Construction of the Safety Edge$_{SM}$ with the "Willow Designs" Safety Edge$_{SM}$ Hardware

Draft Report

July 13, 2015

Prepared By:

Chris Wagner, P.E.

Christopher.wagner@dot.gov

Federal Highway Administration

FHWA Technical Service Team

Executive Summary

The Safety Edge$_{SM}$ (SE) is a relatively simple but effective solution that can help save lives by allowing drivers who drift off highways to return to the travel lane safely.

During conventional paving processes, the pavement is constructed with vertical or near vertical edges. Instead of a vertical drop-off, the finished Safety Edge$_{SM}$ forms the edge of the pavement with a slope of approximately 30 degrees (26 to 40 degrees). (Figure 1) Research has shown this "transition from on-roadway surface to shoulder and back is so smooth it defies assignment of any degree of severity." The Safety Edge$_{SM}$ provides a strong, durable transition for all vehicles and helps prevents pavement edge raveling.

The recommended practice is to bring the adjacent soil or aggregate material (unpaved shoulder or modified soil) flush with the top of the pavement often requiring frequent maintenance. When the vertical edge is exposed due to wear or erosion of the unpaved shoulder, it can contribute to drivers losing control of the vehicle when attempting to recover from a roadway departure. The Safety Edge$_{SM}$ concept is that when drop-offs along the pavement edge occur, the edge will not be vertical, but has a shape that will not induce tire scrubbing.

This report documents the construction of the Safety Edge using the Willow Designs Safety Edge$_{SM}$ hardware on two projects near State College, Pennsylvania on May 19th and 20th, 2015. The report represents the views and observations of the author. Each agency should perform an assessment of any new Safety Edge$_{SM}$ hardware for compliance with specifications before approving for use on a project.

Figure 1: Typical Safety Edge$_{SM}$ installation

Scope

This report documents the observations made on May 19th and 20th, 2015 on State Route 322 near College Station, Pennsylvania and on State Route 150 near Beech Creek, Pennsylvania. These observations include assessment of the edge of roadway conditions and the construction of the Safety Edge$_{SM}$ using the Willow Designs SE hardware.

***State Route 322*:**

Approximately 2 miles of paving of the paved shoulder were observed on the east bound section of SR 322 on May 19th, 2015. State Route 322 is a primary arterial four lane divided highway with grade separated crossings. The highway consists of two 12' lanes with a 4' paved inside shoulder and a 10' paved outside shoulder outside shoulder. The roadway also has a 5' unpaved dense graded limestone aggregate shoulder. The typical section is included in the Appendix Figure A1.

The construction consisted of a 4 ½" hot mix asphalt overlay of the jointed plain concrete pavement (JPCP). The existing pavement consisted of 9 to 10 inch JPCP with skewed joints. The existing paved shoulders were also JPCP.

The overlay was paved in three lifts. The 3 lifts from the surface down consisted of a 9.5 mm mixture at 1 ½" thickness, a 19 mm mixture at 2 ½" thickness, and a 9.5 mm leveling course with a minimal thickness of ½". All of the mixtures were constructed with dense graded Superpave mixtures. The binder course and wearing course included a PG 76-22 polymer modified binder. (Figure A1)

During the site visit both the outside travel lane and the paved shoulder were being paved in echelon. Observations and measurements were made on the outside shoulder surface wearing course that included the Safety Edge$_{SM}$. (Figure 3)

Figure 2: SR 322 SE installation

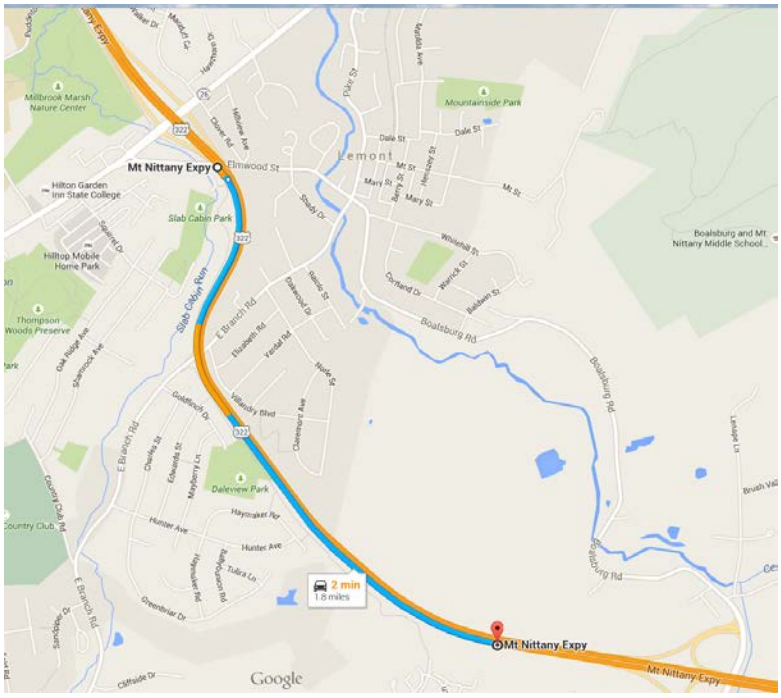


Figure 3: Paving operation on SR 322

Findings on State Route 322:

Observations of the SE installation were made on the final lift of the shoulder asphalt wearing course. The underlying binder course had previously been paved using the SE. As seen in Figure 4 the successive layers were paved so that the toe of the wearing course lined up with the break point of the underlying binder course.

The height differential between the paved shoulder and the unpaved limestone shoulder was measured to be 6-8 inches (approximately 8-10 inches of slope length). The greater height differential (overlay thickness compared to the edge of pavement thickness) at the paved shoulder/aggregate interface is common and can be attributed to an existing shoulder edge drop off or a difference in cross slope between the pavement and unpaved shoulder. The 8” to 10” slope is longer than the SE hardware screed length of 6”. As seen in Figure %, additional HMA material flowed out in front of the SE hardware onto the underlying SE slope. This has been seen in previous installations and is to be expected where the slope is greater than the SE screed length. The constructed SE will be backed up with the aggregate shoulder. The finished 6” SE will provide a sufficient exposure length if the aggregate shoulder does pull back from the paved shoulder.

Figure 4: PennDOT multi lift design detail

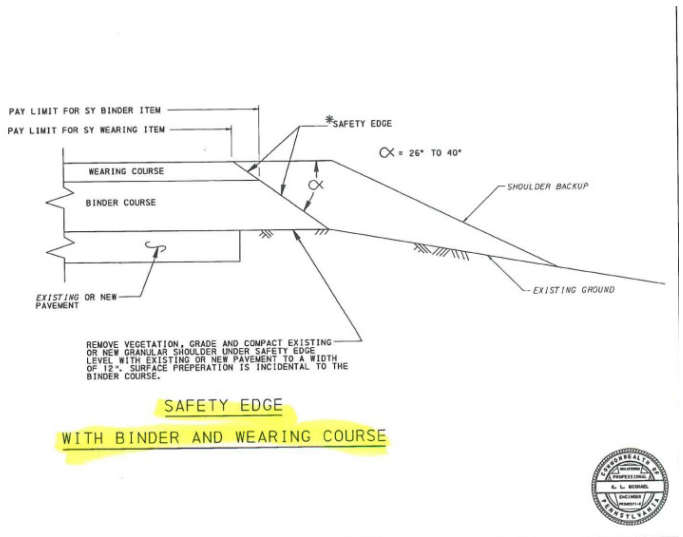


Figure 5: Measurement of SE before rolling

Ten measurements of the angle (α) of the edge of the pavement including both the SE and the control section without the SE were made. These measurements were made before and after final rolling of the pavement. The SE section had an average angle of 21 degrees before rolling and an average angle of 26 degrees after rolling. The control section had an average angle of 39 degrees before rolling and 44 degrees after rolling. The finish of the SE was consistent with that of the main pavement surface. The

finished SE texture appeared smooth and uniform indicating that the Willow Designs SE hardware is extruding the asphalt and not simply acting as a strike off plate.

Table 1: SE angle measurements on SR 322

	Before Rolling	**After Rolling**
Safety Edge Section	21 degrees	26 degrees
Control Section	39 degrees	44 degrees

State Route 150:

The section of State Route 150 visited is a secondary undivided 2 lane roadway near the city of Beech Creek, Pennsylvania. The roadway consists of two 12' lanes with 2' paved shoulders. The roadway also has a 2' unpaved dense graded limestone aggregate shoulder. A typical section is included in the appendix Figure A3.

Approximately 1 mile of paving of the west bound lane and shoulder were observed on May 20th, 2015. The construction consisted of a 1 ½" hot mix asphalt overlay with a ½" scratch course over a milled surface. (Figure A3) All of the mixtures were constructed with dense graded 9.5 Superpave mixtures with a PG 64-22 binder. (Figure A4)

Ten measurements of the angle (α) of the edge of the pavement including both the SE and the control section without the SE were made. These measurements were made before and after final rolling of the pavement. The SE section had an average angle of 22 degrees before rolling and an average angle of 24 degrees after rolling. The control section had an average angle 40 degrees after rolling. Angle measurements of the control section before rolling were not made. As with SR 150, the finish of the SE was consistent with that of the main pavement surface. This indicates extrusion of the SE shape as opposed to acting as a strike off plate.

Table 2: SE angle measurements on SR 150

	Before Rolling	**After Rolling**
Safety Edge Section	22 degrees	24 degrees
Control Section	n/a	40 degrees

Figure 1: SR 150 SE installation

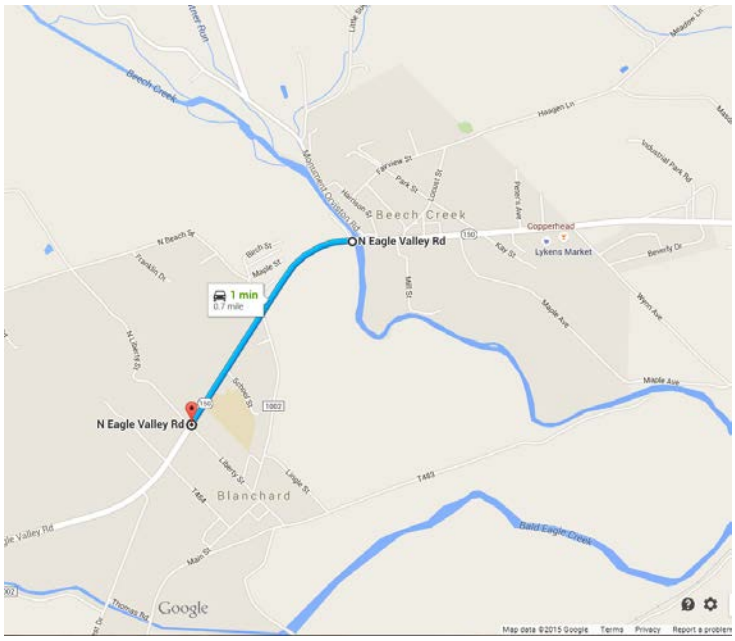


Figure 2: Paving on SR 150

Assessment of the Willow Designs SE hardware

The Willow Designs SE hardware screed is 6” in width and 7” in length and includes a bull nosed leading edge and a 2 degree (1/4” over 7 inch length) slope or angle of attack that is similar to that of the main paver screed. This angle of attack is included in order to extrude the material and provide some densification as the HMA passes under the 7” exposure of the screed length. The Willow Designs SE hardware extends 6 inches beyond the end gate when the angle is set to zero. This distance is reduced when the angle is set to create the 30 degree SE shape. The 6-inch extension may be an obstacle when paving near obstacles such as guardrail. This was not observed to be an issue on the paving on SR 322 or SR 150. The SE hardware can quickly and easily be removed in locations where obstacles are within 6” of the paver end gate.

Figure 3: Willow Designs SE screed length

Figure 4: SE installation on SR 150

Figure 5: Willow Designs SE extension

The Willow Design SE hardware is attached on the outside of the paver end gate with a one pin threaded connection as seen in Figure 6 and 7. The device slides onto the paver channel iron in approximately 1 minute and requires no special hardware for installation. The channel iron connection point is specific to each paver and the units may not be transferable between pavers. The manufacturer indicated that the connection can be modified to fit all paver types. Both SR 150 and SR 322 were paved with a Caterpillar paver.

Figure 6: Willow Designs SE being installed on channel iron

Figure 7: Final installation showing the one pin connection

The angle of the SE is controlled through a small integrated motor requiring AC power. The unit is capable of changing the angle (α) from 0 to 45 degrees in 5 to 10 seconds. The whole SE screed can also be raised and lowered using the hand crank. By lowering the unit below the height of the main paver screed a small (6”) notched wedge can be also be made with this device. The SE can be disengaged when needed in approximately 2-5 feet of paving at normal speeds.

Figure 8: Hand crank and motor controlled angle adjustment

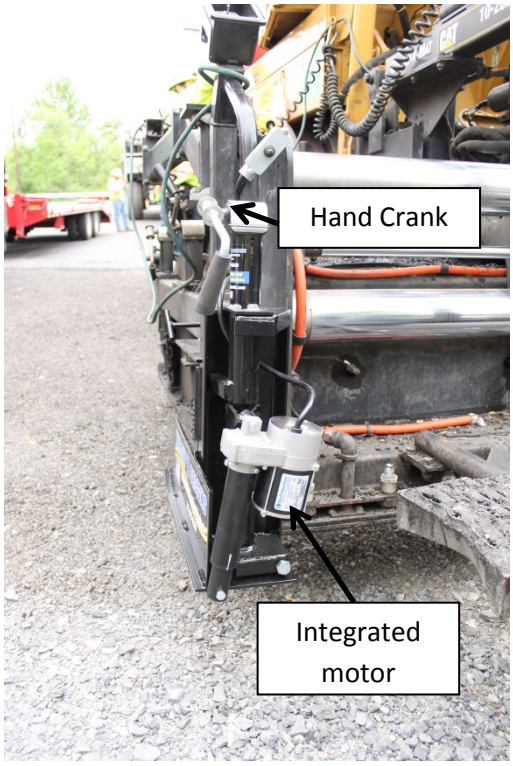
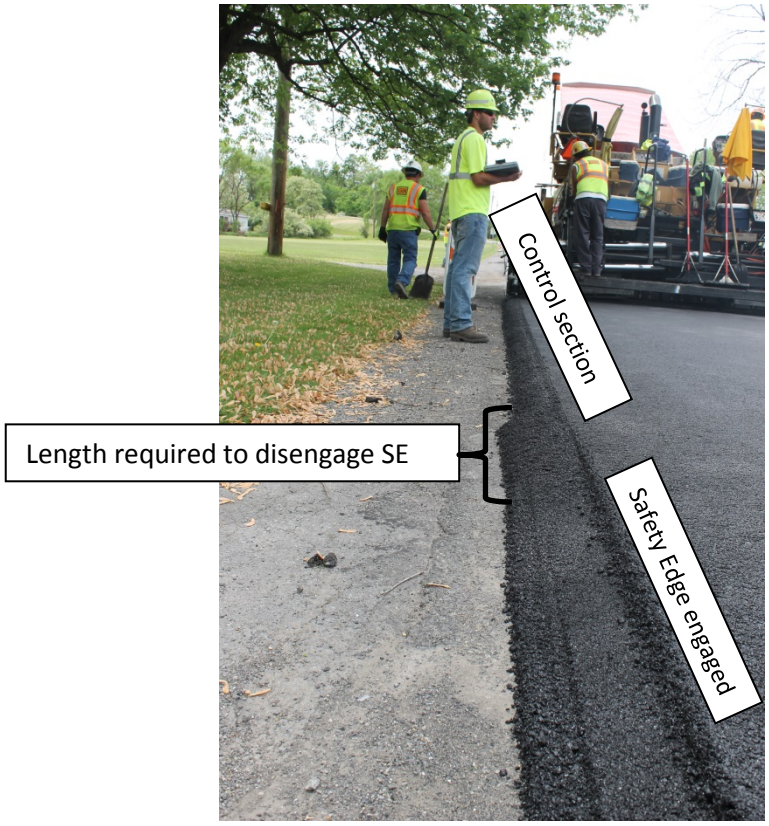


Figure 9: Angle adjustment by screed operator

The Willow Designs hardware is capable of producing the required 30 degree SE shape with an extruded finish consistent with that of the main pavement surface. Figure 10 shows the comparison of the SE engaged versus the control section where the device was disengaged. The SE section has a finished surface and 30 degree angle. The control section had an unfinished appearance and was a more rounded shape of approximately 40-45 degrees. Figure 10 also shows the length (2-3 feet) required to disengage the Willow Designs SE.

Figure 10: Control section vs. SE section



In discussions with project personnel, the motor actuated angle adjustments and ease of installation were key benefits to the Willow Designs SE hardware. The location of the Willow Designs SE outside of the paver auger box was also cited as a benefit.

Conclusions

Based on the observations on the 2 project installations using the Willow Design SE the following conclusions can be made.

- The Willow Designs SE hardware was able to produce the required 26 to 40 degree SE edge on the two paving projects observed. The finish of the SE indicated that the hardware is extruding the asphalt mixture as opposed to acting as a strike off plate.
- Angle adjustments are made with an integrated motor. This angle adjustment is critical for creating the required angle with various asphalt mixtures and paving conditions.
- Control sections paved without the SE have a finished angle between 40 to 46 degrees and did not have a smooth finished appearance.
- The Willow Designs SE hardware is able to create a small 6" notched wedge.
- The hardware extends 5 ½" beyond the paver end gate. The hardware can be removed quickly and easily if there are obstructions within 6" of the paver end gate.
- The hardware requires AC power which can be supplied by most new pavers or by using an inverter connected to the paver battery.

Acknowledgements:

A special thanks is given to the paving crews of Glenn O Hawbaker Inc., Mr. Jerod Willow of Willow Designs, and Mr. Chris Cepko of the Pennsylvania Department of Transportation for providing project specific information and knowledge on the use of the SE hardware in Pennsylvania.

Appendix:

Figure 11: SR 322 typical section

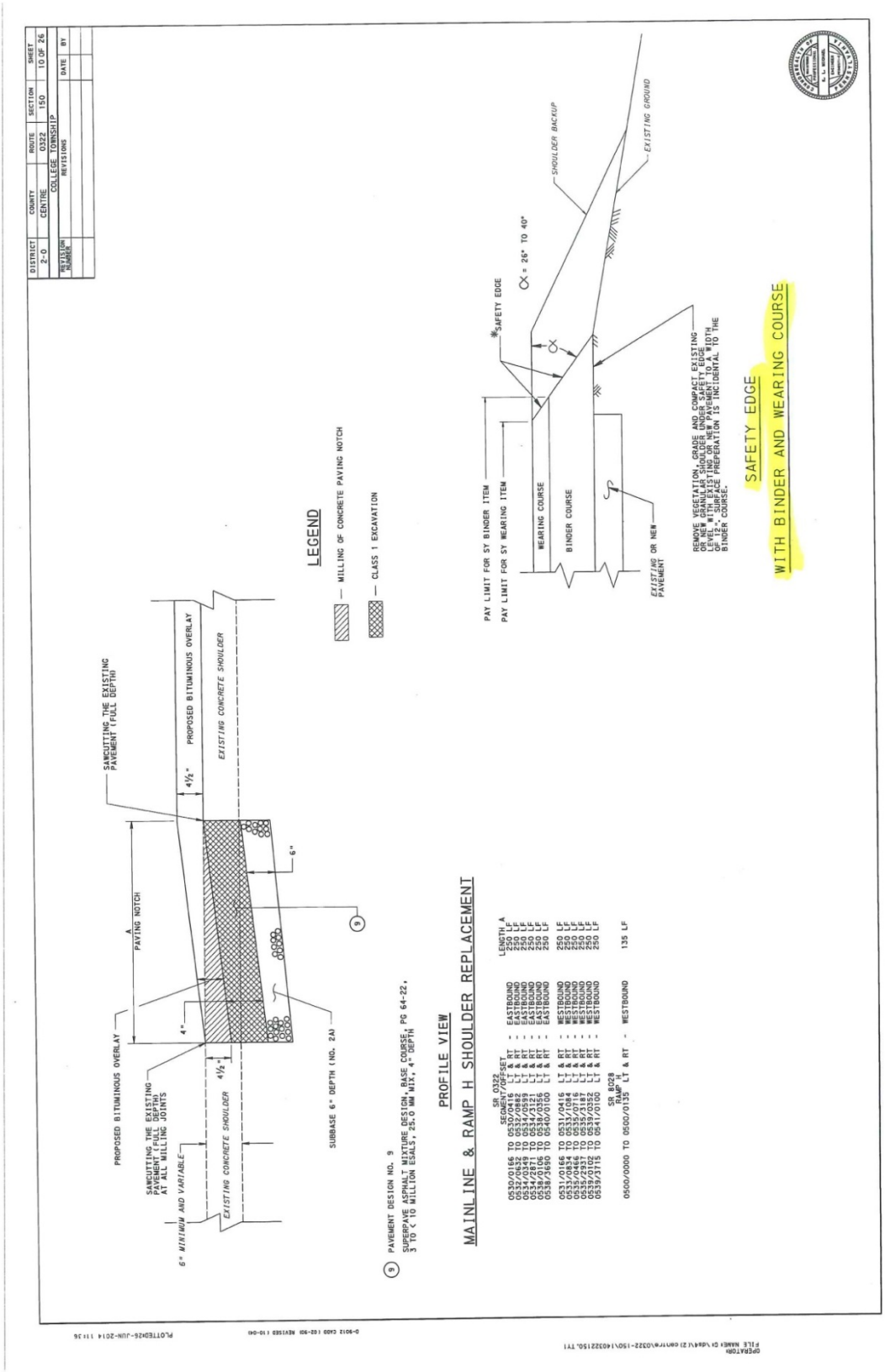


Figure A2: SR 322 Typical Section

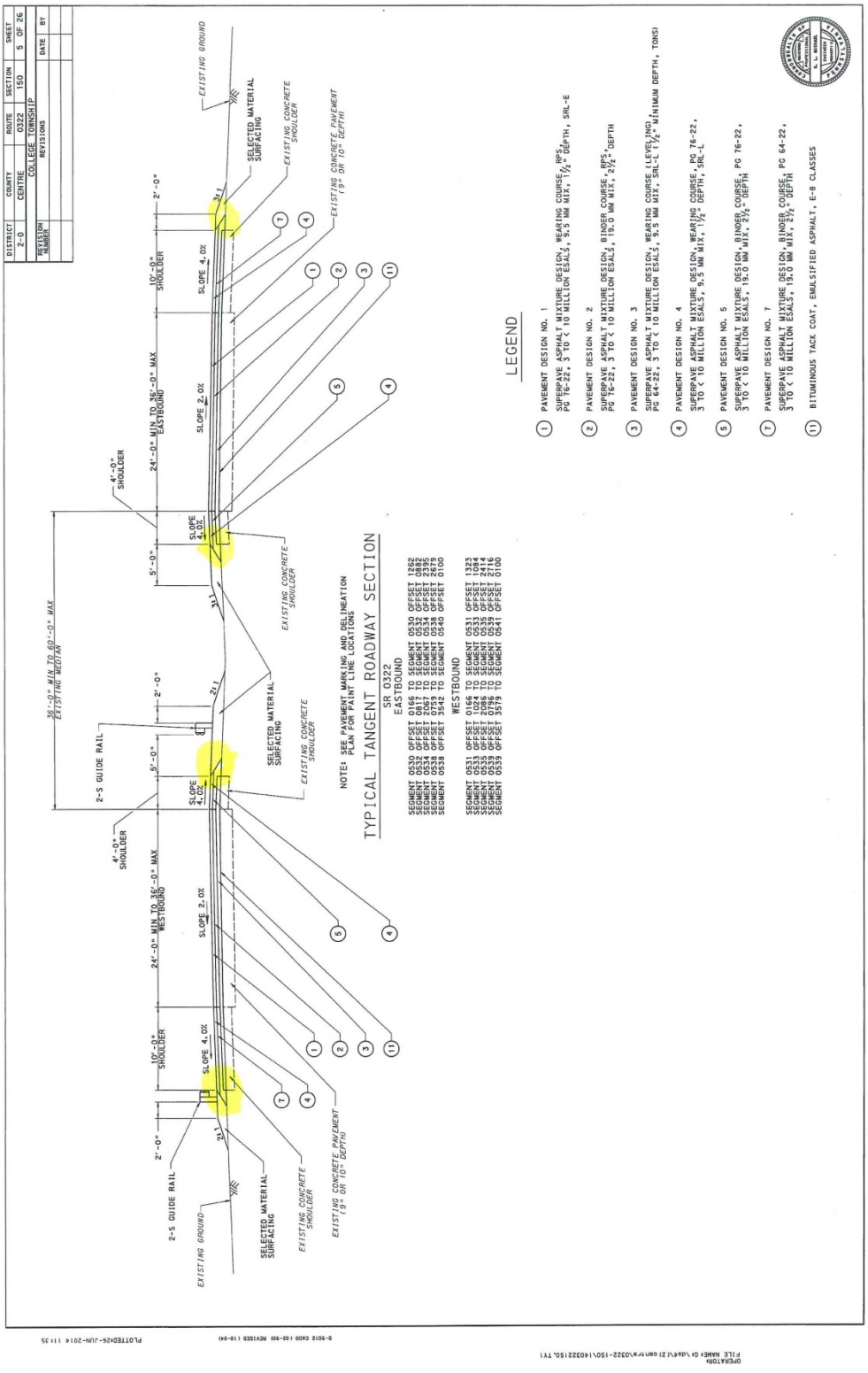


Figure A3: SR 150 typical section and SE design detail

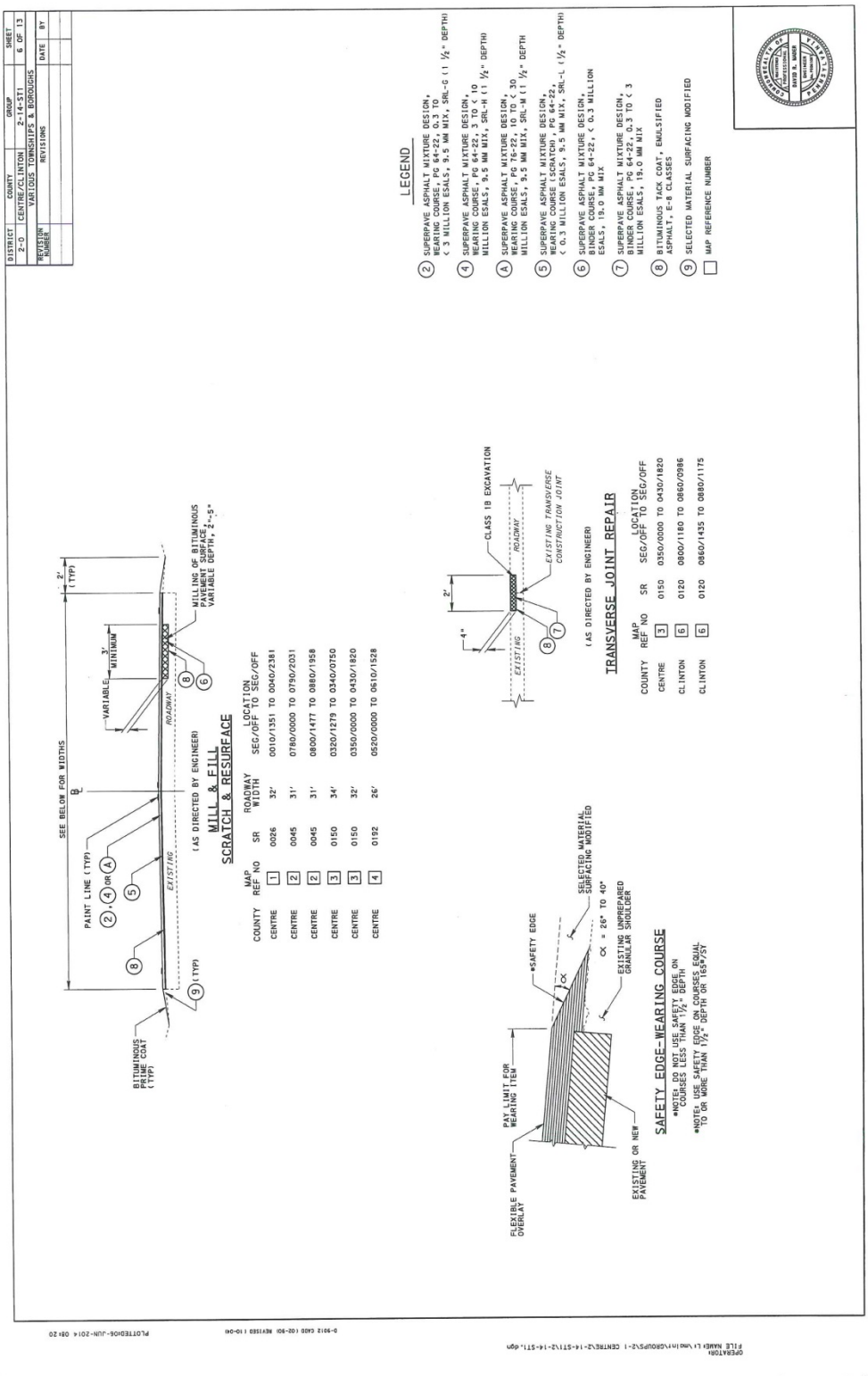
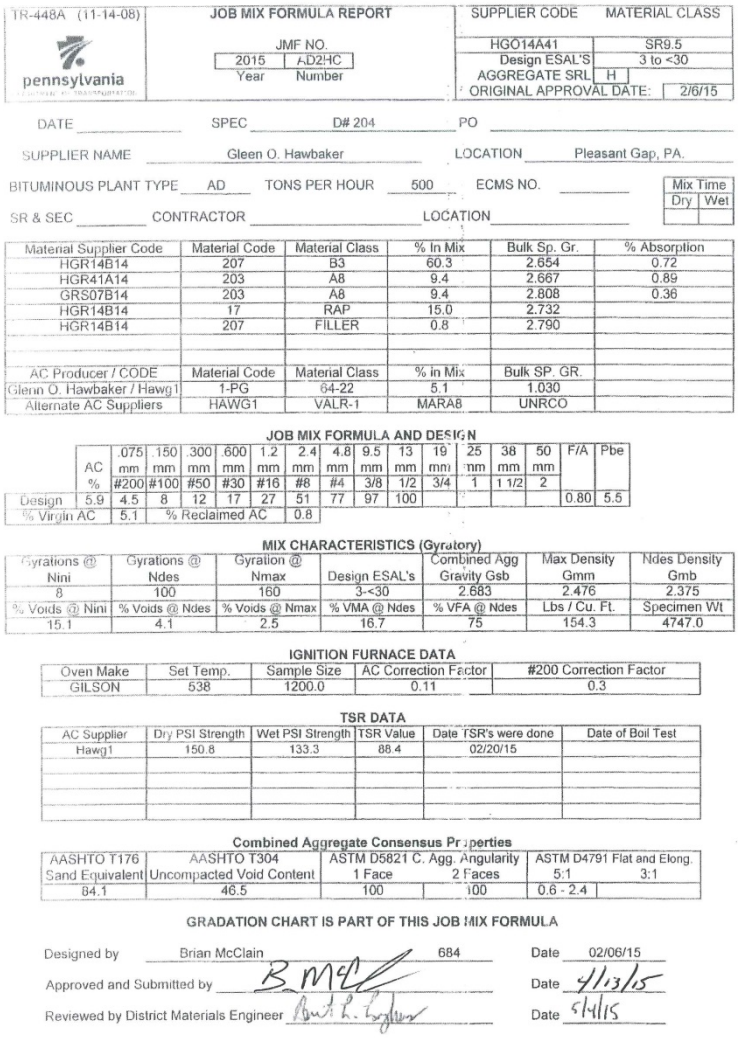


Figure 5A: SR 150 job mix formula



TR-448A (11-14-08) — pennsylvania

JOB MIX FORMULA REPORT

JMF NO. 2015 (Year) AD2HC (Number)

SUPPLIER CODE	MATERIAL CLASS
HGO14A41	SR9.5
Design ESAL'S	3 to <30
AGGREGATE SRL	H
ORIGINAL APPROVAL DATE:	2/6/15

DATE _____ SPEC D# 204 PO _____

SUPPLIER NAME Gleen O. Hawbaker LOCATION Pleasant Gap, PA.

BITUMINOUS PLANT TYPE AD TONS PER HOUR 500 ECMS NO. _____ Mix Time: Dry _____ Wet _____

SR & SEC _____ CONTRACTOR _____ LOCATION _____

Material Supplier Code	Material Code	Material Class	% In Mix	Bulk Sp. Gr.	% Absorption
HGR14B14	207	B3	60.3	2.654	0.72
HGR41A14	203	A8	9.4	2.667	0.89
GRS07B14	203	A8	9.4	2.808	0.36
HGR14B14	17	RAP	15.0	2.732	
HGR14B14	207	FILLER	0.8	2.790	
AC Producer / CODE	Material Code	Material Class	% in Mix	Bulk SP. GR.	
Glenn O. Hawbaker / Hawg1	1-PG	64-22	5.1	1.030	
Alternate AC Suppliers	HAWG1	VALR-1	MARA8	UNRCO	

JOB MIX FORMULA AND DESIGN

	AC %	.075 mm #200	.150 mm #100	.300 mm #50	.600 mm #30	1.2 mm #16	2.4 mm #8	4.8 mm #4	9.5 mm 3/8	13 mm 1/2	19 mm 3/4	25 mm 1	38 mm 1 1/2	50 mm 2	F/A	Pbe
Design	5.9	4.5	8	12	17	27	51	77	97	100					0.80	5.5
% Virgin AC		5.1	% Reclaimed AC				0.8									

MIX CHARACTERISTICS (Gyratory)

Gyrations @ Nini	Gyrations @ Ndes	Gyration @ Nmax	Design ESAL's	Combined Agg Gravity Gsb	Max Density Gmm	Ndes Density Gmb
8	100	160	3-<30	2.683	2.476	2.375
% Voids @ Nini	% Voids @ Ndes	% Voids @ Nmax	% VMA @ Ndes	% VFA @ Ndes	Lbs / Cu. Ft.	Specimen Wt
15.1	4.1	2.5	16.7	75	154.3	4747.0

IGNITION FURNACE DATA

Oven Make	Set Temp.	Sample Size	AC Correction Factor	#200 Correction Factor
GILSON	538	1200.0	0.11	0.3

TSR DATA

AC Supplier	Dry PSI Strength	Wet PSI Strength	TSR Value	Date TSR's were done	Date of Boil Test
Hawg1	150.8	133.3	88.4	02/20/15	

Combined Aggregate Consensus Properties

AASHTO T176 Sand Equivalent	AASHTO T304 Uncompacted Void Content	ASTM D5821 C. Agg. Angularity 1 Face	2 Faces	ASTM D4791 Flat and Elong. 5:1	3:1
84.1	46.5	100	100	0.6 - 2.4	

GRADATION CHART IS PART OF THIS JOB MIX FORMULA

Designed by Brian McClain 684 Date 02/06/15

Approved and Submitted by B McC Date 4/13/15

Reviewed by District Materials Engineer Date 5/4/15