AIM Innovation Showcase Application

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to present the innovation at the Innovation Showcase during the AASHTO Spring Meeting.

1. Sponsoring DOT (State): Utah Department of Transportation

2. Name and Title: Howard James Anderson, State Asphalt Engineer

Organization: Utah Department of Transportation

Street Address: UDOT Laboratories, 4503 S 2700 W

City: Taylorsville

State: UT

Zip Code: 84129

Email: handerson@utah.gov

Phone: 801 633-8770

Innovation Description (30 points)

The term "innovation" may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

Highly-modified, high-density asphalt mix

4. Please describe the innovation.

Using a highly-modified binder and a high-density mix design to create a more durable, more rut-resistant asphalt mixture for use in thick lift and thin lift applications.

5. What is the existing baseline practice that the innovation intends to replace/improve?

Standard polymer-modified mixes have been in used in Utah with good success for some time. UDOT's standard binders are AASHTO M320 "plus" binders with some UDOT "plus" parameters including elastic recovery and ΔT_c requirements. Our typical binder for dense-graded mixes is a PG 64-34 binder.

This innovation replaces a typical modified asphalt binder with a binder that has a higher polymer content, and lowers the design air voids in the mix, driving asphalt contents significantly higher, with improved rutting performance over even SMA pavements. Pavements have been constructed with these mixes with better aggregate utilization and lower cost, while utilizing conventional mixing and paving operations. They are performing remarkably well; longer life is expected because of the lower permeability, greater cracking resistance, and greater strength.

6. What problems associated with the baseline practice does the innovation propose to solve?

Asphalt mix durability and rutting resistance using typical Superpave Mix Design parameters with typical modified performance-graded asphalt binders are good, but higher asphalt content and density would improve durability and better rut resistance would provide for more economical and serviceable pavements. Stone Matrix Asphalt addresses some of these concerns, but at a higher cost and with inferior aggregate utilization.

7. Briefly describe the history of its development.

Traditional mix design targets 96% compaction at a specified gyratory content, typically 75 gyrations in UDOT. These produce good mixes that are rut resistant and perform well in our climate. They are rut-resistant as confirmed with our Hamburg rut-testing.

Knowing that asphalt binder content plays a significant role in durability, UDOT has used stone matrix asphalt mixes with cellulose fiber to allow and suspend more binder in the mix. In dense-graded mixes, we've decreased aggregate size and mix design compaction effort to push for higher asphalt contents and better durability. That has improved our mixes for many years.

Howard has long followed research and information regarding highly-modified asphalts and polymers. Beginning in 2015, he worked with others to specify binders with high polymer contents in our mix designs. He dropped those binders into a couple of pilot projects. Lessons were learned.

More recently, Howard partnered with our binder suppliers to use this new performance-graded binder having a higher polymer content and combined that with a low-void asphalt design concept targeting near-100% compaction content at our typical 75 gyrations, and 99% compaction at 50 gyrations. He specified a PG 76-34 binder with our UDOT “Plus” parameters, something our binder suppliers could readily and reliably produce with the same components they were using for our other binders. These mixes were required to meet our standard Hamburg wheel tracking tests for rutting resistance.

Rigorous laboratory testing proved the concept: A high-asphalt, high-density asphalt mix that was readily compactable and extremely rut resistant. Moreover, it could be compacted in much thicker lifts, where necessary, to reduce weak planes in the asphalt pavement and perhaps simplify traffic control.

In June of 2021 this new mixture was placed ahead and behind the scales of UDOT’s I-80 Wendover Port of Entry in a six-inch lift. Previous asphalt mixes were unable to perform under the stress of slow-moving trucks slowing, stopping, and accelerating. This mix performed very well initially and continues to perform without any significant rutting or deterioration.

Implementation has accelerated rapidly as surprising performance and industry support for better aggregate utilization has led to more projects and change-orders to use this new mix.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation below (if electronic, please provide a separate file). Please list your attachments or weblinks here.

The special provision for the modified asphalt mix is attached.

Other articles include:

https://site.utah.gov/connect/2024/06/27/udot-engineers-new-asphalt-blend-that-is-transforming-the-paving-industry/

https://theasphaltpro.com/articles/utah-thick-lift-stands-up-to-truck-traffic/

http://asphaltmagazine.com/thick-and-rich-in-utah/

Pilot Project Photos, Then and Now

Figure 1 June 2021 Test Strip, Staker Parson Facility

Figure 2 June 2021 Wendover Port of Entry

Figure 4 June 2021 Wendover Port of Entry

Figure 3 August 2024 Wendover Port of Entry, Howard Anderson

Table 1: UDOT AASHTO M320 “Plus” Parameters

PG76-34 Highly Modified		
Original Binder		
Dynamic Shear Rheometer, AASHTO T 315	@ 76° C, G*, kPa	1.30 Min.
	@ 76° C, phase angle, degrees	70. 0 Max.
Rotational Viscometer, AASHTO T 316	@ 135° C, Pa.s	3 Max.
Flash Point, AASHTO T 48	°C	260 Min.
RTFO Residue, AASHTO T 240		
Dynamic Shear Rheometer, AASHTO T 315	@ 76° C, G*/sinδ, kPa	2.20 Min.
Elastic Recovery, AASHTO T 301 mod (a)	%	90 Min.
PAV Residue, 20 hours, 2.10 MPa, 100 °C, AASHTO R 28		
Dynamic Shear Rheometer, AASHTO T 315	@ 25° C, kPa	5,000 Max.
Bending Beam Rheometer, AASHTO T 313	@ -24° C, S, MPa	300 Max. 150 Min.
	@ -24° C, m-value	0.300 Min.
Delta Tc from additional BBR test, ASTM D 7643	@ -30° C	-1.0 Min.
(a) Modify paragraph 4.5 as follows: Stop the ductilometer after 20 cm has been reached and within 2 seconds. Sever the specimen at its center with a pair of scissors.		

State of Development (10 points)

Innovations must be successfully deployed in at least one State DOT. The AIM selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Innovation is fully functional and yet to be piloted.

☒ Innovation has been piloted successfully in an operational environment.

☒ Innovation has been deployed multiple times in an operational environment.

☒ Innovation is ready for full-scale implementation.

After a pilot project in June of 2021, implementation has accelerated in Utah. In 2024, 15 projects were awarded using this new mix in various applications across the state and four binder suppliers have approved Utah PG 76-34 binders for these mixtures.

10. What additional development is necessary to enable implementation of the innovation for routine use?

While additional refinements are expected, these binder and mix specification adjustments are ready for wide implementation as demonstrated in rapidly expanding utilization within UDOT. Implementation in thick-lift applications would be facilitated by larger hoppers or inserts on pavers, and higher-rate mix delivery.

11. Do you have knowledge of other organizations using, currently developing, or showing interest in this innovation? ☒ Yes ☐ No

If so, please list organization names and contacts.

Organization	Name	Phone	Email
Montana DOT	Ross, “Oak,” Metcalf	406 444-9201	rmetcalfe@mt.gov
Idaho DOT	John Arambarri	208 991-7328	john.arambarri@itd.idaho.gov
Colorado DOT	Craig Weiden	720 660-2076	craig.wieden@state.co.us
Asphalt Institute	David Johnson	406 794-7454	djohnson@asphaltinstitute.org

Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice.

12. Identify the top three benefits your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Asset Performance	Greater rutting resistance, expected longer life, and additional options for construction operations using thicker lifts.
Environmental Benefits	Better utilization of aggregates from crushing operations, as the dense-graded designs do not create the waste products of gap-graded designs. More significantly, if these mixes continue to perform as they are, longer life cycles will decrease necessary maintenance and reconstruction, leading to lower overall life-cycle costs and significantly lower overall carbon footprint.
Cost Savings	These mixes are generally less expensive than stone matrix asphalt pavements placed in similar applications. Our 2024 median bid price for highly-modified asphalt mix was $132 per ton across 15 projects. For reference, average prices for dense-graded asphalt mix and stone matrix asphalt are $123 and $144, respectively.

Provide any additional details below:

Deployability (30 points)

The AIM selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

13. What challenges and/or lessons learned should other organizations be aware of before adopting this innovation?

Use a specification that retains the pumpable viscosity requirements of AASHTO M320 for the highly-modified asphalt binders in production.

Implementation can be achieved with a performance specification for binder using available sources. We are aware that elastomeric or SBS type polymers and modifiers already in use will do the job, without prescribing a polymer content.

14. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: Our 2024 median bid price for highly-modified asphalt mix was $132 per ton across 15 projects. For reference, average prices for dense-graded asphalt mix and stone matrix asphalt are $123 and $144, respectively.

Level of Effort: This requires relatively little effort in developing specifications, the greatest effort will be in education and information for industry partners.

Time: From UDOT's first deployment in June of 2021, expansion proceeded quickly to full statewide implementation in three years, with fifteen significant projects in 2024.

15. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

Implementation in Utah included a combined effort between binder suppliers, mix suppliers, contractors, and our Utah Asphalt Pavement Association. The cooperative approach facilitated implementation.

SECTION 2740S

HIGHLY-MODIFIED ASPHALT MIX

PART 1 GENERAL

1.1 SECTION INCLUDES

A. A high-performance asphalt mixture of one or more layers comprised of aggregate, asphalt binder, hydrated lime, an option to incorporate RAP and other additives.

1.2 RELATED SECTIONS

A. Section 01456: Materials Dispute Resolution

B. Section 02701: Pavement Smoothness

C. Section 02742S: Project Specific Surfacing Requirements

D. Section 02745: Asphalt Material

E. Section 02746: Hydrated Lime

F. Section 02748: Prime Coat/Tack Coat

1.3 REFERENCES

A. AASHTO M 323: Superpave Volumetric Mix Design

B. AASHTO R 35: Superpave Volumetric Design for Asphalt Mixtures

C. AASHTO T 11: Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing

D. AASHTO T 19: Bulk Density ("Unit Weight") and Voids in Aggregate

E. AASHTO T 27: Sieve Analysis of Fine and Coarse Aggregates

F. AASHTO T 89: Determining the Liquid Limit of Soils

G. AASHTO T 90: Determining the Plastic Limit and Plasticity Index of Soils

H. AASHTO T 96: Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

I. AASHTO T 104: Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate

J. AASHTO T 112: Clay Lumps and Friable Particles in Aggregate

K. AASHTO T 176: Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

L. AASHTO T 195: Determining Degree of Particle Coating of Asphalt Mixtures

M. AASHTO T 209: Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures

N. AASHTO T 255: Total Evaporable Moisture Content of Aggregate by Drying

O. AASHTO T 278 Surface Frictional Properties Using the British Pendulum Tester

P. AASHTO T 279: Accelerated Polishing of Aggregates Using the British Wheel

Q. AASHTO T 304: Uncompacted Void Content of Fine Aggregate

R. AASHTO T 305: Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

S. AASHTO T 335: Determining the Percentage of Fracture in Coarse Aggregate

T. UDOT Materials Manual of Instruction

U. UDOT Minimum Sampling and Testing Requirements

V. UDOT Quality Management Plans

1.4 DEFINITIONS

A. Longitudinal Joint – Any new asphalt lift abutting an existing paving lift. This includes joints created by echelon paving and new asphalt placed against a milled asphalt edge.

B. Lot – The amount of Asphalt Mix placed in a single Production Day.

C. Minor Target Change – A change from the verified mix design gradation target on a maximum of two sieves with the following limitations.
   1. The maximum change from the verified target gradation on the No. 8 or any coarser sieve is limited to 3 percent passing per sieve.
   2. The maximum change from the verified target gradation on the No. 16 or No. 50 sieves is 2 percent passing per sieve.
   3. The maximum change from the verified target gradation on the No. 200 sieve is 0.5 percent passing.
   4. No target change may violate the mix design requirements in this section.

D. Overband – an 8 inch protective asphalt coating sealing the longitudinal joint of final riding surface, as proposed by the contractor and approved by the Engineer

E. Production Day – A 24 hour period in which Asphalt Mix is being placed.

F. RAP – Recycled Asphalt Pavement. Crushed or milled asphalt materials that have been removed from pavements for recycling.

G. Thin Overlay Pavement – New Asphalt Mix design thickness less than 2 inches.

H. Lane-Leveling – Variable depth paving to correct minor rutting and longitudinal variations in the roadway. Depth varies from the maximum aggregate size to the depth needed to correct variations.

I. Profile leveling - Variable depth paving to correct minor profile variations in the roadway. Depth varies from the maximum aggregate size to the depth needed to correct variations.

1.5 SUBMITTALS

A. Mix design for verification and approval before paving according to UDOT Materials Manual of Instruction Section 960.

B. Changes in job mix design
   1. Submit a written request for any proposed change in the job-mix design
      a. Allow at least 12 hours for approval before incorporating a minor target change into production.
      b. Allow at least six working days for verification and approval of any other change.

2. Include documentation supporting correlation between suggested target changes and mix design volumetric requirements.
    a. Acceptable documentation may include Department or Contractor testing data.
3. Submit samples according to the UDOT Materials Manual of Instruction 960 for a volumetric mix design verification for anything other than approved minor target changes.

C. Corrective action plan for approval according to this Section, Article 3.3, paragraph C2 and Article 3.4, paragraph A4b.

D. Laboratory correlation test results. Refer to this Section, Article 3.4

E. Mat joint layout plan to the Engineer for review before placement.

1.6 ACCEPTANCE

A. Acceptance sampling and testing of material is according to UDOT Minimum Sampling and Testing Requirements in general and following 02741.

B. Gradation and asphalt binder content
1. The Engineer evaluates a lot on the test results of four or more samples, except when only three samples can be taken.
2. Evaluate the lot using the number of tests “n” in Table 3.
3. The Engineer informs the Contractor of the time and place of sampling not more than 15 minutes before sampling.
4. Increase sample sizes to accommodate validation or third-party testing as required.

C. Density and Thickness
1. Obtain cores from the mat and longitudinal joint within two calendar days after the pavement is placed and according to UDOT Materials Manual of Instruction, Section 984.
    a. The Engineer marks coring location for in-place mat density and longitudinal joint density cores.
    b. Fill core holes with Asphalt Mix, SMA or high-asphalt-content cold mix and compact in thin lifts within 24 hours and before returning to traffic.
    c. The Department witnesses the coring operation, takes possession of the cores immediately, and begins testing the cores within 24 hours for density acceptance.

2. Density Requirements
   a. The target for in-place density for the top three inches of the mat is 96.0 percent of Theoretical Maximum Specific Gravity.
   b. For information only, take the remaining lower portion of the core and test and report the density, percent of Theoretical Maximum Specific Gravity.
   c. The target for in-place density for the longitudinal joint is 94.0 percent of the Theoretical Maximum Specific Gravity (G_{mm}).
   d. The target for in-place density is 96.0 percent of theoretical maximum specific gravity for thin overlay pavements.
      1) Do not take longitudinal joint cores for thin overlay pavements.
3. Thickness is evaluated with mat density cores. The thickness requirement may be waived when matching up to existing pavement, curb and gutter for Pavement in or next to intersections.
   a. The Department accepts a lot for thickness when:
      1) The average thickness is not more than ½ inch greater or ¼ inch less than the total design thickness specified.
      2) No individual sublot shows a deficient thickness of more than ⅜ inch.
   b. Excess Thickness – The Engineer may allow excess thickness to remain in place or may order its removal.
      1) The Department pays for 50 percent of the mix for material in excess of the +½ inch tolerance when excess thickness is allowed to remain in place.
   c. Deficient Thickness – Place additional material where lots or sublots are deficient in thickness.
      1) The Department pays for material necessary to reach specified thickness.
      2) The Department pays for 50 percent of the mix for additional material over specified thickness necessary to achieve minimum lift thickness.
      3) Minimum compacted lift is 3 times the nominal maximum aggregate size.
   d. Thickness tolerances established above do not apply to leveling courses.
      1) Check final surfaces in staged construction.
   e. Check thickness regularly with a depth probe during placement and take corrective action as necessary.

4. Longitudinal Joint
   a. The edge of a new asphalt mat may be removed for the purpose of meeting longitudinal joint density requirements.
      1) The material wasted is still included in the payment.
      2) Up to 3 inches for a confined edge is allowed.
      3) Up to 6 inches for an unconfined edge is allowed.

D. The Department applies one Incentive/Disincentive for the lowest dollar value for Gradation/Asphalt Content, one Incentive/Disincentive for In-Place Mat Density, and one Incentive/Disincentive for Longitudinal Joint Density. The Engineer computes Incentives/Disincentives as follows for each lot
   1. Compute incentive/disincentive for Gradation/Asphalt Binder and In-place Mat Density and Longitudinal Joint Density according to Table 1.
   2. Base the incentive/disincentive on Percent within Limit (PT) computation using Tables 2, 3, and 4.
   3. Use lowest single PT value combined for gradation (each of the sieves) and asphalt binder content for calculating the gradation/asphalt binder content incentive/disincentive.
   4. Use Tables 2, 3, and 4 to determine PT for in-place Mat Density and Longitudinal Joint Density.
   5. Meet PT of 88 or greater for in-place mat density or the Department does not pay incentives on joint density or gradation/asphalt binder content except for lane-leveling material.
   6. The Department pays or assesses the longitudinal joint density incentive/disincentive per ton of Asphalt Mix placed adjacent to, and on the hot side of the longitudinal joint for each lift:
      a. The incentive/disincentive will be calculated from the core densities taken from all abutting joints if the Asphalt Mix mat has a longitudinal joint on more than one side.

E. The Department applies incentive/disincentive for smoothness according to Section 02701.
   1. Refer to Section 02701 for smoothness requirements.

F. The Department rejects lots:
   1. If the PT for any individual gradation measurement is less than 52 percent as shown in Table 1.
   2. If the PT for asphalt binder content or mat density measurement is less than 60 percent as shown in Table 1.

3. The Engineer may accept a reject or non-conforming lot. Refer to Section 01456.
    a. A price reduction of 35 percent of the pay item or $20 per ton, whichever is greater, will be assessed.
    b. The lot will not be eligible for any incentive.

G. The Engineer may elect to accept material on visual inspection according to the Minimum Sampling and Testing Requirements.
  1. Incentives/Disincentives are not applied to material accepted visually.
  2. The Engineer reserves the option of conducting any acceptance tests necessary to determine that the material and workmanship meets the project requirements.

H. Meet production control requirements of Table 10.
  1. Material placed within the Cease Production Limit in Table 10 is not eligible for incentives.

1.7 DISPUTE RESOLUTION

A. Refer to Section 01456 when disputing the validity of the Department's acceptance tests.

Table 1

Incentive/Disincentive for Asphalt Binder Content, and Mat Density	
PT Based on Min. Four Samples	**Incentive/Disincentive (Dollars/Ton)**
>99	2.00
96-99	1.50
92-95	1.00
88-91	0.00
84-87	-0.26
80-83	-0.60
76-79	-0.93
72-75	-1.27
68-71	-1.60
64-67	-1.93
60-63	-2.27
<60	Reject
Incentive/Disincentive for Gradation	
PT Based on Min. Four Samples	**Incentive/Disincentive (Dollars/Ton)**
>99	2.00
96-99	1.50
92-95	1.00
88-91	0.00
84-87	-0.26
80-83	-0.60
76-79	-0.93
72-75	-1.27
68-71	-1.60
64-67	-1.93
60-63	-2.27
56-59	-5.00
52-55	-10.00
<52	Reject
Incentive/Disincentive for Longitudinal Joint Density	
PT Based on Min Four Samples	**Incentive/Disincentive (Dollars/Ton)**
>99	2.00
96-99	1.50
92-95	1.00
88-91	0.00
84-87	-0.26
80-83	-0.60
76-79	-0.93
72-75	-1.27
68-71	-1.60
64-67	-1.93
60-63	-2.27
56-59	-2.60
52-55	-5.00
<52	Apply $5 penalty and Overband Longitudinal Joint if Final Surface Lift

Table 2

Upper and Lower Limit Determination	
Parameter	**UL and LL**
⅜ inch sieve for ½ inch Asphalt Mix No. 4 sieve for ⅜ inch Asphalt Mix	Target Value ± 6.0%
No. 8 sieve	Target Value ± 5.0%
No.50 sieve	Target Value ± 3.0%
No. 200 sieve	Target Value ± 2.0%
Asphalt Binder Content	Target Value ± 0.35%
Mat Density	Lower Limit Target Value - 2.0% Upper Limit Target Value + 3.0%
Longitudinal Joint Density	Lower Limit Target Value - 2.0% Upper Limit Target Value + 5.0%

Table 3

Use the appropriate "number of tests" column and round down to the nearest value.

Quality Index Values (QU or QL) for Estimating Percent Within Limits										
PU or PL	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=10**	**n=12**	**n=15**	**n=20**
100	1.16	1.50	1.75	1.91	2.06	2.15	2.29	2.35	2.47	2.56
99	1.16	1.47	1.68	1.79	1.89	1.95	2.04	2.09	2.14	2.19
98	1.15	1.44	1.61	1.70	1.77	1.80	1.86	1.89	1.93	1.97
97	1.15	1.41	1.55	1.62	1.67	1.69	1.74	1.77	1.80	1.82
96	1.15	1.38	1.49	1.55	1.59	1.61	1.64	1.66	1.69	1.70
95	1.14	1.35	1.45	1.49	1.52	1.54	1.56	1.57	1.59	1.61
94	1.13	1.32	1.40	1.44	1.46	1.47	1.49	1.50	1.51	1.53
93	1.12	1.29	1.36	1.38	1.40	1.41	1.43	1.43	1.44	1.46
92	1.11	1.26	1.31	1.33	1.35	1.36	1.37	1.37	1.38	1.39
91	1.10	1.23	1.27	1.29	1.30	1.31	1.32	1.32	1.32	1.33
90	1.09	1.20	1.23	1.24	1.25	1.25	1.26	1.26	1.27	1.27
89	1.08	1.17	1.20	1.21	1.21	1.21	1.21	1.21	1.22	1.22
88	1.07	1.14	1.16	1.17	1.17	1.17	1.17	1.17	1.17	1.17
87	1.06	1.11	1.12.	1.12	1.12	1.13	1.13	1.13	1.13	1.13
86	1.05	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
85	1.03	1.05	1.05	1.05	1.05	1.04	1.04	1.04	1.04	1.04
84	1.02	1.02	1.02	1.01	1.01	1.01	1.00	1.00	1.00	1.00
83	1.00	0.99	0.98	0.97	0.97	0.96	0.96	0.96	0.96	0.96
82	0.98	0.96	0.95	0.94	0.94	0.93	0.93	0.92	0.92	0.92
81	0.96	0.93	0.92	0.91	0.90	0.90	0.89	0.89	0.89	0.88
80	0.94	0.90	0.88	0.87	0.86	0.86	0.85	0.85	0.85	0.85
79	0.92	0.87	0.85	0.84	0.83	0.83	0.82	0.82	0.82	0.81
78	0.89	0.84	0.82	0.81	0.80	0.79	0.79	0.78	0.78	0.78
77	0.87	0.81	0.79	.0.78	0.77	0.76	0.76	0.75	0.75	0.75
76	0.84	0.78	0.76	0.75	0.74	0.73	0.72	0.72	0.72	0.72
75	0.82	0.75	0.73	0.72	0.71	0.70	0.69	0.69	0.69	0.68
74	0.79	0.72	0.70	0.68	0.67	0.67	0.66	0.66	0.66	0.65
73	0.77	0.69	0.67	0.65	0.64	0.64	0.62	0.62	0.62	0.62
72	0.74	0.66	0.64	0.62	0.61	0.61	0.60	0.59	0.59	0.59
71	0.71	0.63	0.60	0.59	0.58	0.58	0.57	0.56	0.56	0.56
70	0.68	0.60	0.58	0.56	0.55	0.55	0.54	0.54	0.54	0.53
69	0.65	0.57	0.55	0.54	0.53	0.52	0.51	0.51	0.51	0.50
68	0.62	0.54	0.52	0.51	0.50	0.50	0.48	0.48	0.48	0.48
67	0.59	0.51	0.49	0.48	0.47	0.47	0.46	0.45	0.45	0.45
66	0.56	0.48	0.46	0.45	0.44	0.44	0.43	0.42	0.42	0.42
65	0.53	0.45	0.43	0.42	0.41	0.41	0.40	0.40	0.40	0.39
64	0.49	0.42	0.40	0.39	0.38	0.38	0.37	0.37	0.37	0.37
63	0.46	0.39	0.37	0.36	0.35	0.35	0.35	0.34	0.34	0.34
62	0.43	0.36	0.34	0.33	0.33	0.33	0.32	0.31	0.31	0.31
61	0.39	0.33	0.31	0.30	0.30	0.30	0.29	0.29	0.29	0.28
60	0.36	0.30	0.28	0.27	0.26	0.26	0.25	0.25	0.25	0.25
59	0.32	0.27	0.25	0.25	0.24	0.24	0.24	0.23	0.23	0.23

Table 3 Continued										
PU/PL	**n=3**	**n=4**	**n=5**	**n=6**	**n=7**	**n=8**	**n=10**	**n=12**	**n=15**	**n=20**
58	0.29	0.24	0.23	0.22	0.21	0.21	0.21	0.21	0.21	0.20
57	0.25	0.21	0.20	0.19	0.19	0.19	0.18	0.18	0.18	0.18
56	0.22	0.18	0.17	0.16	0.16	0.16	0.16	0.16	0.15	0.15
55	0.18	0.15	0.14	0.14	0.13	0.13	0.13	0.13	0.13	0.13
54	0.14	0.12	0.11	0.11	0.11	0.11	0.10	0.10	0.10	0.10
53	0.11	0.09	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
52	0.07	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05
51	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4

Definitions, Abbreviations, and Formulas for Acceptance	
Term	**Explanation**
Target Value (TV)	The target values for gradation and asphalt binder content are given in the Contractor’s volumetric mix design. See this Section, Article 1.6 for density target values.
Average (AVE)	The sum of the lot’s test results for a measured characteristic divided by the number of test results–the arithmetic mean.
Standard Deviations (s)	The square root of the value formed by summing the squared difference between the individual test results of a measured characteristic and AVE, divided by the number of test results minus one.
Upper Limit (UL)	The value above the TV of each measured characteristic that defines the upper limit of acceptable production. (Table 2)
Lower Limit (LL)	The value below the TV of each measured characteristic that defines the lower limit of acceptable production. (Table 2)
Upper Quality Index (QU)	QU = (UL - AVE)/s
Lower Quality Index (QL)	QL = (AVE - LL)/s
Percentage of Lot Within UL (PU)	Determined by entering Table 3 with QU.
Percentage of Lot Within LL (PL)	Determined by entering Table 3 with QL.
Total Percentage of Lot Within UL and LL (PT)	PT = (PU + PL) – 100
Incentive/Disincentive	Determined by entering Table 1 with PT or PL.

PART 2 PRODUCTS

2.1 ASPHALT BINDER

A. Use PG 76-34 Highly Modified Binder. Refer to Section 02745 and Quality Management Plan 509.

B. Use a minimum total asphalt binder content according to Table 8.

2.2 AGGREGATE

A. Crusher produced virgin aggregate material consisting of crushed stone, gravel, or slag.

B. Refer to Table 5 to determine the suitability of the aggregate.
   1. Coarse aggregates
      a. Retained on No. 4 sieve, AASHTO T 27
   2. Fine aggregates
      a. Clean, hard grained, and angular
      b. Passing the No. 4 sieve, AASHTO T 27

C. Meet the gradation requirements in Table 6. (AASHTO T 11, AASHTO T 27)

Table 5

Aggregate Properties – Highly-Modified Asphalt Mix		
Test Method	**Test No.**	**50 Design Gyrations**
One Fractured Face	AASHTO T 335	95% minimum
Two Fractured Faces	AASHTO T 335	90% minimum
Fine Aggregate Angularity	AASHTO T 304	45 minimum
Flakiness Index	UDOT MOI 933 (Based on ⅜ inch sieve and above)	17% maximum
L.A. Wear	AASHTO T 96	35% maximum
Sand Equivalent	AASHTO T 176, alternate method 2, pre-wet method (test the sample in the wet condition).	60 minimum
Plasticity Index	AASHTO T 89 and T 90	0
Unit Weight	AASHTO T 19	minimum 75 lb/ft^3
Polishing	AASHTO T 278 and T 279	31 minimum
Soundness (sodium sulfate)	AASHTO T 104	16% maximum loss with five cycles
Clay Lumps and Friable Particles	AASHTO T 112	2% maximum
Natural Fines	N/A	0%

Table 6

Aggregate Gradations (Percent Passing by Dry Weight of Aggregate)			
Sieve Size		**½ inch**	**⅜ inch**
Control Sieves	**¾ inch**	100.0	
	½ inch	90.0 – 100.0	100.0
	⅜ inch	< 90	90.0 - 100.0
	No. 4		< 90
	No. 8	28.0 - 58.0	32.0 - 67.0
	No. 200	2.0 – 10.0	2.0 – 10.0

2.3 ADDITIVES / STABILIZERS

A. Hydrated Lime:
Meet the requirements of Section 02746.

B. Notify the engineer of all warm mix additives used on the project.

2.4 RECLAIMED ASPHALT PAVEMENT (RAP) (OPTIONAL)

A. Do not adjust the asphalt binder grade.

B. Do not use more than 15 percent RAP.

C. RAP aggregate is required to meet Table 5 with exception of Sand Equivalent. Refer to AASHTO T 176.

2.5 VOLUMETRIC MIX DESIGN

A. Perform Superpave Volumetric Mix Design according to UDOT Materials Manual of Instruction Section 960 and the following:
   1. Incorporate hydrated lime into all designs. Refer to Section 02746.
   2. Comply with Table 7 and Table 8.

B. Obtain Department approval for the mix design. Refer to the UDOT Materials Manual of Instruction Section 960.
   1. Submit for verification and approval.
   2. Do not begin paving until verification is complete.

Table 7

Volumetric Design Gyrations			
Compaction Parameters			**Voids Filled with Asphalt (VFA) (%)**
$N_{initial}$ /% of G_{mm}*	**N_{design} /% of G_{mm}***	**N_{max} /% of G_{mm}***	
5 /≤ 91.5	50 / ≥ 98.75	75 /≤ 100	90 - 95

* G_{mm}: Theoretical maximum specific gravity of the mix. Refer to AASHTO T 209.

Table 8

Minimum Asphalt Binder Content	
Combined Aggregate Bulk Specific Gravity Including Lime G_{sb}	Minimum Asphalt Binder Content %*
2.375 - 2.424	6.8
2.425 - 2.474	6.7
2.475 - 2.524	6.6
2.525 - 2.574	6.5
2.575 - 2.624	6.3
2.625 - 2.674	6.2
2.675 - 2.724	6.1
> 2.724	6.0
* Percent of total mix.	

Table 9

Mix Design Requirements	
Asphalt Mix design mixing and compaction temperatures	Provided by the approved mix design
Dust Proportion Range	0.6 - 1.40
Voids in Mineral Aggregate (VMA) at N_{design} AASHTO R 35.9.2 using G_{sb} Oven Dry. Equation based on percent of total mix.	15.0% - 17.0% for ½ inch 16.0% - 18.0% for ⅜ inch
Air voids at N_{design}	0.75 - 1.25%
Voids Filled with Asphalt (VFA) at N_{design}	90.0 – 95.0
Hamburg Wheel Tracker UDOT MOI 990, Slab and or puck air voids 3.5 – 4.5% Water temperature: 54º C	< 10.0 mm at 20,000 Passes
Draindown (AASHTO T 305)	0.3 maximum

2.6 CONTRACTOR INITIATED CHANGES TO MIX DESIGN

A. The Department may allow up to two minor target changes to the most current verified mix design per project, per mix design, without penalty to the Contractor.
   1. The Department charges $1,000 for each additional minor target change.

B. The Department performs up to two volumetric mix design verifications per project, per mix design, at no cost to the Contractor.
   1. The Department charges $3,000 for each additional laboratory or field verification required including all laboratory or field volumetric mix design verifications required due to contractor initiated target changes.

C. Submit requests in writing to the Engineer at least 12 hours before incorporating changes into production.
   1. Include documentation supporting correlation between suggested minor target change and mix design volumetric requirements.
   2. Acceptable documentation may include Department or Contractor testing data.
   3. The Region Materials Engineer approves the target change if the mix meets the requirements.

D. Do not make changes to production mix until the request is approved.

E. Submit a new laboratory volumetric mix design for any change made to mix design properties other than gradation.

1. When adding or modifying an additive/stabilizer to the mix design, only the portions of the verification affected by the addition or modification of the additive/stabilizer need to be verified.

F. The Engineer may require Hamburg Wheel-Track testing after a target change to evaluate the performance of the mix with the target change.

2.7 TACK COAT

A. Refer to Section 02748.

PART 3 EXECUTION

3.1 HIGHLY-MODIFIED ASPHALT MIX

A. Dry aggregate to an average moisture content of not more than 0.2 percent by weight.
   1. May be verified by AASHTO T 255.
   2. Adjust burners to avoid damage or soot contamination of the aggregate.

B. Treat aggregate with hydrated lime. Refer to Section 02746.
   1. Method A or B
   2. The Department applies a deduction for mix produced by a non-certified supplier to cover the costs of inspection.
      a. The deduction is applied according to the UDOT Quality Management Plan 514.

C. Coat with asphalt binder 100 percent of the particles passing and 98 percent of the particles retained on the No. 4 sieve.
   1. May be verified by AASHTO T 195.
   2. Discontinue operation and make necessary corrections if material is not properly coated.

D. Maintain temperature of the Asphalt Mix between the limits identified on the Volumetric Mix Design Verification Letter for mixing and compacting.
   1. The Department rejects materials heated over the identified limits.
   2. Remove all material rejected by the Department for overheating.

E. Minimum compacted lift thickness is 3 times the nominal maximum aggregate size.

3.2 ASPHALT MIX PLANT

A. Provide the following:
   1. Positive means to determine the moisture content of aggregate on a daily basis.
   2. Positive means to sample all material components.
   3. Sensors to measure the temperature of the Asphalt Mix at discharge.
   4. The ability to maintain discharge temperature of the mix according to the mix design.

B. Asphalt Binder Storage Tanks
   1. Provide a positive means for separating and identifying asphalt grades when multiple products are used in mix production.

2. Provide positive means of determining the quantity of material in the tank at any time.
3. Provide a positive means of sampling the asphalt binder from the tanks.
    a. The Engineer determines a common sampling point where multiple products are used in mix production.

3.3 PRODUCTION CONTROL LIMITS

A. Apply the production control requirements as outlined in Table 10.

B. Action Limit
1. Take appropriate action when air voids or VMA at N_{des} averaged for each lot are within the Action Limit.
2. Continue paving the next scheduled work day at the Contractors discretion.
3. Enter into the Cease Production Limit after three (3) consecutive production lots within the Action Limit.

C. Cease Production Limit
1. Take appropriate action when air voids or VMA at N_{des} averaged for each lot are within the cease Production Limit.
2. Submit a letter to the Engineer providing information on production changes to be made along with Contractor volumetric data verifying the results.
3. Suspend paving until Contractor provides test results from a minimum of two samples meeting the gradation and asphalt content requirements in Table 2 and air void and VMA requirements for the proceed limit in Table 10
    a. Produce and place material for Cease Production evaluation at a location outside of the project limits.
    b. Allow UDOT 24 hours to review the volumetric data.
    c. After to two (2) occurrences per project per year of ceased production, contract time may be added for the necessary days missed to correct the cease production item(s).
        1) Submit critical path information for evaluation.
        2) Maximum ten (10) calendar days per project.
4. The Engineer may require a new mix design after two (2) cease-production lots.

Table 10

Production Control for VMA		
VMA (%) Range from Target Value (TV) X = Average Value (Minimum of three Samples)	**Air Voids (%) Range from Target Value (TV) X = Average Value (Minimum of three Samples)**	**Action**
X > TV - 1.3 and X < TV + 1.3	X > TV - 1.0 and X < TV + 1.3	Proceed Limit
X ≤ TV - 1.3 and X ≥ TV - 1.5 or X ≥ TV + 1.3 and X ≤ TV + 1.5	X ≤ TV - 1.0 and X > TV - 1.5 or X ≥ TV + 1.3 and X < TV + 1.8	Action Limit This Section, Article 3.3.B
X < TV - 1.5 or X > TV + 1.5	X ≤ TV - 1.5 or X ≥ TV + 1.8	Cease Production Limit This Section, Article 3.3.C

3.4 LABORATORY CORRELATION

A. Perform split-sample, paired *t*-testing with the Department based on project quality control testing using Department-qualified lab.
   1. Perform split-sample, paired *t* analysis on all mix acceptance tests and tests related to volumetric properties.
   2. Perform paired *t* analysis as defined in the UDOT Materials Manual of Instruction, Appendix C.
   3. Continue paired *t*-testing until at least two consecutive production days meet $\alpha = 0.05$ for a two tailed distribution.
   4. Resolve discrepancies in lab results within the first five production days.
      a. Cease production if the requirements for two consecutive days of the first five days cannot be met.
      b. Submit a corrective action plan to the Engineer before production continues indicating the changes in procedures that will be implemented to correct the deficiencies.
      c. Both Contractor and Department labs must make paired *t* test results available within 24 hours of sampling.

3.5 SURFACE PREPARATION

A. Locate, reference, and protect all utility covers, monuments, curb and gutter, and other components affected by the paving operations.

B. Remove all moisture, dirt, sand, leaves, and other objectionable material from the prepared surface before placing the tack coat and mix.

C. Complete spot leveling, lane-leveling or profile leveling before placing pavement courses.
   1. Place, spread, and compact leveling mix on portions of the existing surface.
   2. Fill and compact any localized potholes more than 1 inch deep.
   3. Allow compacted mix to cool sufficiently to below 150 degrees F to provide a stable structural platform before placing additional lifts of Asphalt Mix.

D. Apply tack coat to all paved surfaces and longitudinal and transverse joints before applying a leveling course or pavement lift as required in Section 02748.

E. Allow sufficient cure time for prime coat/tack coat before placing Asphalt Mix. Refer to Section 02748.

3.6 SURFACE PLACEMENT

A. Adjust the production of the mixing plant and material delivery until a steady paver speed is maintained.

B. Do not allow construction vehicles, general traffic, or rollers to pass over the uncompacted end or edge of freshly placed mix until the mat temperature drops to a point where damage or differential compaction will not occur

C. Echelon paving is the preferred method for constructing a longitudinal joint. When full-width or Echelon paving is impractical and more than one pass is required, provide a compactable sloped edge adjacent to the next pass.
   1. Coat edge with tack coat according to Section 02748 at the same application rate as the surface placement.
      a. Angle nozzle to allow for proper application on the vertical or sloped edge.
      b. Provide a 6 inch overlap of tack coat beyond the longitudinal and transverse joints.

D. Construct the longitudinal joint to within 6 inches of the roadway centerline, the lane lines or at the center of the lane but never in a wheel path. Offset longitudinal joints 6 to 12 inches in succeeding courses.
   1. Core and test all longitudinal joints for compaction according to the specification if the lift is 2 or more inches thick.
   2. Verify all edges of the adjacent areas to through lanes have straight and uniform longitudinal lines and neat vertical edges.
   3. Fill core holes with Asphalt Mix, SMA, or high-asphalt-content cold mix and compact in thin lifts.

E. Offset transverse construction joints at least 6 ft longitudinally.

F. Taper the end of a course subjected to traffic at approximately 50:1 (horizontal to vertical).
   1. Make a transverse joint by saw or wheel cutting and remove the portion of the pass that contains the tapered end before placing fresh mix.
   2. Tack the contact surfaces before fresh mix is placed against the compacted mix.

G. Use a Material Transfer Vehicle (MTV) to apply all courses of asphalt mix. Use an MTV that internally performs additional mixing of the asphalt mix and then deposits material into the paver at a uniform temperature and consistency.
   1. Use other approved means to deposit material into the paver when an MTV is impractical, placements such as utility work, traffic signals, detours, lane leveling, and driveways, side street tie-ins, other hand work, or small projects with plan quantities less than 500 tons.

H. Use a laydown machine for all lane-leveling and profile leveling activities.
   1. Place and drag the screed of the paving machine along the high portions of the roadway when lane-leveling to correct, rutting, minor variations and covering roadway crack seal material.
   2. Use a string line or follow a given profile when profile leveling to establish a best fit profile from high point to high point.

3.7 COMPACTION

A. Compact the asphalt mixture to meet density requirements without crushing aggregates.

B. Adjust compaction methods over bridge decks and approach slabs to avoid damage to the structures and appurtenances.
   1. Do not use vibratory compaction with large rollers on bridge decks or approach slabs.

2. Adjust the rolling patterns to achieve specified density without vibratory compaction.

3. Use a small compactor or a vibratory roller weighing less than ½ ton in addition to normal rolling to compact material adjacent to expansion joints, parapets, drainage inlets and other features.

C. Operate compaction equipment in a transverse direction next to the sleeper slab stems and approach slabs.

3.8 LIMITATIONS

A. Do not place Asphalt Mix on frozen base or subbase or during adverse climatic conditions such as precipitation or when roadway surface is icy or wet.

B. Use a release agent that does not dissolve asphalt and is satisfactory to the Engineer for all equipment and hand tools used to mix, haul, and place the Asphalt Mix.

C. Place Asphalt Mix from April 15 through October 15, and when the air temperature in the shade and the roadway surface temperature are above 50 degrees F.
   1. The Department determines if it is feasible to place Asphalt Mix outside these dates and temperature limits.
   2. Obtain authorization from the Engineer before paving outside these requirements.

END OF SECTION