FINAL REPORT

FEASIBILITY OF SUBSTITUTING #78 FOR #8 AGGREGATE IN S-5 MIXES

by

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Virginia Highway and Transportation Research Council
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SUMMARY

The study investigated the feasibility of using a coarse aggregate in the S-5 asphalt mixes. Virginia Department of Highways and Transportation specifications were adhered to with the exception of incorporating into the mix a small percentage of +1/2" material.

A #78 aggregate was selected from three quarries in Virginia and substituted for the #8 aggregate in the S-5 mixes. In the design of the mixes, consideration was given to the gradation of material from each quarry, and tests were performed on the mixes using the Marshall method to determine the density, flow, stability, voids, and asphalt content.

The results of tests on the mixes were compared graphically with Department specifications and the acceptability of each mix was determined.

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INTRODUCTION

The specifications of the Virginia Department of Highways and Transportation on the gradation of the S-5 surface asphalt mix require that 100% of the material pass the 1/2" sieve. This requirement is met by using a #8 aggregate in the mix. Recent increases in the cost of #8 aggregate and the unavailability of material in certain areas of the state have caused difficulties. Therefore a study was undertaken to investigate the feasibility of using #78 stone instead of the #8 aggregate.

PURPOSE AND SCOPE

The purpose of the project was to determine the feasibility of substituting a #78 aggregate for the scarcer, more costly #8 aggregate presently used in the S-5 mix. With this substitution, the mix design was modified to allow a small percentage of aggregate larger than 1/2". The modified S-5 mix was tested to determine whether it met the stability and volumetric requirements and thus was of the same quality as the regular S-5 mix.

PROCEDURE

Gradation information on #78 aggregate was collected from eight randomly selected quarries in Virginia, and three quarries chosen. (Most of the quarries contacted produced #78 aggregate with very little plus 1/2" material.)

Sand, screenings, and aggregate were collected from the three quarries chosen for their relatively high percentage of plus 1/2" material; namely, Martin Marietta in Red Hill, Luck in Shadwell, and Lone Star (Jack Plant) in Richmond. Gradations were run on each sample and asphalt mixes were designed for the material from each quarry (Appendix A).

The material from each quarry was separated by 1/2", #4, #30, and #200 sieves and reblended. The Lone Star (Jack Plant) aggregate was separated and reblended twice, first with plus 1/2", #4, #30, #200 and pan material (Lone Star A) and then with plus 1/2", #4, #30 and pan material (Lone Star B). This was done to determine the variation between separating the finer material and using it as a single quantity.

Samples were weighed out for each aggregate source and different asphalt content and Marshall tests were performed on each mix. Data on the density, voids, flow and stability were collected. Rice tests were performed on each S-5 mix to determine the maximum theoretical specific gravity. All data were plotted for comparison.

RESULTS

The standards for the S-5 asphalt set forth in the 1978 Virginia Department of Highways and Transportation Road and Bridge Specifications are as follows:

Stability	Over 1,450 lb.
Voids Total Mix	3% to 6%
Voids in Mineral Aggregate	Min. 14.8%
Voids Filled with Asphalt	65% to 85%
Flow	0.08" to 0.18"
Percent Bitumen	5.0% to 8.5%

All data are shown in Appendix B.

The results from the mix produced with the Red Hill material show only small deviations from the interpolated curve. Increases and decreases were relatively smooth and there were no extremely wide variations. (See Figure B-1.)

The Shadwell material (Figure B-2) produced a mix with uniform results also. Deviations were small, except for the stability, where a slight decrease occurred from 5.2% to 5.4% asphalt content.

The two mixes using Lone Star material developed slightly different results. Lone Star A produced relatively smooth curves for the voids (see Figure B-3). However, the density and stability graphs show a large variance in data points between the 5.2% and 5.4% asphalt contents. These points were rechecked and the same results were obtained. The Lone Star B (Figure B-4) mix produced smooth curves for all graphs with very few deviations in data points.

DISCUSSION

The data on voids and stability are compared for an optimum asphalt content in Figure 1. The standards used are 75% voids filled with asphalt and 3% to 4% voids total mix.

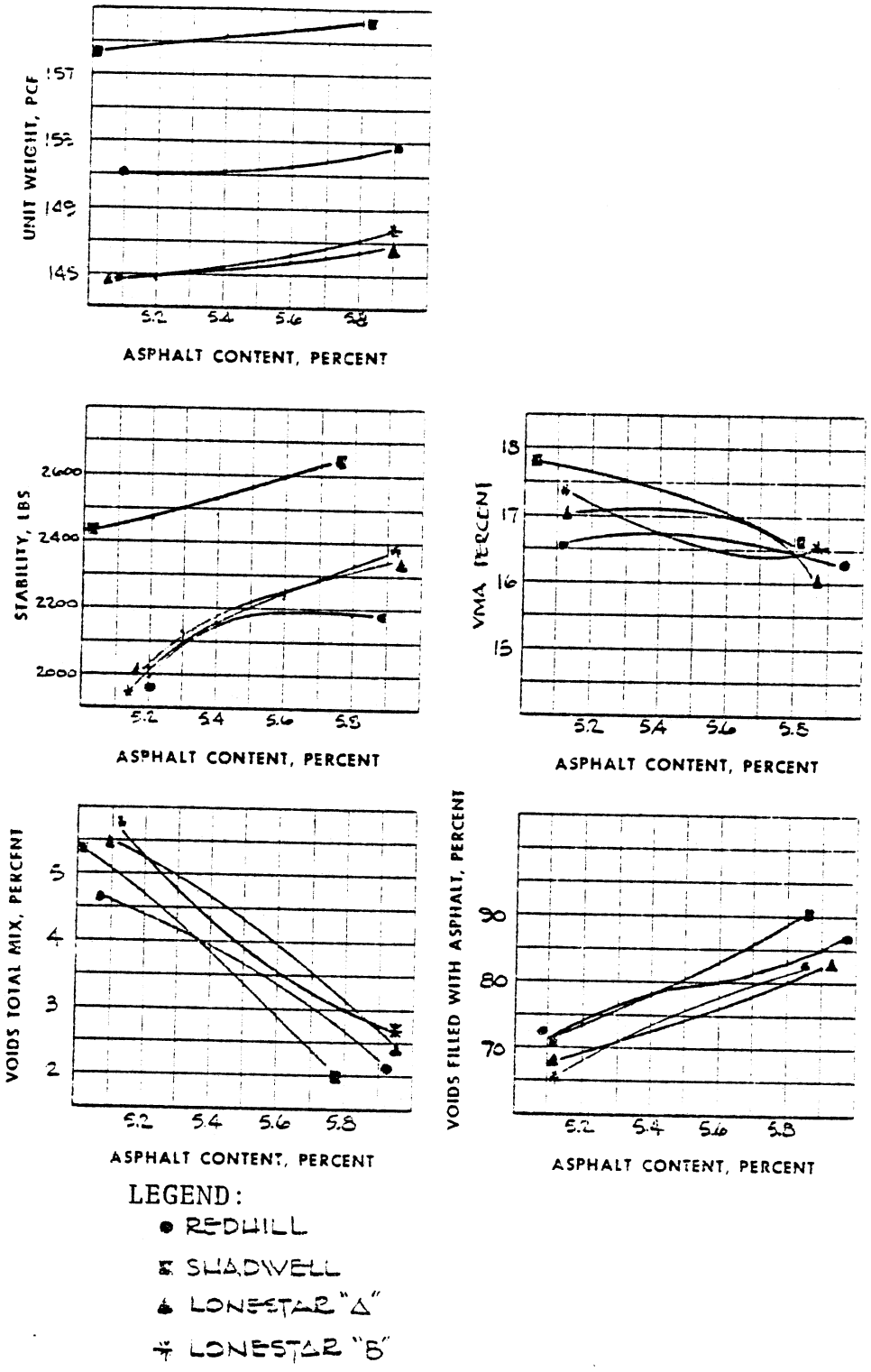


Figure 1. Summary of Marshall Test Results

The mix produced from the Red Hill material provided 75% VFA at an asphalt content of 5.3%. At this asphalt content, the VTM was 4.1%. At an asphalt content of 5.4%, the VFA was 77% and the VTM was 3.8%. Therefore, the optimum asphalt content for this material is taken to be between 5.3% and 5.4%. This value yields a density of 151.1 pcf, a stability of 2,150 lb., a VTM of 4.0%, a VFA of 76%, and a VMA of 16.8%.

The material from Shadwell produced a 75% VFA value at an asphalt content of 5.3%. This gave a VTM of 4.4%. At an asphalt content of 5.4%, the VTM was 3.9% and the VFA was 77%. The optimum asphalt content was between 5.3% and 5.4%, and this value produced a density of 159.3 pcf, a stability of 2,520 lb., a VTM of 4.1%, a VFA of 76%, and a VMA of 17.5%.

The Richmond material was blended in two ways. The original blend (Lone Star A) gave an optimum content of 5.6% at 76% VFA with a density of 145.9 pcf, a stability of 2,225 lb., a VTM of 4.0%, and a VMA of 17.0%.

The modified blend (Lone Star B) at an optimum asphalt content of 5.5% gave a density of 145.9 pcf, a stability of 2,220 lb., a VTM of 4.0%, a VFA of 76%, and a VMA of 16.5%.

In comparing the two blending methods for the Richmond material it was seen that the densities, stabilities, and VFA were identical. The differences were 0.2% for VTM, 0.5% for VMA, and 0.1% for asphalt content. Therefore, although the curves differ slightly, the two blending methods give identical results for all practical purposes.

The Marshall results using the three #78 aggregates are very similar to results that would be expected from normal S-5 mixes incorporating #8 aggregate.

CONCLUSIONS

It was determined that a #78 aggregate can be substituted for a #8 aggregate in an S-5 surface asphalt mix without sacrificing the intended mix qualities. All requirements stipulated in the Virginia Department of Highways and Transportation Road and Bridge Specifications were met, with the exception that slightly less than 100% of the aggregate passed the 1/2" sieve. The amount retained never exceeded 4% and produced no negative effects.

APPENDIX A

SIEVE ANALYSES AND MIX GRADATIONS FOR RED HILL, SHADWELL, AND RICHMOND AGGREGATES

Table A-1

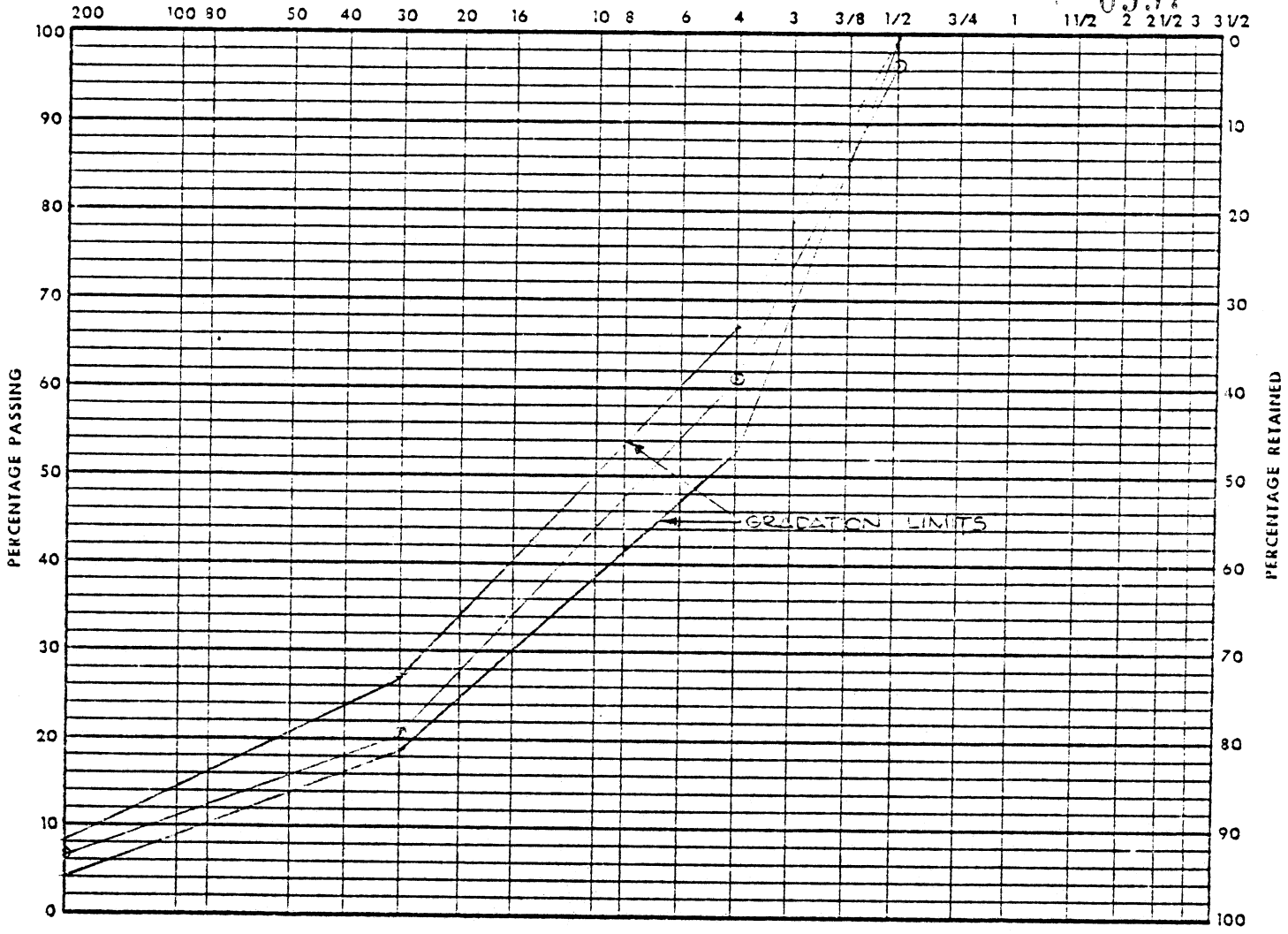
RED HILL (Martin Marietta) AGGREGATE

SIEVE ANALYSIS

Sieve Size	#78	#10	Sand
3/4"	100.00	100.00	100.00
1/2"	92.06	100.00	100.00
#4	17.17	96.92	96.96
#30	3.27	45.62	21.49
#200	2.04	17.73	1.72

MIX GRADATION

Sieve Size	#78-45%	#10-30%	Sand-25%	Total
3/4"	45.00	30.00	25.00	100.00
1/2"	41.43	30.00	25.00	96.43
#4	7.73	29.08	24.24	61.05
#30	1.47	13.69	5.37	20.53
#200	0.92	5.32	0.43	6.67



SAMPLE OF S-5 ASPHALT FROM REDHILL PRODUCER MARTIN MARIETTA

TESTED BY _____ FOR _____ FIN. MOD. _____

MESH	OPEN INCHES	WEIGHT	PERCENT PASS	PERCENT RETAIN	PERCENT CUMUL.	MESH	OPEN INCHES	WEIGHT	PERCENT PASS	PERCENT RETAIN	PERCENT CUMUL.
	3 1/2					6	.132				
	3					8	.0937				
	2 1/2					10	.0787				
	2					16	.0469				
	1 1/2					20	.0331				
	1					30	.0232		20.53	40.52	79.47
	3/4		100.00	0.00	0.00	40	.0165				
	1/2		96.43	3.57	3.57	50	.0117				
	3/8					80	.0070				
3	.265					100	.0059				
4	.137		61.05	35.38	38.95	200	.0029		6.67	13.86	93.33
TOTAL						TOTAL					

Figure A-1. Red Hill Gradation

Table A-2

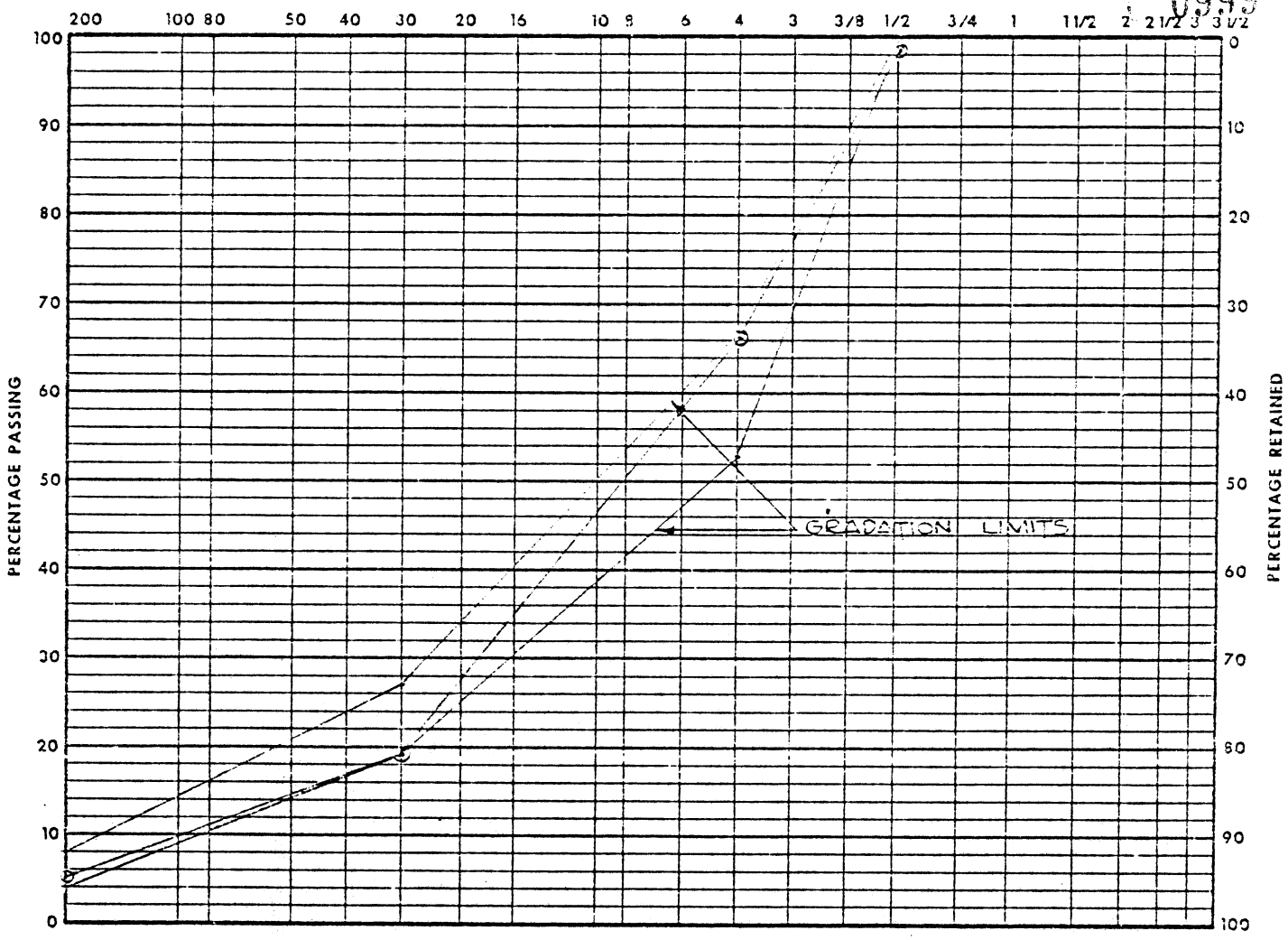
SHADWELL (Luck) AGGREGATE

SIEVE ANALYSIS

Sieve Size	#78	#10	Sand
3/4"	100.00	100.00	100.00
1/2"	95.90	100.00	100.00
#4	16.35	100.00	95.13
#30	1.66	30.56	22.96
#200	1.12	7.68	1.29

MIX GRADATION

Sieve Size	#78-40%	#10-60%	Sand—0%	Total
3/4"	40.00	60.00		100.00
1/2"	38.36	60.00		98.36
#4	6.54	60.00		66.54
#30	0.66	18.34		19.00
#200	0.45	4.61		5.06



SAMPLE OF S-5 ASPHALT FROM SHADWELL PRODUCER LUCK

TESTED BY _____ FOR _____ FIN. MOD. _____

MESH	OPEN INCHES	WEIGHT	PERCENT PASS	PERCENT RETAIN	PERCENT CUMUL.	MESH	OPEN INCHES	WEIGHT	PERCENT PASS	PERCENT RETAIN	PERCENT CUMUL.
	3 1/2					6	.132				
	3					8	.0937				
	2 1/2					10	.0787				
	2					16	.0469				
	1 1/2					20	.0331				
	1					30	.0232		19.00	47.54	81.00
	3/4		100.00	0.00	0.00	40	.0165				
	1/2		98.36	1.64	1.64	50	.0117				
	3/8					80	.0070				
3	.265					100	.0059				
4	.187		66.54	31.82	33.46	200	.0029		5.06	13.94	94.94
TOTAL						TOTAL					

Figure A-2. Shadwell Gradation

1000

Table A-3

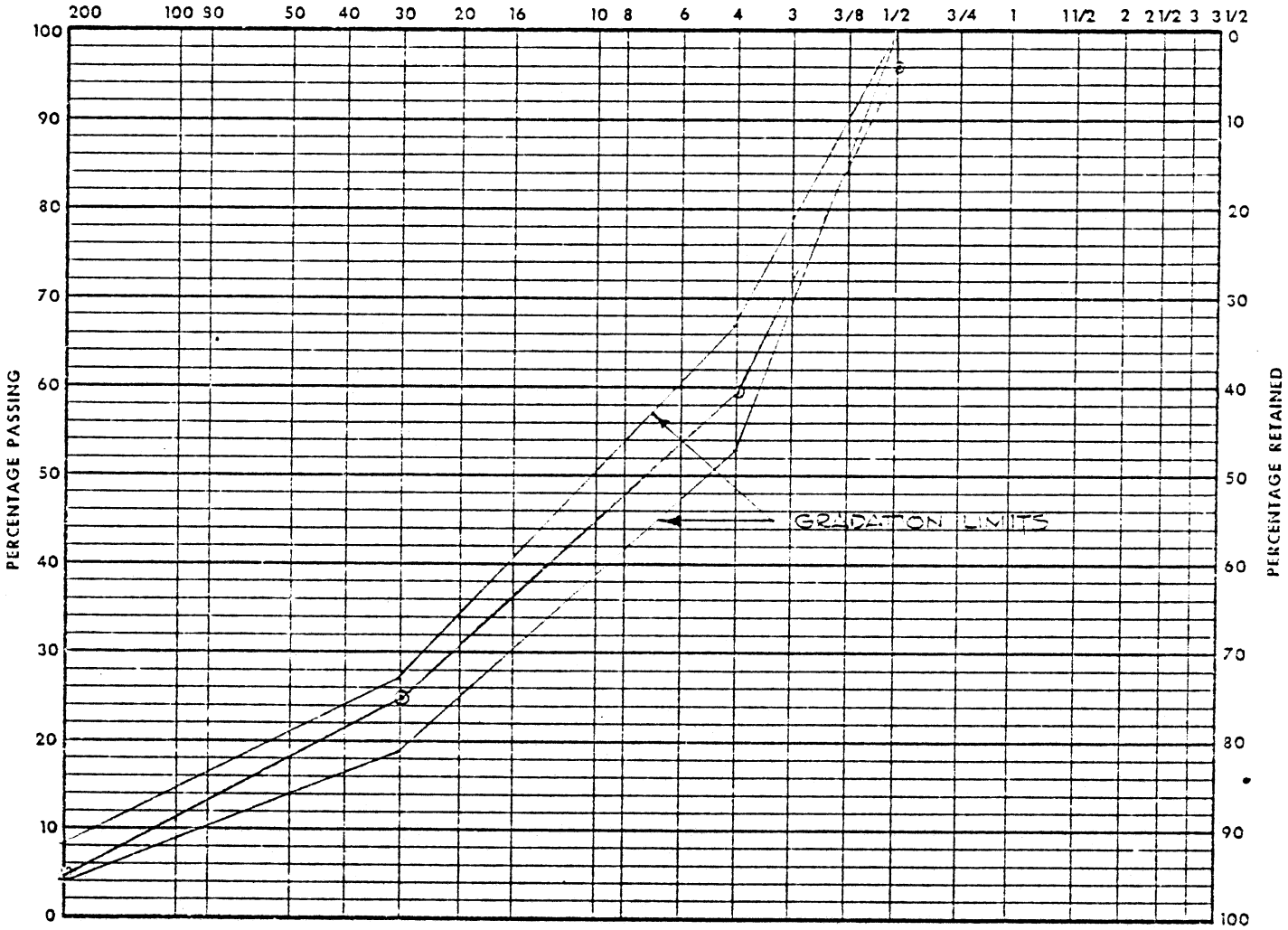
RICHMOND (Lone Star) AGGREGATE

SIEVE ANALYSIS

Sieve Size	#78	#10	Sand
3/4"	100.00	100.00	100.00
1/2"	92.50	100.00	100.00
#4	20.50	98.46	99.60
#30	4.11	42.95	51.82
#200	1.62	9.91	0.58

MIX GRADATION

Sieve Size	#78-50%	#10-35%	Sand-15%	Total
3/4"	50.00	35.00	15.00	100.00
1/2"	46.25	35.00	15.00	96.25
#4	10.25	34.46	14.94	59.65
#30	2.06	15.03	7.77	24.86
#200	0.81	3.47	0.09	4.37



SAMPLE OF S-5 ASPHALT FROM RICHMOND PRODUCER LONE STAR

TESTED BY _____ FOR _____ FIN. MOD. _____

MESH	OPEN INCHES	WEIGHT	PERCENT PASS	PERCENT RETAIN	PERCENT CUMUL.	MESH	OPEN INCHES	WEIGHT	PERCENT PASS	PERCENT RETAIN	PERCENT CUMUL.
	3 1/2					6	.132				
	3					8	.0937				
	2 1/2					10	.0787				
	2					16	.0469				
	1 1/2					20	.0331				
	1					30	.0232		24.86	34.79	75.14
	3/4		100.00	0.00	0.00	40	.0165				
	1/2		36.25	3.75	3.75	50	.0117				
	3/8					80	.0070				
3	.265					100	.0059				
4	.187		59.65	36.60	40.35	200	.0029		4.37	20.29	95.63
TOTAL						TOTAL					

Figure A-3. Richmond Gradation

APPENDIX B

RESULTS OF MARSHALL TESTS

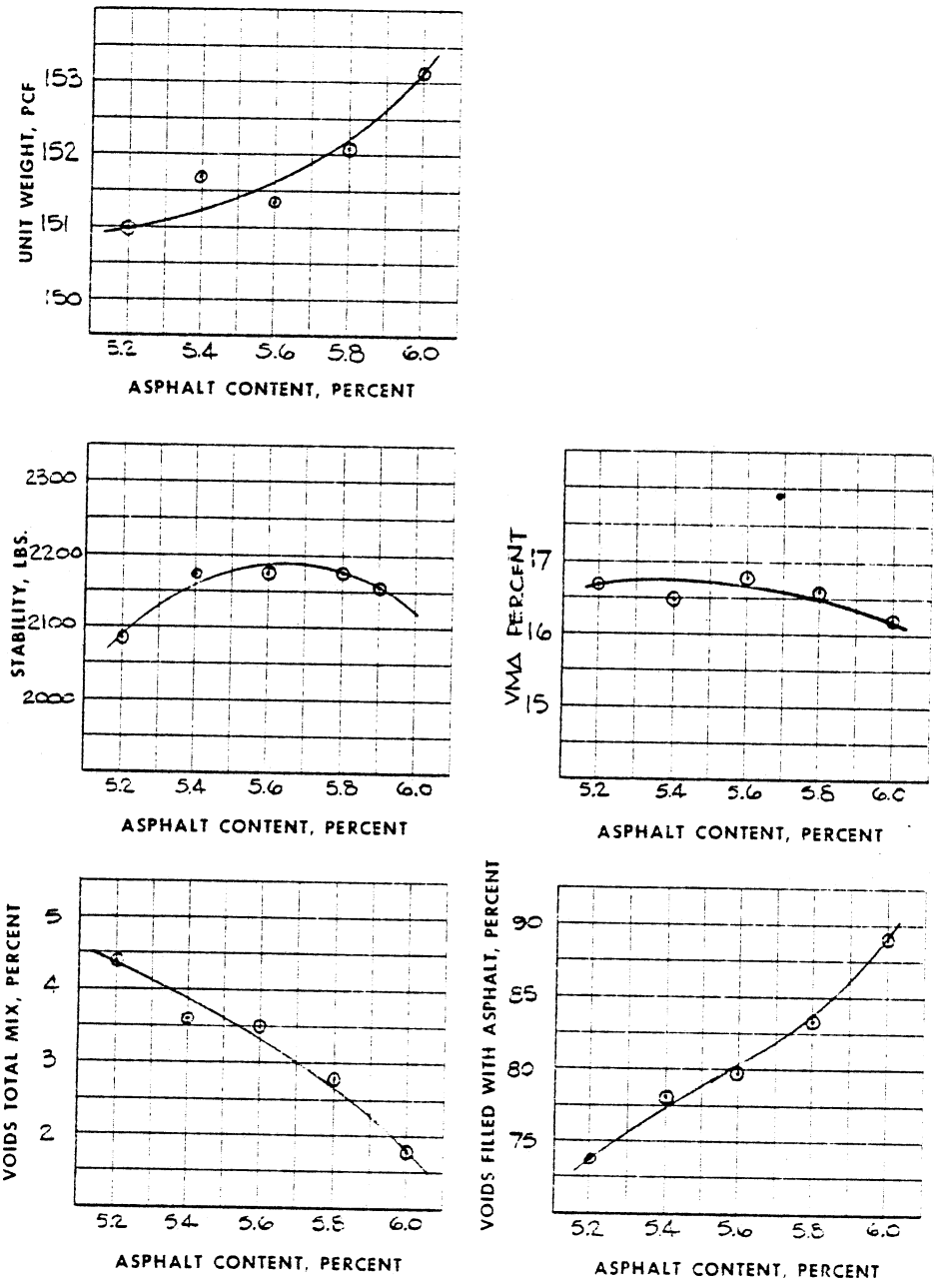


Figure B-1. Results of Marshall tests on Red Hill mix.

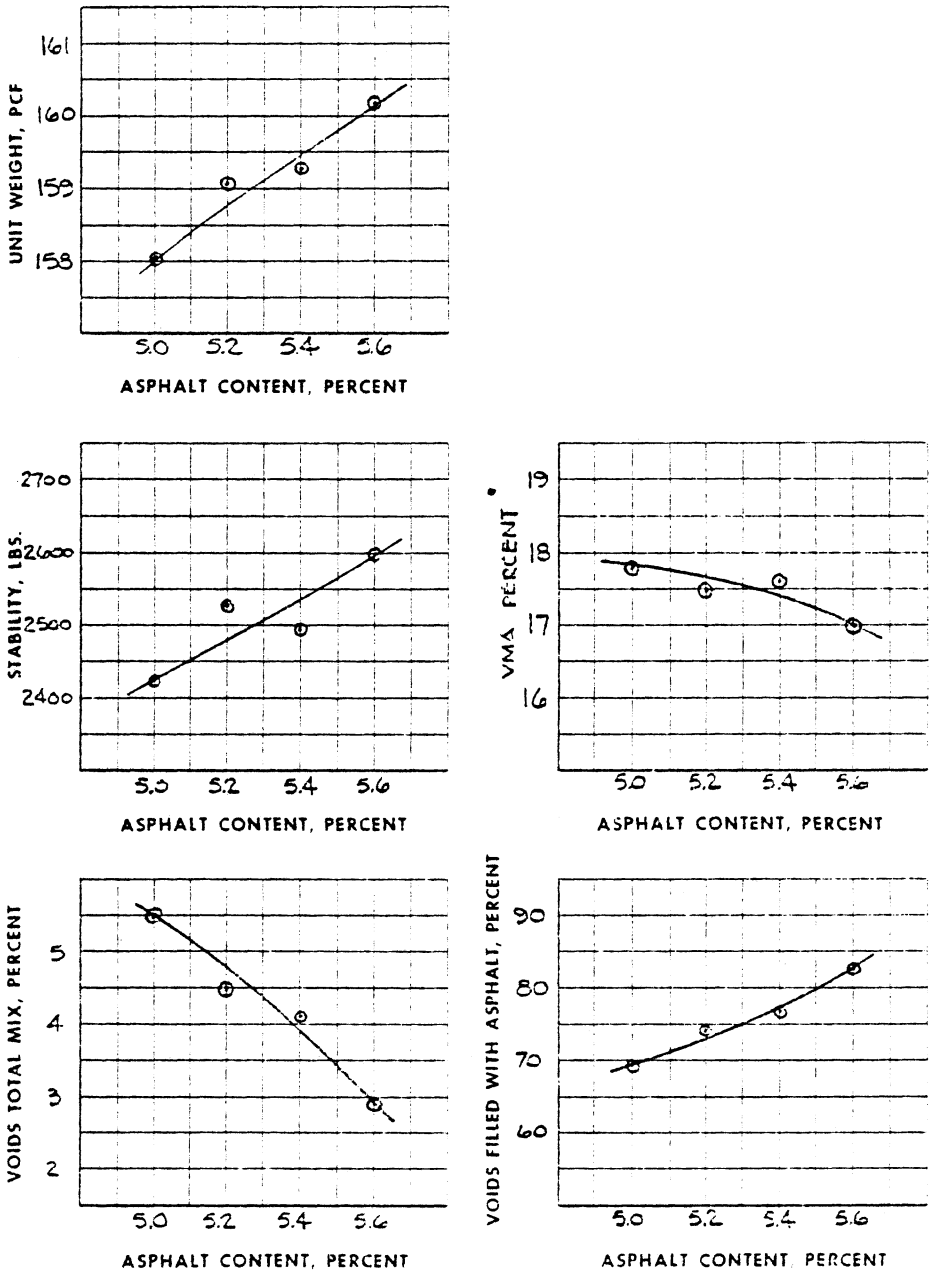


Figure B-2. Results of Marshall tests on Shadwell mix.

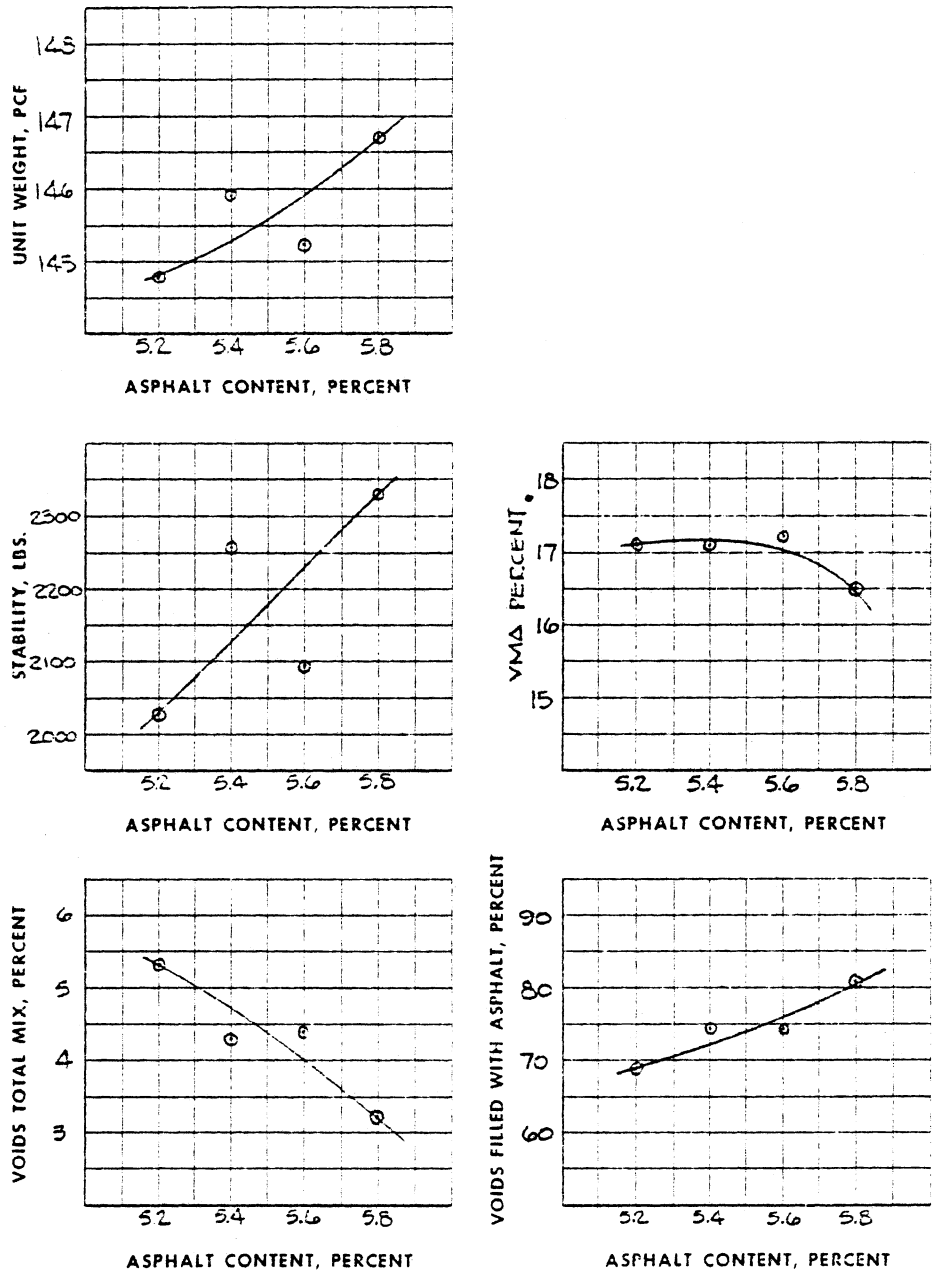


Figure B-3. Results of Marshall tests on Lone Star A mix.

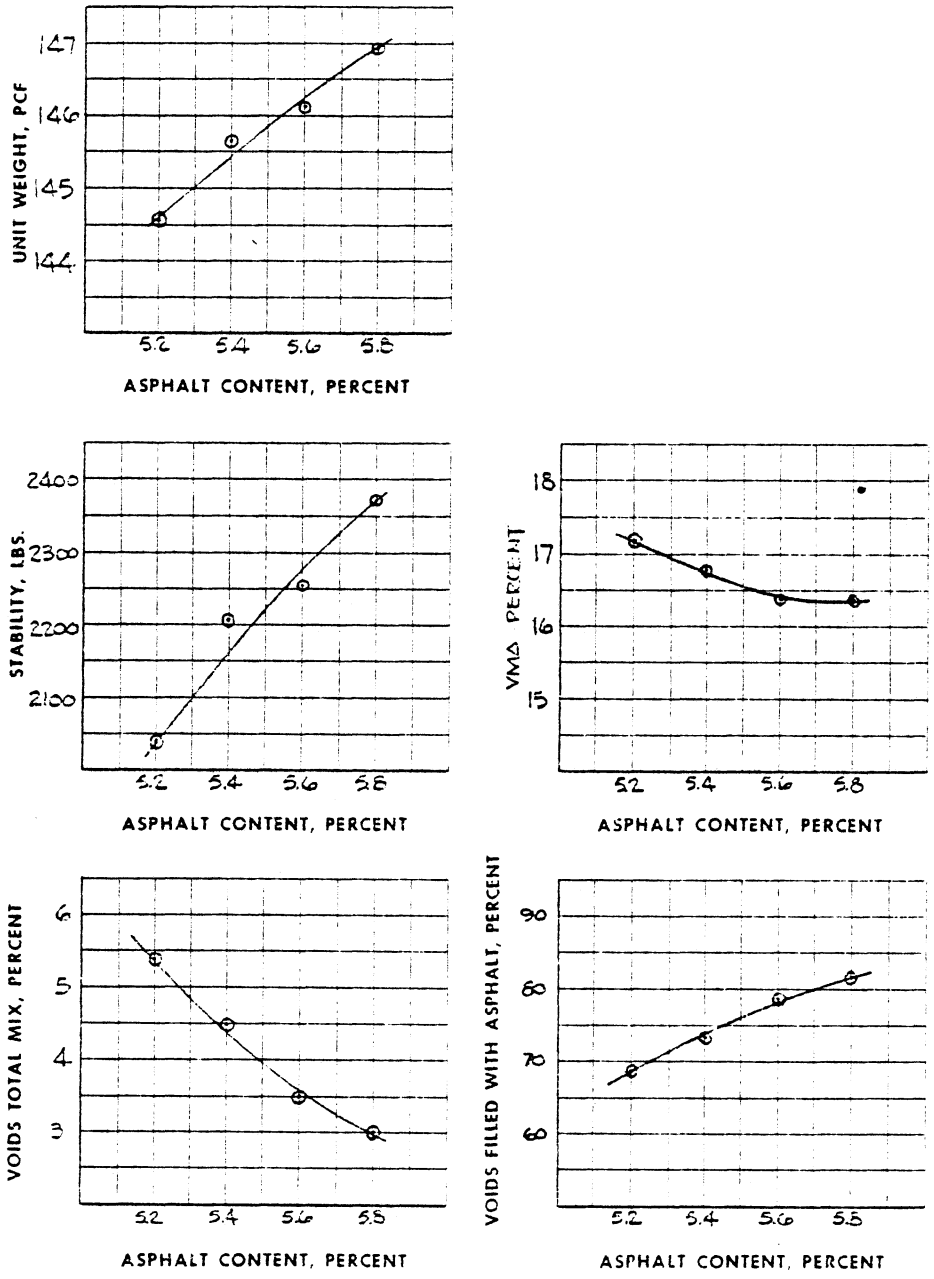


Figure B-4. Results of Marshall tests on Lone Star B mix.