Influence of Tack Coat Type on the Density of Compacted HMA Mixtures

Samuel B. Cooper, Jr.

Louay N. Mohammad

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LTRC

Presentation Outline

- Background
- Objective
- Scope
- Methodology
- Test Sections
- Rheology of Trackless Tack Coat
- Discussion of Results
- Observations

Background

- Asphalt tack coat is a light application of asphalt, usually asphalt diluted with water.
- Used to ensure bonding between the surface being paved and the overlying course.
  - Act as a monolithic system to withstand the traffic and environmental loads.
  - Bonding critical to transfer radial tensile and shear stresses into the entire pavement structure.
- No bond or insufficient bond or excessive tack decreases pavement bearing capacity and may cause slippage.
  - accelerate fatigue cracking and lead to total pavement failure.

Background

- First man-made emulsion by GALIEN.
  - 1800 years ago.
  - Used for cosmetics.
- The first plant produced bitumen emulsion was made in 1905 in Elsass, in the city of Lutterbach by a chemist named Emile FEIGEL.
- Significant utilization actually started during the end of the Twenties with the process patented by a British chemist, MAC KAY, in 1922.
  - This patent defined the anionic emulsion and deposited the Trade Mark : Cold Spray which was modified into ***COL****d* ***AS****phalt* in 1925, and later on contracted into COLAS (1929).
- Another significant breakthrough.
  - Development of cationic emulsion.
  - By ESSO in France in 1951.

Background

- Common Tack Coat Types.
  - Hot asphalt cements,
  - Emulsified asphalts,
  - Cutback asphalts.
- Paul and Scherocman conducted a tack coat survey.
  - Most emulsions used are SS-1, SS-1h, CSS-1 and CSS-1h.
  - Only one state (Georgia) used hot asphalt (AC-20, and AC-30) as tack coats.
  - The residual application rates varied.
    - between 0.06 (0.01) and 0.26 (0.06) l/m^2 (gal/yd^2) depending on the type of surface for application.

Background

- **Mohammad Tack Coat Study, 2002.**
  - **Evaluated Influence of Tack Coat on Interface Bond Strength Between HMA Lifts.**
    - **Controlled Laboratory Study.**
    - **Laboratory prepared samples.**
    - **Residual application rates.**
      - **0.00, 0.02, 0.05, 0.1, 0.2 gal/sq. yd.**
    - **Tack coat materials.**
      - **PG 64-22, PG 76-22M, CRS-2P, CSS-1, SS-1, SS-1H.**
    - **CRS-2P provided greatest interface shear strength @ 0.02 gal/sq. yd. residual application rate.**

Background

- NCHRP 9-40: “Optimization of Tack Coat for HMA Placement”.
  - Principal Investigator.
    - Louay N. Mohammad
  - Objective.
    - Determine the optimum application methods,
      - Equipment type,
      - Calibration procedures,
      - Application rates,
      - Asphalt binder materials.
    - Recommend revisions to relevant AASHTO methods and practices related to tack coats.

Background

- Trackless Tack Coats.
  - Two Types.
    - COLAS.
      - Polymer Modified Emulsion.
      - Applied using a modified distributor.
        - 3 step process.
        - First, adhesive agent placed,
        - Then polymer modified emulsion,
        - Then additive to promote breaking.
    - Blackledge Emulsions.
      - Polymer Modified Emulsion.
        - Utilizes Conventional Distributor.
        - Sprayed at approximately 165F.
        - Set time approximately 10 minutes, depending on application rate.

Background

- **Longitudinal Joint.**
  - **Formed when previous mat (Cold Lane) has cooled and adjacent lane is then placed (Hot Lane).**
  - **Problems.**
    - **Cold Lane Unconfined edge slides during compaction.**
      - **Lower density (Higher air voids),**
      - **Oxidation,**
      - **Permeability,**
      - **Stripping,**
      - **Separation,**
      - **Cracking,**
      - **Raveling.**

Background

- Question?
  - What influence does tack coat material type have on the longitudinal joint?
  - Will tamping the near vertical edge of the Longitudinal joint improve density?
    - Previously required in LA specifications.
  - Will these help improve density at the joint without requiring joint density specification?

Objective

- Evaluate the influence of tack coat material.
  - Longitudinal joint density,
  - Permeability,
  - Interlayer Bond strength.
    - Between HMA lifts,
    - Between cold mat and hot mat.

Scope

- 3 Projects to be selected.
- Emulsion Types.
  - Conventional,
    - SS-1
  - Polymer Modified.
- Cold Lane Longitudinal Joint Compaction.
  - Tamped,
  - Untamped.
- Factorial
  - 4 Test Sections per HMA Lift
    - Conventional Section
      - Tamped
      - Untamped
    - Polymer Modified Section
      - Tamped
      - Untamped
- Analysis from field cores.

Methodology

- Determine Project Site
- Select Test Section
- Apply tack coat materials
- Obtain Roadway Cores
- Conduct Testing
  - Density
  - Permeability
  - Interface bond testing
- Analyze Data
- Report findings and recommendations

Project Locations

- LA 3235
  - Between Galliano & Golden Meadow
    - Lafourche Parish
    - 3.3 miles
- LA 315
  - End of the road at Gulf towards Theriot
    - Terrebonne Parish
    - 5.83 miles

LA 3235 Test Sections (Mill and 2-lift overlay)

- Milled Surface (2”)
- 2” Binder Course, Level 1 SP
- Conventional Emulsion, Total Application Rate.
  - 0.08 gal/sq. yd. SS-1 (Untamped)
  - 0.08 gal/sq.yd. SS-1 (Tamped)
- Polymer Modified Emulsion, Total Application Rate.
  - Trackless Tack
  - 0.04 gal/sq. yd. Trackless Tack (Untamped)
  - 0.08 gal/sq. yd. Trackless Tack (Untamped)
  - 0.08 gal/sq. yd. Trackless Tack (Tamped)

LA 3235 Test Sections

- 1 ½” Wearing Course, Level I SP
  - Conventional Emulsion, Total Application Rate.
    - 0.03 gal/sq. yd. SS-1 (Untamped)
    - 0.03 gal/sq. yd. SS-1 (Tamped)
  - Polymer Modified Emulsion, Total Application Rate.
    - 0.03 gal/sq. yd. Trackless Tack (Untamped)
    - 0.03 gal/sq. yd. Trackless Tack (Tamped)

LA 315 Test Section (Mill and 1-lift overlay)

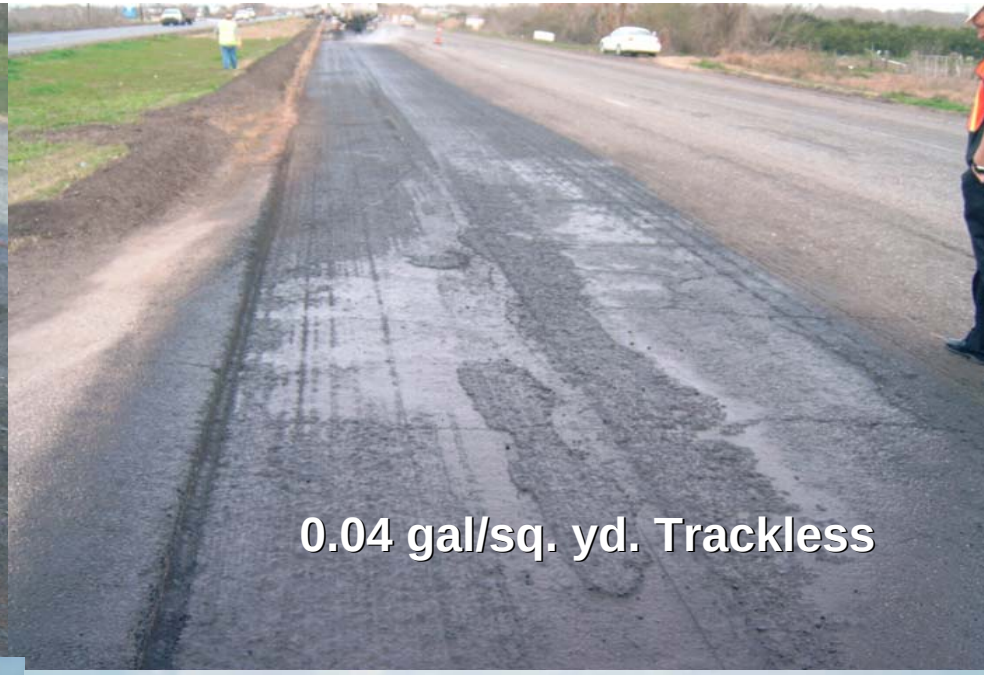
- Milled Surface (1/2”)
- 1 ½” Wearing Course, Level 1 SP
- Conventional Emulsion, Total Application Rate.
  - 0.08 gal/sq. yd. SS-1 (Untamped)
  - 0.08 gal/sq.yd. SS-1 (Tamped)
- Polymer Modified Emulsion, Total Application Rate.
  - Trackless Tack
  - 0.08 gal/sq. yd. Trackless Tack (Untamped)
  - 0.08 gal/sq. yd. Trackless Tack (Tamped)


FRESH
OIL


Etnyre
Black-Topper
CENTENNIAL
BLACKLIDGE
1-800-866-3878
U.S. DOT 382974


Etnyre
SPRAYBAR
POWER
HYD OIL
TEMP
CENTERED
MAIN BAR
LEFT WING
RIGHT WING
WING FOLD
SUCKBACK
BAR LATCH
BAR UNLATCHED


0.08 gal/sq. yd. SS-1
Uniformly distributed???


0.04 gal/sq. yd. Trackless


0.08 gal/sq. yd.
0.04 gal/sq. yd.
Trackless


0.08 gal/sq. yd. Trackless


FRESH
OIL


0.08 gal/sq. yd. Trackless

Typical Core Locations

26 Cores per test section

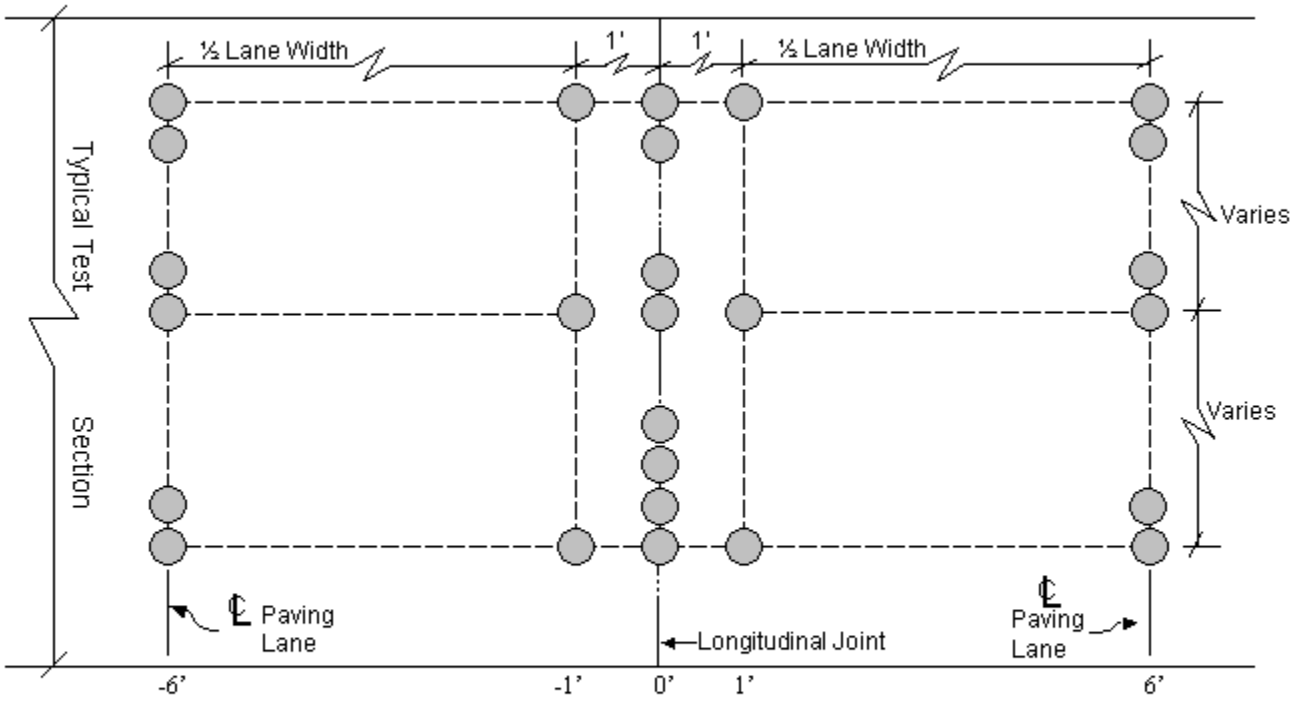


Figure 1

6" Core Locations Per Test Section

Roadway Cores Acquired

- LA 3235
  - Binder Course
    - 130
  - Wearing Course
    - 104
  - 234 Total Cores Taken
- LA 315
  - Wearing Course
    - 104


I 35+00

Rheology of Trackless Tack Coat

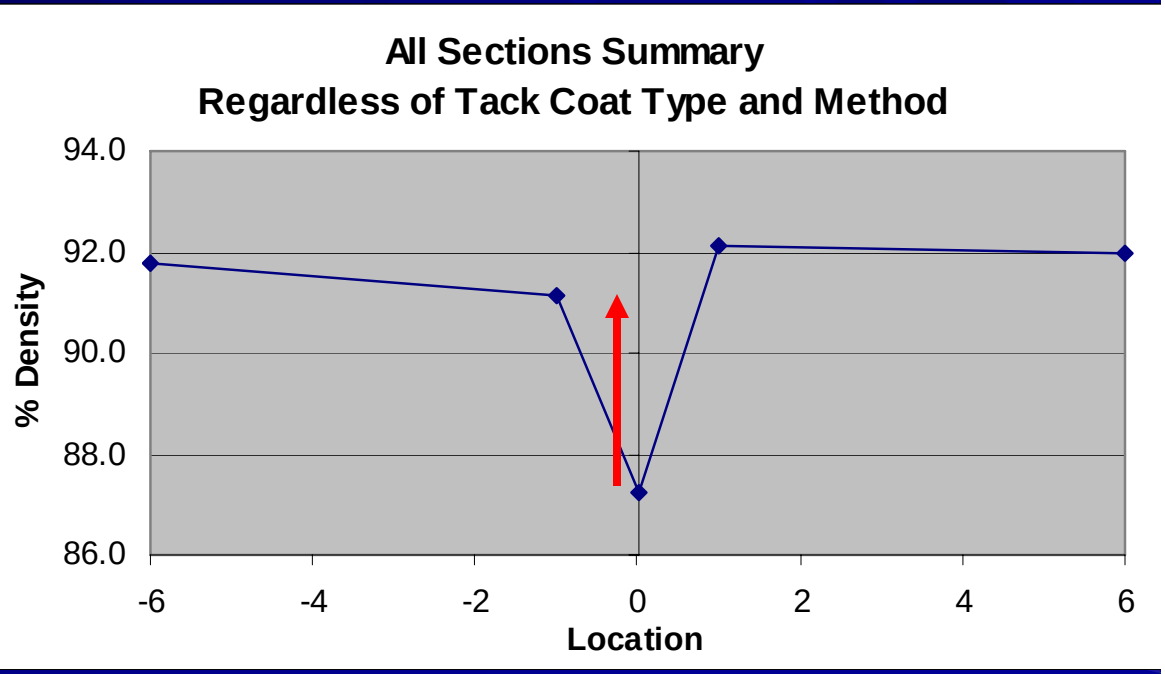
- **Residual Asphalt Binder Evaluation**
  - **% Residual**
    - **31%**
    - **as per Blackledge**
  - **Rotational Viscosity**
    - **1.512 Pa. sec**
  - **Penetration Test, 25C**
    - **10 Pen**
  - **Ring and Ball**
    - **63.5^{0}C (146^{0}F)**
  - **Performance Grade**
    - **PG 82 - XX**

Discussion of Results

LA 3235 only – LA 315 typical

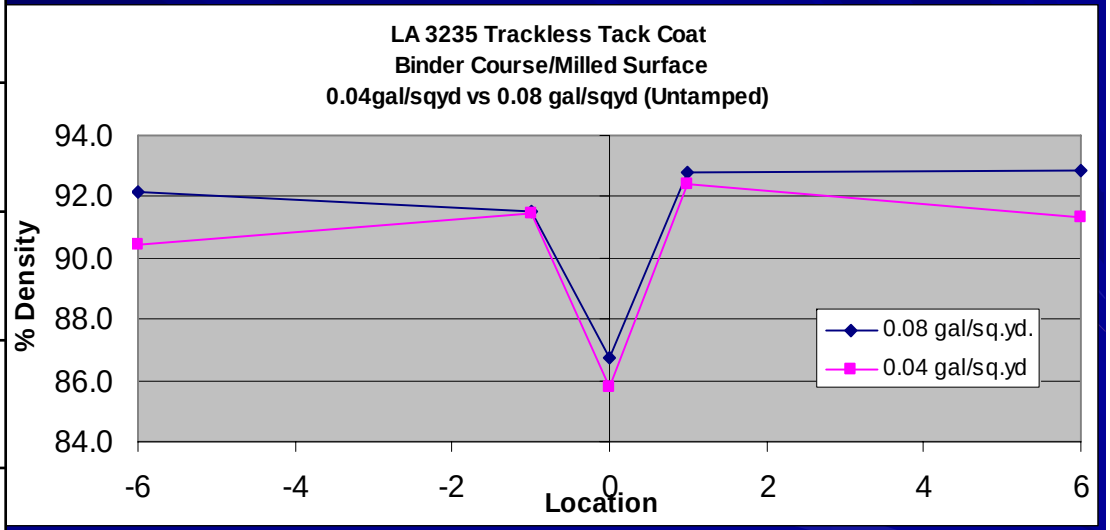
Density: *All Sections*, *0.08gal/sy, Milled Surface/Binder Course*

All Sections Summary			
Location	*% Avg. Density*	*Stdev.*	*%C.V.*
-6	91.8	2.26	2.46
-1	91.1	1.94	2.13
0	87.2	1.26	1.44
1	92.1	1.30	1.41
6	92.0	2.10	2.28



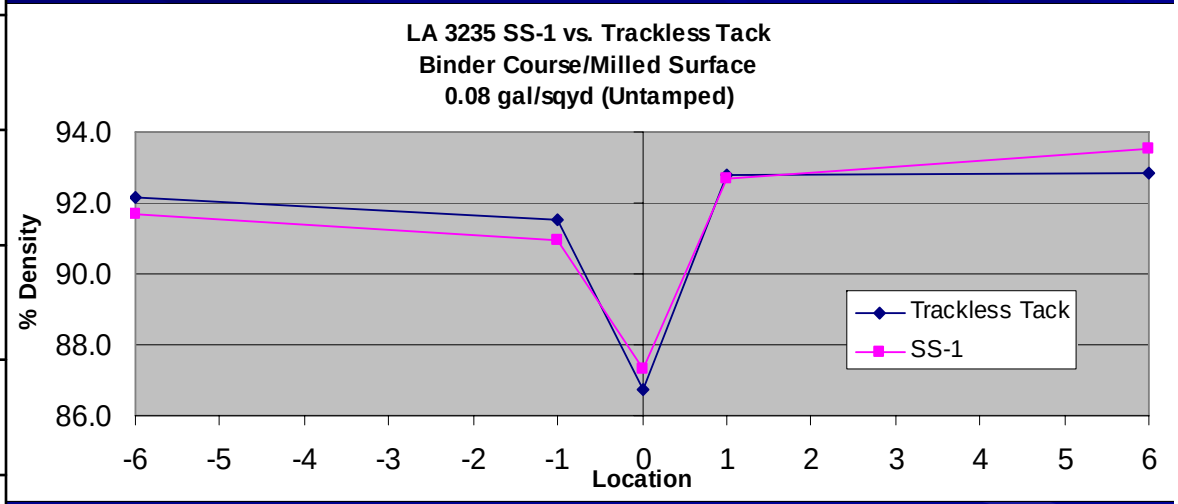
Density: *Trackless, 0.04 vs. 0.08gal/sy, Untamped Milled Surface/Binder Course*

Trackless Untamped 0.08/0.04 gal/sq yd % Avg. Density Comparison Binder Course/Milled Surface			SAS Comparison	
Location	*Trackless Tack 0.08*	*Trackless Tack 0.04*	*TT 0.08*	*TT 0.04*
-6	92.1	90.4	A	A
-1	91.5	91.5	A	A
0	86.8	85.8	A	B
1	92.8	92.4	A	A
6	92.8	91.3	A	A



Density: *Trackless vs SS-1, 0.08gal/sy, Untamped Milled Surface/Binder Course*

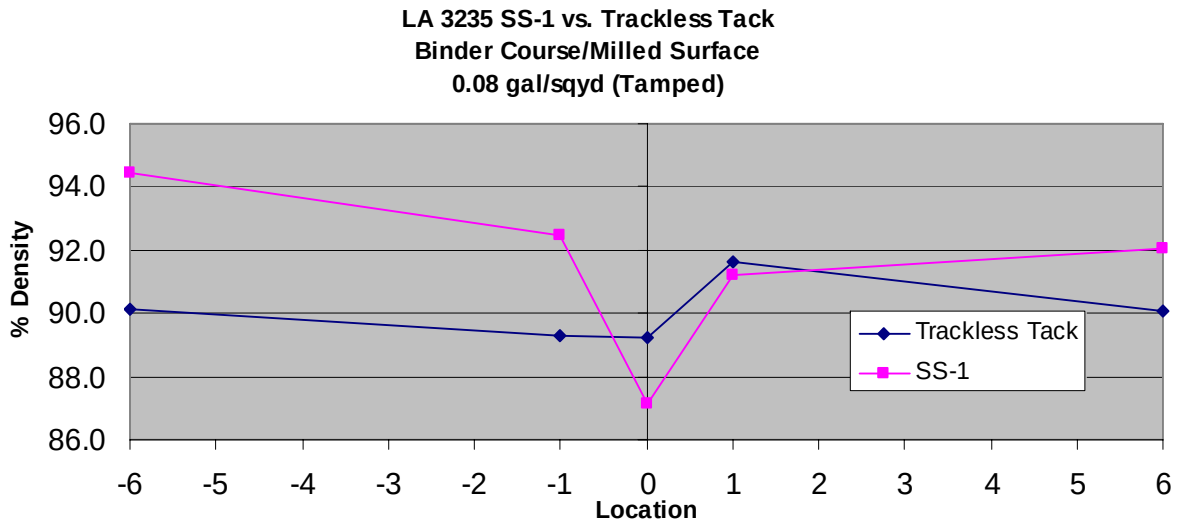
SS-1 vs. Trackless Tack Untamped@ 0.08 gal/sq yd % Avg. Density Comparison Binder Course/Milled Surface			SAS Comparison	
Location	*Trackless Tack*	*SS-1*	*TT*	*SS-1*
-6	92.1	91.7	A	A
-1	91.5	90.9	A	A
0	86.8	87.3	A	A
1	92.8	92.7	A	A
6	92.8	93.5	A	A



Density: *Trackless vs SS-1, 0.08gal/sy, Tamped*

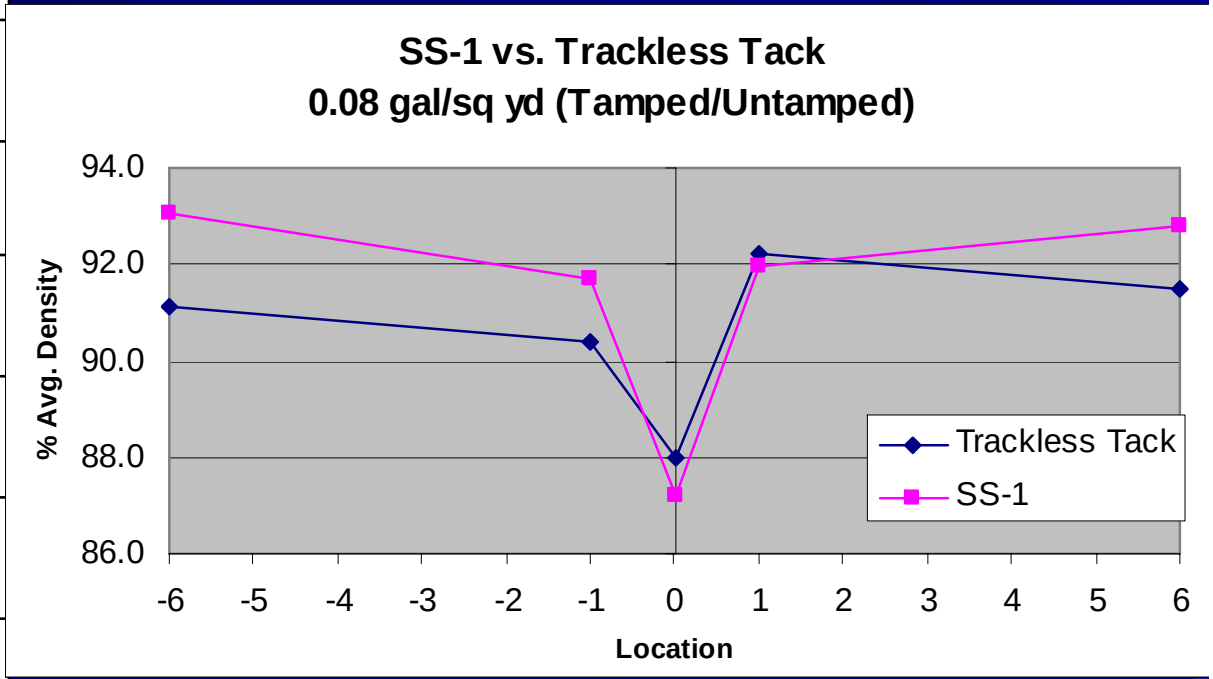
Milled Surface/Binder Course

SS-1 vs. Trackless Tack Tamped @0.08 gal/sq yd %Avg. Density Comparison Binder Course/Milled Surface			SAS Comparison	
Location	*Trackless Tack*	*SS-1*	*TT*	*SS-1*
-6	90.1	94.4	B	A
-1	89.3	92.5	A	A
0	89.3	87.1	A	B
1	91.6	91.2	A	A
6	90.1	92.1	A	A



Density: *Trackless Sections vs. SS-1 Sections, 0.08gal/sy Milled Surface/Binder Course*

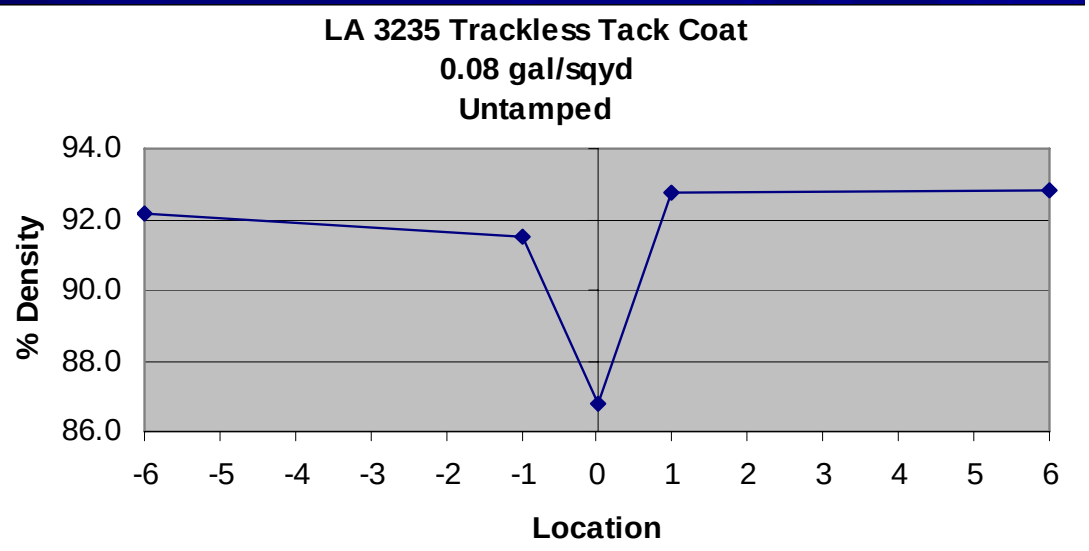
SS-1/Trackless Tack 0.08 gal/sq yd % Avg. Density Comparison Binder Lift (TAMPED/UNTAMPED)			SAS Comparison	
Location	*Trackless Tack*	*SS-1*	*TT*	*SS-1*
-6	91.1	93.1	A	A
-1	90.4	91.7	A	A
0	88.0	87.2	A	A
1	92.2	92.0	A	A
6	91.5	92.8	A	A



LTRC

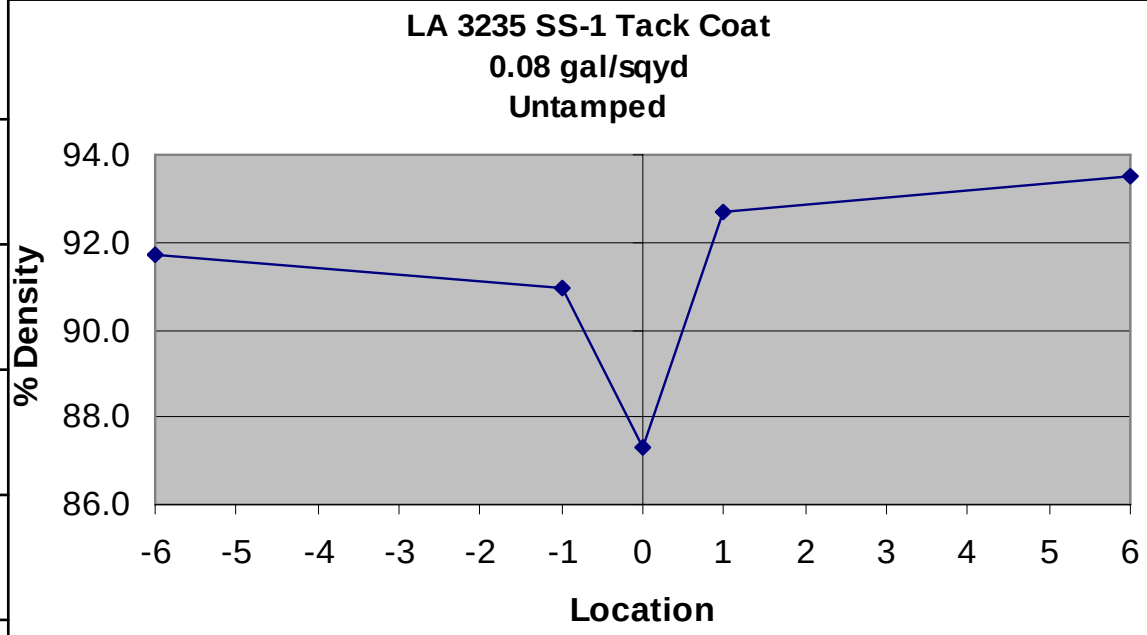
Density: *Trackless*, *0.08gal/sy*, *Untamped* *Milled Surface/Binder Course*

TTC 0.08 Untamped Section				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Analysis
-6	92.1	1.46	1.59	A
-1	91.5	0.64	0.70	A
0	86.8	0.32	0.37	B
1	92.8	0.87	0.93	A
6	92.8	1.38	1.49	A



Density: *SS-1, 0.08gal/sy, Untamped*
Milled Surface/Binder Course

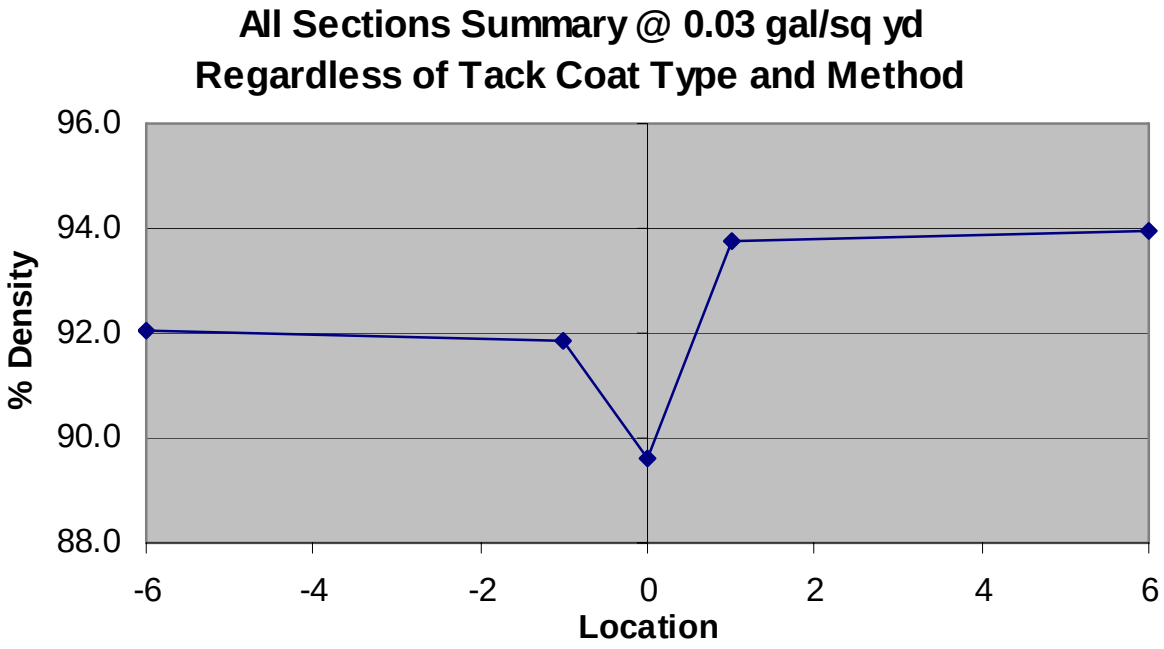
SS-1 Untamped Section				
Location	*% Avg. Density*	*Stdev.*	*%C.V .*	SAS Analysis
-6	91.7	0.42	0.45	B/C
-1	90.9	1.49	1.64	C
0	87.3	0.56	0.65	D
1	92.7	0.63	0.68	B/A
6	93.5	1.15	1.23	A



LTRC

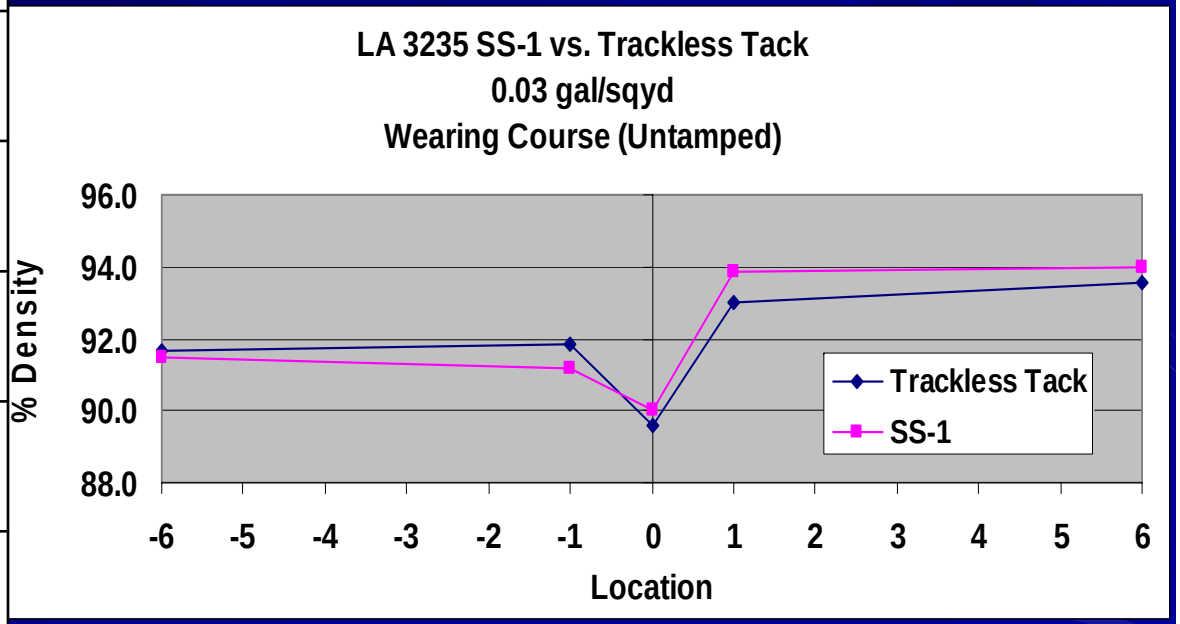
Density: *All Sections, 0.03gal/sy, Wearing Course/Binder Course*

All Sections Summary @ 0.03 gal/sq yd			
Location	*% Avg. Density*	*Stdev.*	*%C.V.*
-6	92.0	1.03	1.12
-1	91.9	1.33	1.45
0	89.6	0.94	1.04
1	93.8	1.16	1.24
6	93.9	0.83	0.89



Density: *Trackless vs. SS-1, 0.03gal/sy, Untamped Wearing Course/Binder Course*

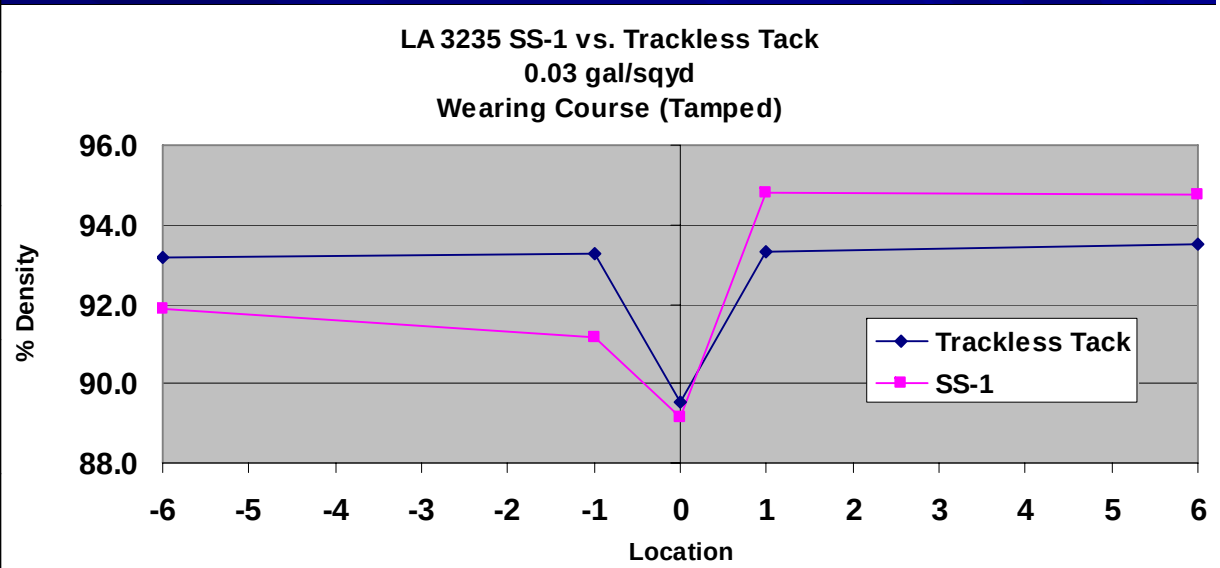
SS-1/Trackless % Avg. Density Comparison @ 0.03 gal/sq yd Wearing Course (Untamped)			SAS Comparison	
Location	*Trackless Tack*	*SS-1*	*TT*	*SS-1*
-6	91.7	91.5	A	A
-1	91.9	91.1	A	A
0	89.6	90.0	A	A
1	93.0	93.9	A	A
6	93.5	94.0	A	A



Density: *Trackless vs. SS-1, 0.03gal/sy, Tamped*

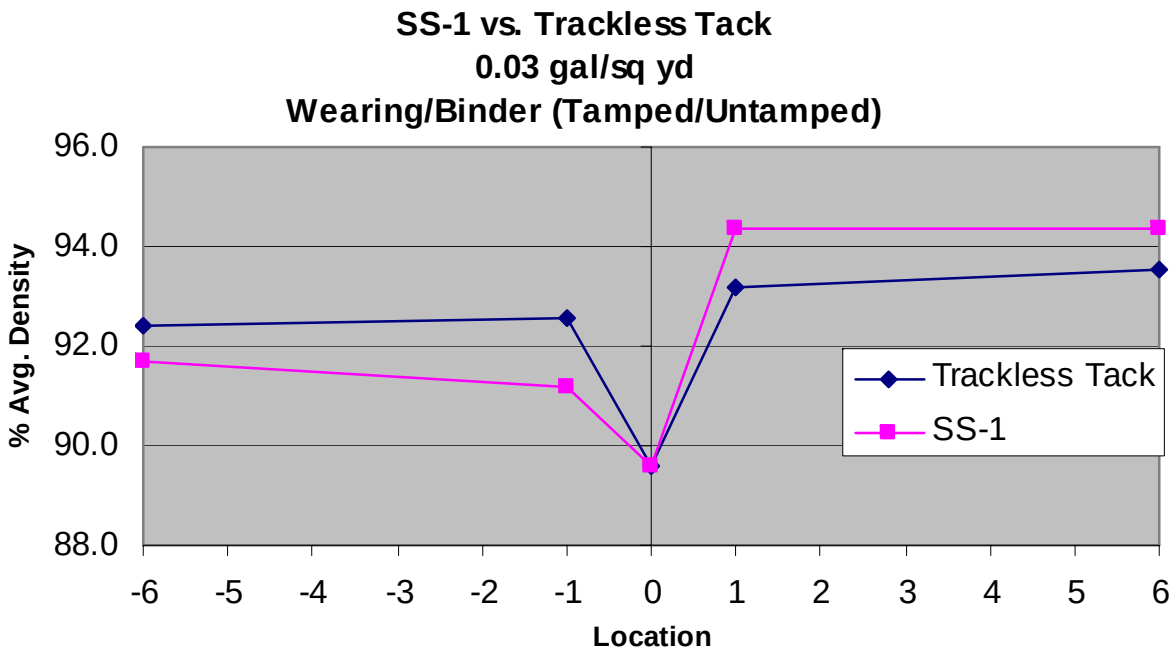
Wearing Course/Binder Course

SS-1/Trackless Tack % Avg. Density Comparison @ 0.03 gal/sq yd Wearing Course (Tamped)			SAS Comparison	
Location	*Trackless Tack*	*SS-1*	*TT*	*SS-1*
-6	93.2	91.9	A	A
-1	93.3	91.2	A	A
0	89.6	89.2	A	A
1	93.3	94.8	A	A
6	93.5	94.8	A	A



Density: *Trackless Sections vs. SS-1 Sections, 0.03gal/sy, Wearing Course/Binder Course*

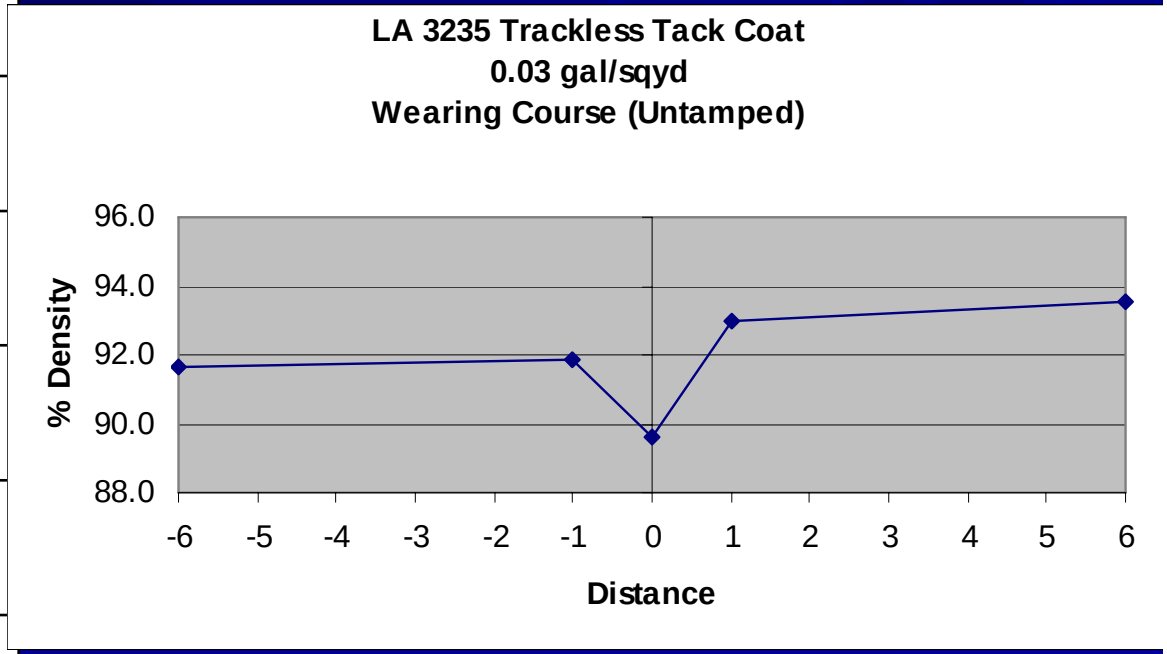
SS-1/Trackless Tack % Avg. Density Comparison @ 0.03 gal/sq yd Wearing Course (Tamped/Untamped)			SAS Comparison	
Location	*Trackless Tack*	*SS-1*	*TT*	*SS-1*
-6	92.4	91.7	A	A
-1	92.6	91.2	A	A
0	89.6	89.6	A	A
1	93.2	94.3	A	A
6	93.5	94.4	A	A



LTRC

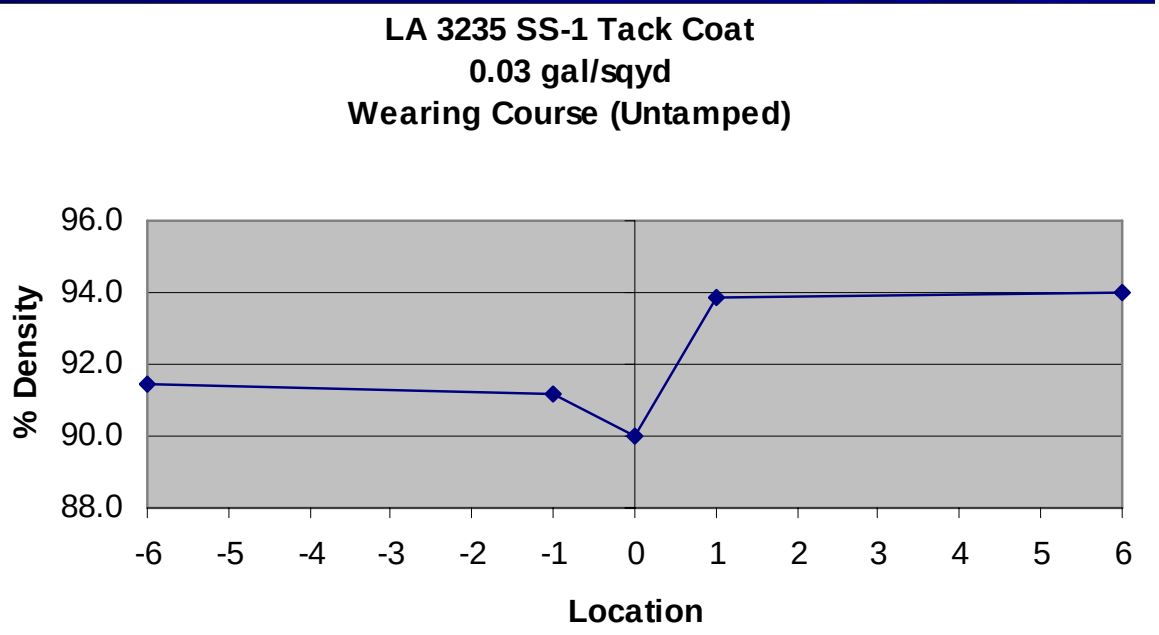
Density: *Trackless, 0.03gal/sy, Untamped*
Wearing Course/Binder Course

Trackless Tack 0.03 gal/sq yd Wearing Course (Untamped)				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Comparison
-6	91.7	0.11	0.12	B
-1	91.9	1.22	1.33	B/A
0	89.6	1.34	1.50	C
1	93.0	1.05	1.13	B/A
6	93.5	0.51	0.55	A



Density: *SS-1, 0.03gal/sy, Untamped*
Wearing Course/Binder Course

SS-1 @ 0.03 gal/sq yd Wearing Course (Untamped)				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Comparison
-6	91.5	0.85	0.93	B
-1	91.1	0.33	0.36	B
0	90.0	1.01	1.12	B
1	93.9	1.02	1.09	A
6	94.0	0.80	0.85	A



Observations

- Longitudinal joint density was lower than mat densities.
- Generally, the cold lane mat had lower densities than the hot lane mat.
  - Wearing/binder courses
  - Trackless Tack Coat and SS-1
- Cold Lane mat had lower densities at the unconfined edge as compared to Hot Lane mat at the confined edge.

Observations

- The 0.08 gal/sq. yd. Trackless Tack Coat yielded overall greater densities than the 0.04 gal/sq. yd. Trackless Tack (Longitudinal Joint Untamped sections).
  - No statistical difference
  - Exception: 1% increase longitudinal joint density @ 0.08 gal/sq. yd. total application rate.
- Density comparison of SS-1 vs. Trackless Tack
  - No statistical difference.
- Similar transverse densities were observed (except LG)
  - Some cases, the statistical analysis comparison of the density profile of the trackless tack vs. the SS-1indicates more uniformity across the mat with the trackless tack.

Observations

- Standard deviation and coefficient of variation is double for binder/milled surface than wearing/binder course
- Density Standard deviation for all LA 3235 & LA 315 cores excluding longitudinal joints, binder & wearing
  - Approx. 1.8 - 1.9%
- Density Standard deviation (Statewide evaluations)
  - Metcalf and Shah – Statistical Evaluation of QA for HMA
    - Year 1960: 1.8%
    - Years 1971-75: 1.7%
    - Years 1975-77: 1.8%
    - Years 1985-97: 1.9%
  - Abadie, Superpave Wearing Course Analysis
    - Years 1997-00: 1.3%
  - Cooper - Statistical Evaluation of PWL Stepped Pay for HMA
    - Years 2004 – 2006: 1.5%

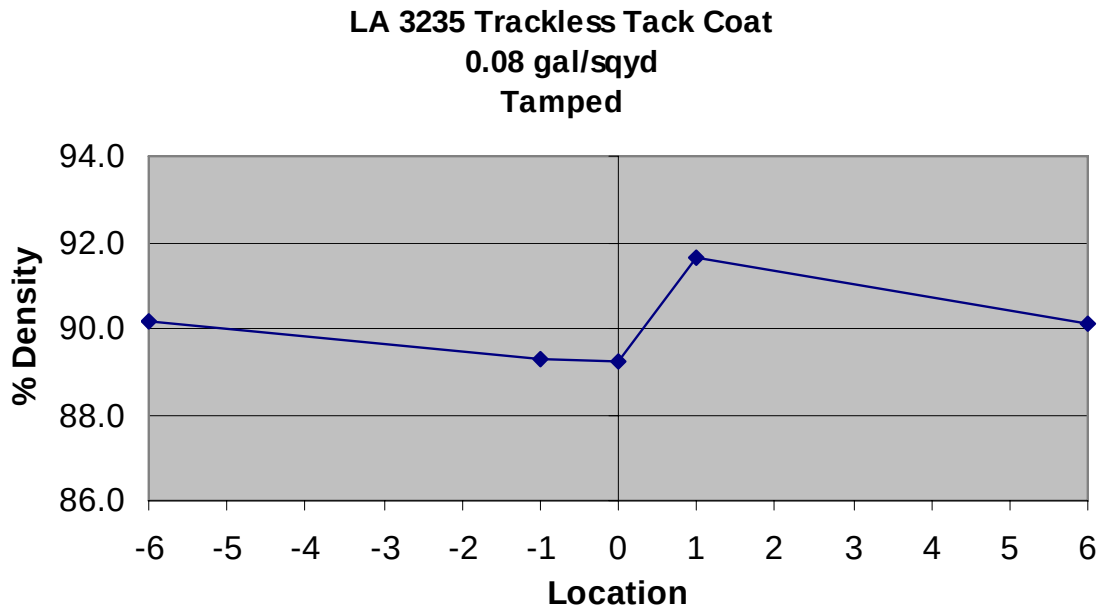
Observations

- Permeability
  - Longitudinal joints permeable
    - Polymer modified/Conventional Emulsion
      - 10 – 100 ft/day
  - Roadway wearing course permeable
- Interface bond strength
  - Milled surface/binder course and milled surface/wearing course inconclusive
    - Effected by condition of underlying existing material
      - Usually stripped and/or delaminated
  - LA 3235 bond strength between binder and wearing course
    - Shear strength increased using Trackless tack vs. SS-1

Thank You

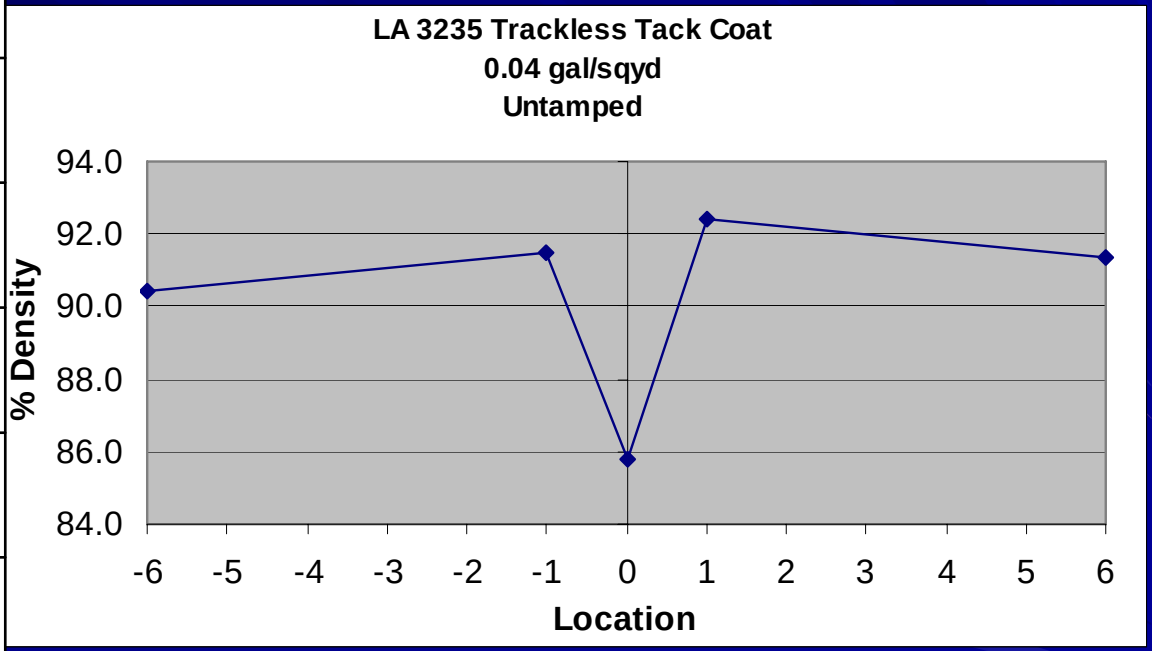
Density: *Trackless, 0.08gal/sy, Tamped*
Milled Surface/Binder Course

TTC 0.08 Tamped Section				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Analysis
-6	90.1	1.73	1.92	A
-1	89.3	2.48	2.78	A
0	89.3	0.44	0.49	A
1	91.6	2.59	2.83	A
6	90.1	3.84	4.27	A



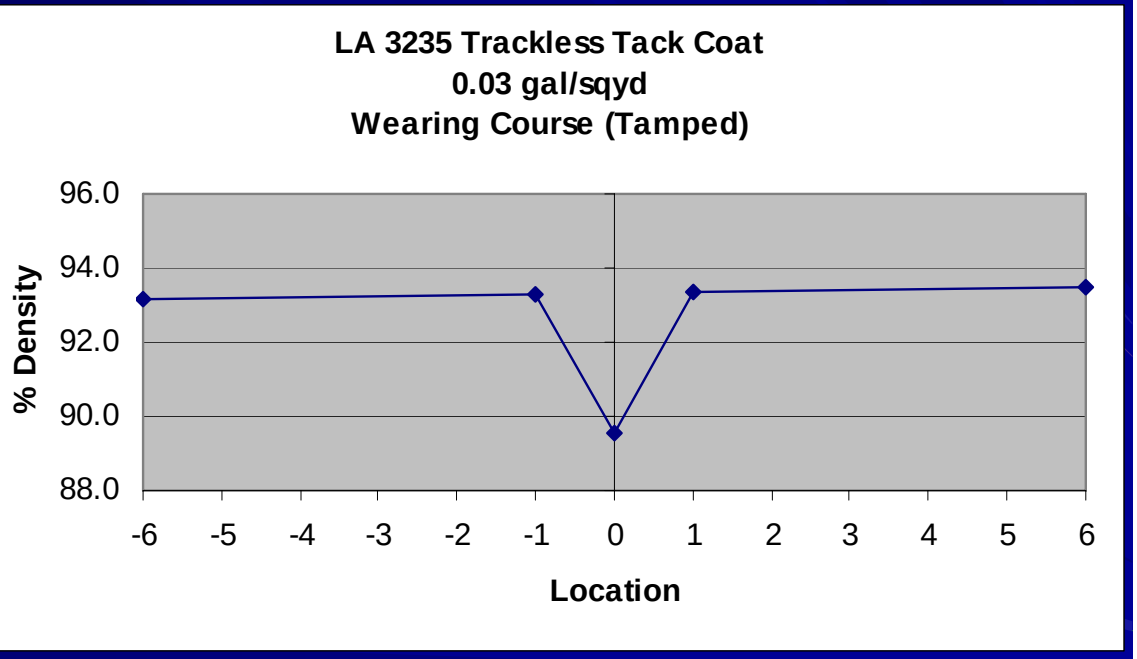
Density: *Trackless*, *0.04gal/sy*, *Untamped* *Milled Surface/Binder Course*

TTC 0.04 Untamped Section Average Density				SAS Analysis
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	
-6	90.4	3.31	3.66	A
-1	91.5	2.13	2.33	A
0	85.8	0.26	0.30	B
1	92.4	0.85	0.92	A
6	91.3	0.15	0.17	A



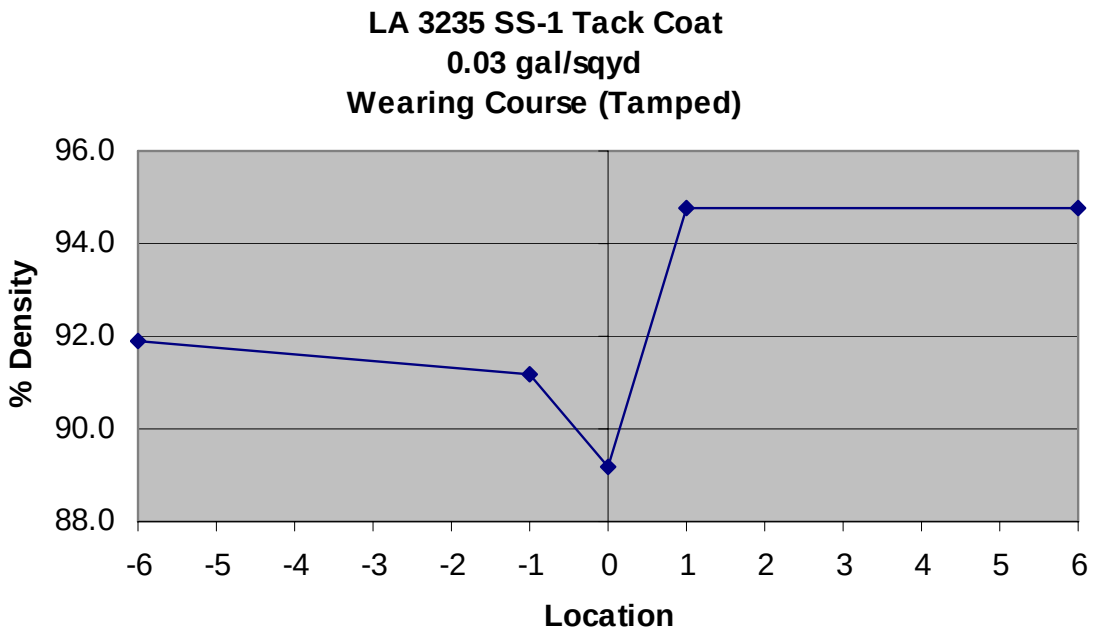
Density: *Trackless, 0.03gal/sy, Tamped*
Wearing Course/Binder Course

Trackless Tack @ 0.03 gal/sq yd Wearing Course (Tamped)				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Comparison
-6	93.2	1.21	1.30	A
-1	93.3	1.10	1.18	A
0	89.6	1.18	1.31	B
1	93.3	1.41	1.51	A
6	93.5	0.70	0.74	A



Density: *SS-1*, *0.03gal/sy*, *Tamped*
Wearing Course/Binder Course

SS-1 @ 0.03 gal/sq yd Wearing Course (Tamped)				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Comparison
-6	91.9	0.98	1.07	B
-1	91.2	1.56	1.71	B
0	89.2	0.21	0.23	C
1	94.8	0.76	0.80	A
6	94.8	0.91	0.96	A



Density: *SS-1, 0.08gal/sy, Tamped*
Milled Surface/Binder Course

SS-1 Tamped Section				
Location	*% Avg. Density*	*Stdev.*	*%C.V.*	SAS Analysis
-6	94.4	1.36	1.44	A
-1	92.5	2.17	2.35	B/A
0	87.1	0.91	1.05	C
1	91.2	0.62	0.68	B
6	92.1	1.43	1.56	B/A