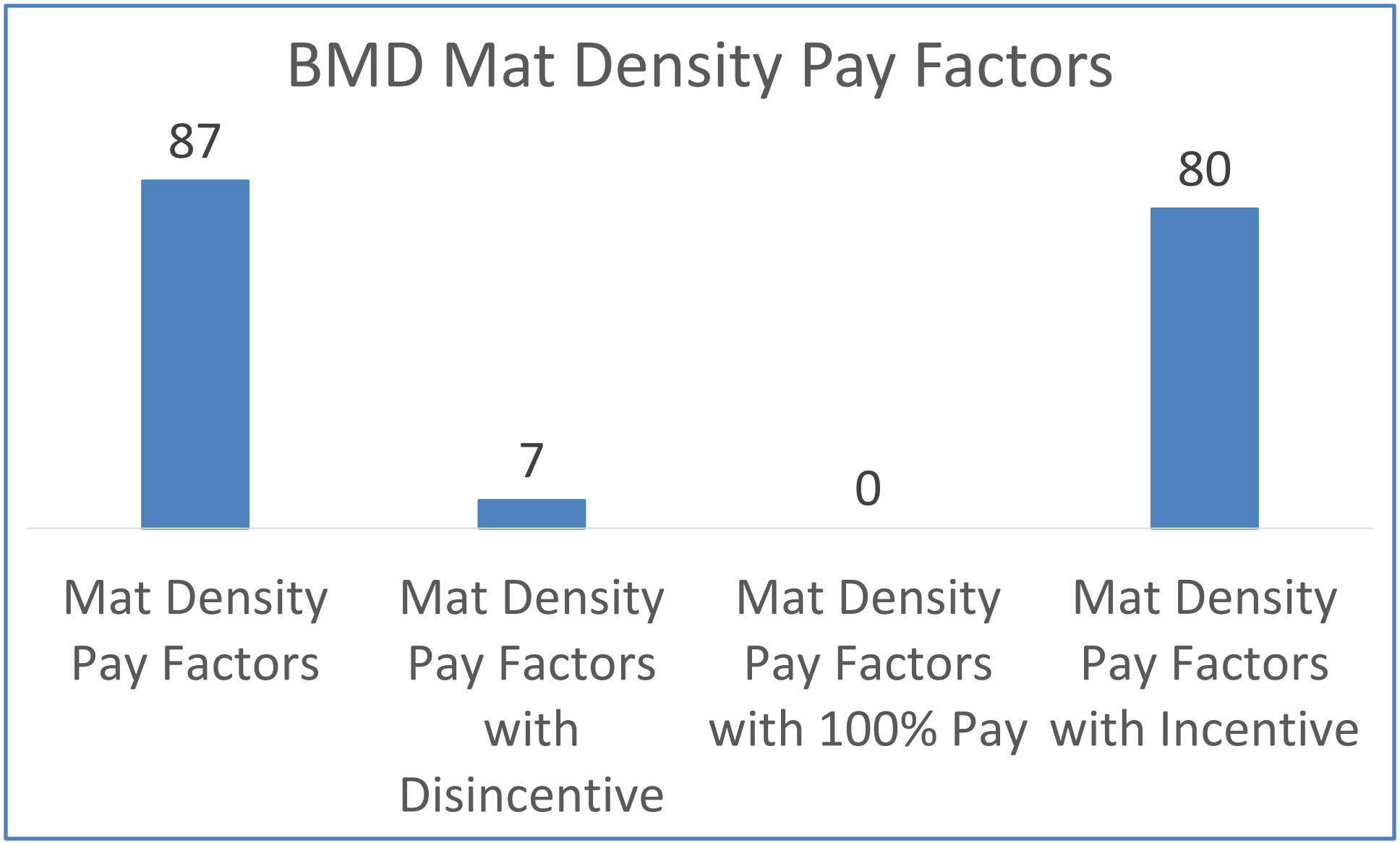
CT_{Index}, RT_{Index}, and TSR Sublot Pay Factors (Combined)

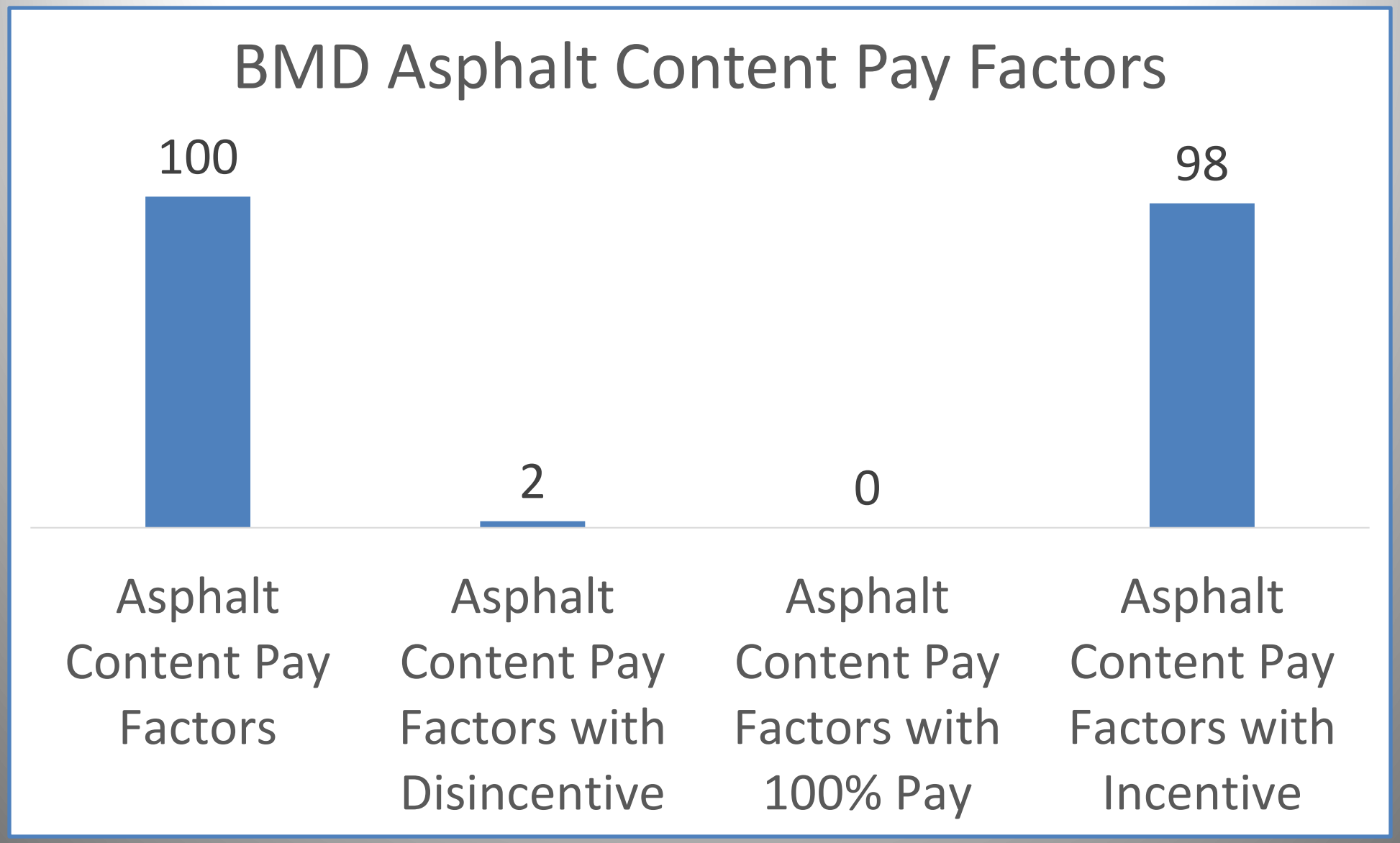


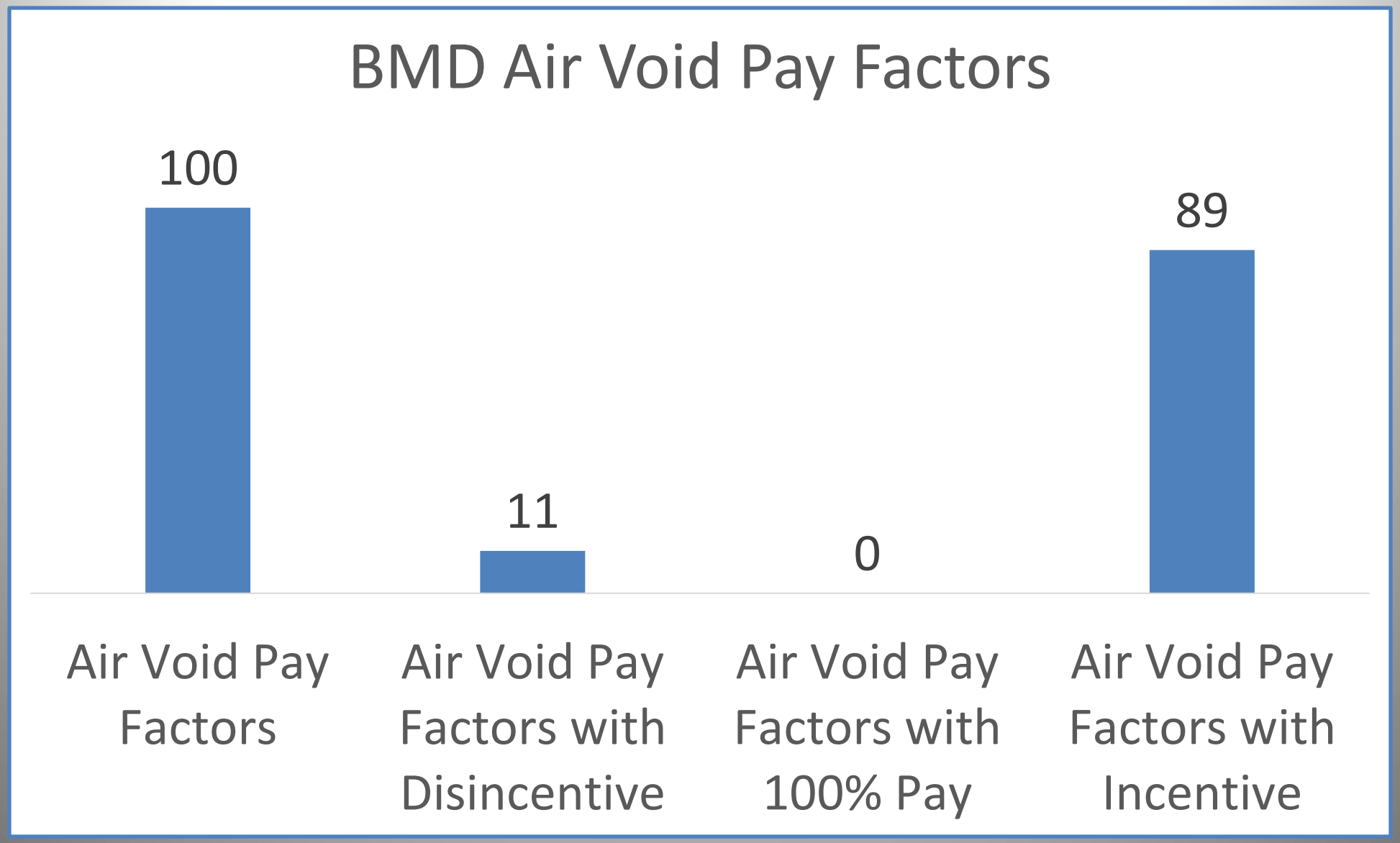
Volumetric Pay factors

- Pay factors for:
  - Mat density
  - Asphalt content
  - Air voids
- Maximum 103% incentive pay
- Voids in Mineral Aggregate (VMA) ***not*** used in the volumetric pay factor for the BMD mixes


BMD Volumetric Pay Factors by Lot
100
6
2
92
Volumetric Pay Factors
Volumetric Pay Factors with Disincentive
Volumetric Pay Factors with 100% Pay
Volumetric Pay Factors with Incentive


BMD Mat Density Pay Factors
87
7
0
80
Mat Density Pay Factors
Mat Density Pay Factors with Disincentive
Mat Density Pay Factors with 100% Pay
Mat Density Pay Factors with Incentive


BMD Asphalt Content Pay Factors
100
2
0
98
Asphalt Content Pay Factors
Asphalt Content Pay Factors with Disincentive
Asphalt Content Pay Factors with 100% Pay
Asphalt Content Pay Factors with Incentive


BMD Air Void Pay Factors
100
11
0
89
Air Void Pay Factors
Air Void Pay Factors with Disincentive
Air Void Pay Factors with 100% Pay
Air Void Pay Factors with Incentive

Response to Topic #3 and #5

Higher AC content and increased density over time in conjunction with BMD improvement

Region	MIX	ID	BMD	Total AC	Avg. Dens.
North East Same Rock	095C	23-34	Y	5.8%	96.0%
	095C	18-54	N	5.2%	94.1%
	095C	17-92	N	5.3%	93.1%
Central Same Rock	125C	25-14	Y	5.6%	95.6%
	095C	16-28	N	5.4%	Modot Archives
	125C	11 - 52	N	4.8%	Modot Archives
North East Same Rock	095C	23-44	Y	5.8%	95.4%
	095C	22-93	Y	5.7%	95.0%
	095C	20-53	N	5.2%	Modot Archives
	095C	19-60	N	5.2%	94.0%
Central Same Rock	125C	25-15	Y	5.6%	95.3%
	125C	24-62	Y	5.6%	95.2%
	125C	24-60	N	5.1%	94.2%
Central Same Rock	125C	21-27	Y	5.6%	Modot Archives
	095C	21-26	N	5.6%	Modot Archives
North West Same Rock	125C	24-4	Y	5.5%	95.7%
	125C	21-46	Y	5.5%	95.1%
	125C	20-33	N	5.2%	94.1%
South East Same Rock	095C	26-	Y	5.8%	TBD
	095C	17-49	N	5.1%	94.6%
	095C	17-19	N	5.1%	Modot Archives
	095C	15-30	N	5.1%	Modot Archives
St. Louis Same Rock	125B	25-53	Y	5.4%	96.1%
	125B	17-61	N	4.7%	93.8%
	125CLP	17-52	N	4.7%	Modot Archives
	125CLP	17-20	N	4.7%	Modot Archives

MIX TYPE	BMD	AVG Density
SP125CLPX	YES	94.4
SP095CLPX	YES	94.6
SP095CLPLG	NO	93.5
SP125CLPX	YES	96.4
SP125CLG	NO	93.5
SP125CLG	NO	94.4
SP095CLPLG	NO	93.4
SP095CLG	NO	93.9
SP095CLPLG	NO	93.9
SP095CLPX	YES	94.9
SP125CLGLP	NO	95.0
BMD AVG		**95.1**
Typical AVG		**93.9**

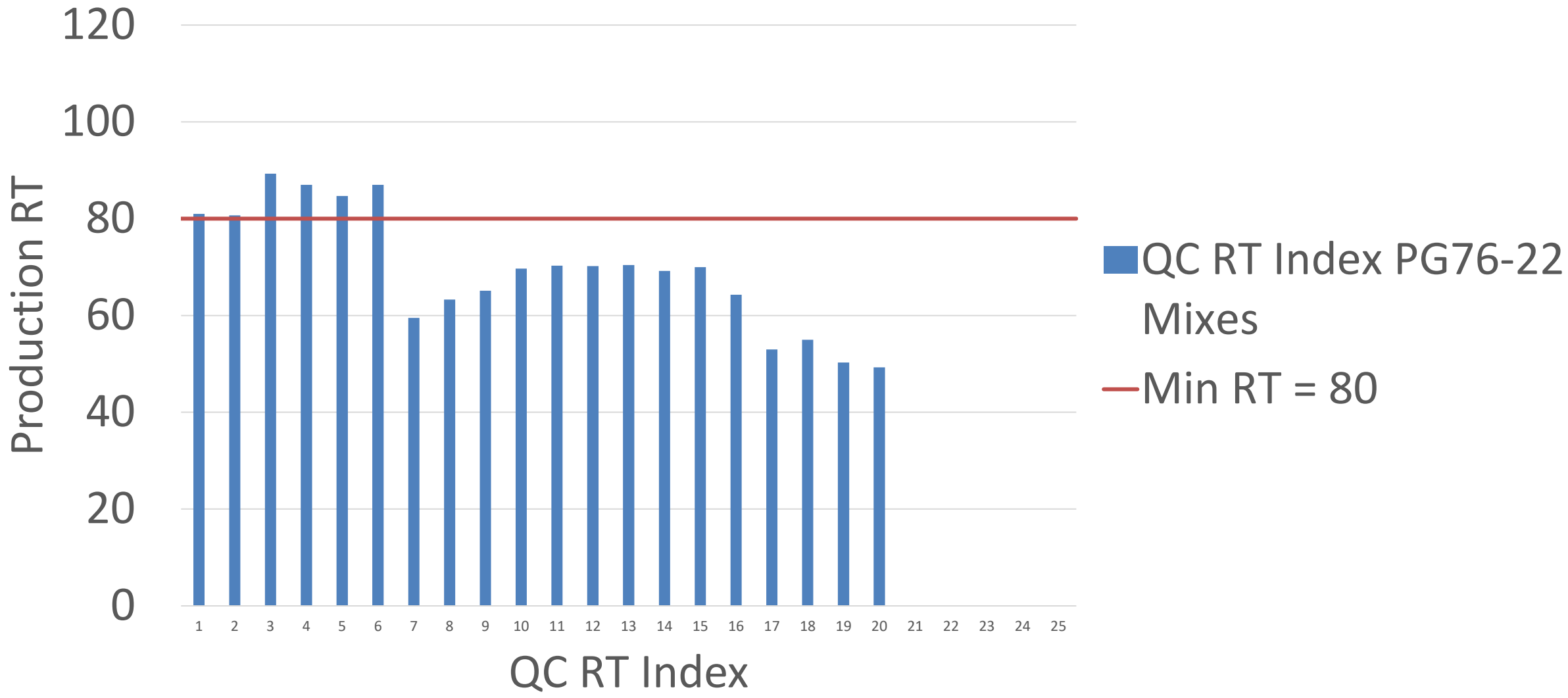
BMD Specification Update

- No major specifications changes made in 2025
- Working on specification tweaks before full implementation
  1. Too much testing –
     - Proposed going from 3000 tons to 6000 tons for BMD Testing
  2. R_T index failures on 64V-22 binders
     - Proposed setting factors based on Hamburg results / Decrease in RT requirement.
  3. Long Term Aging Protocols – Work in Progress

Failing R_T of 64V Binders

PG Grade High Temperature*	Minimum RT_{Index}
58-28H / 64-22	50
64-22H / 70-22	65
64-22V / 76-22	80

QC RT Index PG 76-22 Mixes



2025 JMF Results Failing R_T of 64V Binders

- Not seeing an increase in R_T from 64H to 64V binders
- Is it a binder issue or is RT=80 too high for a 64V binder?
- Are we not allowing the mix to age enough?
- Are we getting the field performance we need?
- More research is needed..

Long-Term Aging Protocol Needed

JMF	CT Specimens Made Early	CT Specimens Made Later
SP125C w/ PG 70-22 JMF CT_{Index}= 127.2 $JMF_{Long\_TermAging}$ = 20.8	175.7	52.3
	136.6	46.9
	RT Specimens Made Early	RT Specimens Made Later
	48.7	76.3
	50.7	74.8

BMD Mixture that Passes Current Specification

JMF	CT Specimens Made Early	CT Specimens Made Later
JMF CT_{Index}= 127.2	175.7	52.3
	136.6	46.9
JMF $CT_{IndexLong-Term}$ = 20.8	RT Specimens Made Early	RT Specimens Made Later
	48.7	76.3
	50.7	74.8

2025 JMF Results

1. What would CT index averages look like if roadway mixture was used?
2. Are we getting long-term crack resistant performance?
3. Is $CT_{IndexLTA}$=25 for 20 hrs @ 115 ◦C (240 ◦F) an effective test to determine 10+ yrs of crack free surface life?

Avg CT Index	Avg CT Critically Aged < 30	% Difference
77.9	35.5	54
117.2	76.5	35
95.8	60.2	37
98.9	30.6	69
83	21.2	74
123.2	16.2	87
140.2	56.5	60
82.3	41.9	49
127.2	20.8	84
228.4	31.9	86
129.3	56.4	56
63	32	49
103.1	75.3	27
140.3	32.6	77
61.7	31.4	49
132	47	64

Real CT Data from 10-Year-Old Samples.

- Long-Term aged CT does not accurately correlate with in-place results.
- 55% variance between lab produced and field sampled CT specimens.
- What Aging Test is Needed?

10 Year Road Samples From 54 Westbound Test Sections						
Mixes	CT from Roadway	AC Grade/Pbe	RT from Roadway	20HR AGE CT	CT DIFF	%DIFF
16-83 AA01	CT: 31	64-22H/4.72	78	22	9	29
16-100 AA02	CT: 33	64-22H/4.62	99.8	19	14	42.4
16-93 AA03	CT: 61	64-22H/4.62	116.8	16	45	73.8
16-84 AA61	CT: 34	64-22H/4.39	126.8	18	16	47.1
16-99 AA62	CT: 15	64-22H/4.69	131.3	9	6	40
16-91 AA63	CT: 51	58-28/4.59	63.6	18	33	64.7
16-89 AA64	CT: 27	58-28/4.63	86.4	9	18	66.7
16-98 AA65	CT: 33	58-28/4.81	123.3	19	14	42.4
16-95 AA66	CT: 18	46-34/4.87	140.8	6	12	66.7
16-94 AA67	CT: 37	58-28/4.5	62.8	9	28	75.7
Averages	**34**		**102.96**	**14.5**	**19.5**	**54.9%**

BMD Spec. Moving Forward

- Continue with additional pilot projects in 2026
- Complete a JSP this Spring with Revised JSP for July Letting.
- Use BMD as a Standard Specification by January 2027?

Questions?