AHTD TRC TRANSPORTATION RESEARCH COMMITTEE

TRC9303

Blending Aggregates for Skid Resistance

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Final Report

2006

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Arkansas Highway and Transportation Department

February 2005

Introduction

Continuing efforts have been made to improve the safety and durability of surface asphalt pavement through research involving wear-resistant aggregate mixes. In past years, several asphalt surface designs were determined to offer superior performance both in durability and traction during wet weather conditions when roadway surfaces are most hazardous. Of those, an open graded friction course (OGFC) design mix was found to offer superior antiskid performance in both dry and wet weather conditions prompting the FHWA to encourage its use on major highways for its additional safety benefits. Integral to this improved surface mix were wear-resistant aggregates. However, those states having only limited amounts of these high-friction wear-resistant aggregates are compelled to import these materials and in so doing experience higher construction costs. However 23 Code of Federal Regulations (CFR) 626 in accordance with Highway Safety Program Standard (HSPS) 12 required that each state project involving construction of a pavement should have a skid resistant surface.

Fundamentally, asphalt pavement is composed of crushed gravel or stone aggregates with an asphalt binder used to hold the mixture together and in place. Ideally, these aggregates are locally available and have sufficient hardness to resist the polishing effects from contact with vehicle tires. Unfortunately, construction costs require that the bulk of roadway aggregates be obtained locally forcing those regions devoid of the more desirable and harder aggregates to import these materials to blend with the more economically available local aggregates.

Accordingly, due to the thousands of miles of roadways within the state, a large portion of highway funds must be reserved annually for roadway construction and resurfacing. In an effort to attain the most benefits from these funds, highway agencies are financially obligated to research those asphalt surface mixes using locally available aggregates that exhibit superior skid resistant properties for the sole purpose of reducing highway construction costs.

Once highway resurfacing projects are completed, FHWA requires that skid testing be performed to ensure public safety. Even so, many factors may mutually contribute to premature skid test failures and hazardous driving conditions. One such factor is that asphalt has a tendency to harden as it ages with the result that the surface's aggregates must absorb more of the tire's impact. Related to this condition is raveling where the surface aggregates and asphalt binder are dislodged or worn away. The types of fine material admixtures (microtexture) included with the larger aggregates (macrotexture) play an important part towards preventing this condition. The surface microtexture is important at lower speeds and contributes more to general tire wear than the surface macrotexture which is more important at higher speeds and essential for channeling water from underneath tires preventing hydroplaning in wet weather. Beyond macrotexture is megatexture which tends to excessive road noise and rolling tire resistance. Coincidently, during tire contact, the courser aggregates in a mix also account for the major portion of skid resistance.

Project Objective

The project objective was to investigate the skid resistant qualities of various asphalt aggregate admixtures used by the state's asphalt producers. It was the purpose of this project to determine what locally available and cost effective aggregates or blends of aggregates can produce acceptable skid resistant surfaces and from these establish safe and durable suitable asphalt pavement mixes for statewide specifications.

Evaluations should include not just the type of aggregates but the ratios or composition of the mix components. Accordingly, a bitumen mix works well for microtexture purposes may not be satisfactory for macrotexture purposes.

Problem Statement

FHWA currently requires that each project involving construction or replacement of a surface pavement should have a skid resistant surface. AHTD specifications addressed this by limiting the use of limestone aggregate in wearing courses. Evaluations of skid tests over the last three years have found that blending aggregates has improved skid resistance on most jobs; however on some projects, it had been found that blending sandstone and limestone together yielded poorer skid numbers than limestone mixes. Research was needed to determine the performance of blended surface mixes and recommend appropriate changes to the Department' specifications.

Project Work Plan

Phase 1 - Perform a literature search to determine the complexity and equipment needs necessary to complete the project.

Phase 2 – Determine which highway sites had been constructed with single aggregates and blended aggregates that promised the greatest statewide cost benefits regarding highway construction projects.

- Past highway surface course materials found locally throughout the state included gravel, limestone or sandstone materials.
- Field work would include collection of the selected highway surface course mixes and respective quarries for virgin rock samples.
- Corresponding core samples may also be required to determine actual asphalt composition regarding aggregate type, size and volume.

Phase 3 – Perform the necessary laboratory testing that would best correlate aggregate wear resistance numbers to skid test numbers to complete the project.

Phase 4 – Perform a statistical analysis of the lab test results and surface monitored data collected from the selected highways.

Phase 5 – Prepare the blended aggregates for testing and evaluation and test for aggregate wear and durability.

Phase 6 – Evaluate the test results and determine what balance of qualities and admixtures would provide the most cost effective surface.

- Durability
- Asphaltene
- Bituminous materials
- Anti-polishing
- Pavement surface friction

The benefits of durable skid resistant roadway surfaces:

- Reduction in Wet Weather Accident Rates
- Less resurfacing to correct the hazardous condition

Failure to meet skid test specifications can result in:

- Increase in Wet Weather Accident Rates
- Increased fuel consumption
- Increased tire wear
- Increased resurfacing costs to correct the hazardous condition.
- Additional noise and vibration

Many factors can affect the skid resistance. Not the least of these are the surface's ability to shed water to prevent hydroplaning and asphalt base bleeding over the exposed aggregates presenting a slick water-oil film rather than direct tire-aggregate contact. Other variables include aggregate type and gradation, asphalt content, mixing temperature, compaction, traffic, and voids.

Project History

This project began in July 1992. Initially the project incorporated various roadways with a wide range of surface and traffic characteristics. However, repairs and modifications to both the British Portable Tester (BPT) test and Accelerated Polishing Device (APD) equipment and limitations on manpower delayed the project completion date. Efforts to correct the test equipment continued until 1996 when the equipment was relocated to District 6. At that time, the skid truck was experiencing frequent breakdowns. Further delays included personnel changes and additional manpower constraints until 1998 when the project was incorporated into the Skid Program, Job Number H456. Consequently, many of the roadways had received only sporadic skid testing or had been resurfaced with the jobs shown in Table 1 remaining substantially intact.

Table 1

Material	Job#	ADT	Mix Design	County	Rte	Sect.	Logmile	Length	Year
Limestone	9847	1420	Type 2	Newton	7	18	5.65-11.00	5.35	84
	9841	2010	Type 2	Carroll	412	5	10.58-21.21	10.63	85
	9811	2070	Type 2	Benton	12	1	5.81-6.05	0.24	86
	9825	4130	Type 2	Boone	7	19	1.58-7.31	5.73	83
	9839	7010	Type 2	Baxter	5	19	0.00-6.14	6.14	84
	9823	7970	Type 2	Baxter	201	1	0.00-1.54	1.54	84
	9824	11750	Type 2	Benton	62	2B	0.00-1.99	1.99	83
Gravel	3875	710	Type 2	Montgomery	240	1	9.69-11.75	2.06	82
	3898	1260	Type 2	Nevada	4	7	0.00-12.50	12.5	82
	2959	1590	Type 2	Chicot	82	10	1.52-3.00	1.48	82
	3921	4450	Type 2	Sevier	71	6	0.00-5.44	5.44	82
	30028	4970	Type 2	Hempstead	4	5	23.70-25.44	1.74	89
	3797	6590	Type 2	Howard	27	2	11.38-14.75	3.37	83
	3858	11440	Type 2	Little River	71	4	7.69-12.39	4.7	82
Sandstone/ Limestone	9891	4100	Type 2	Benton	264	1	0.00-7.75	7.754	88
	9844	4460	Type 2	Madison	412	4	0.00-6.00	6	85
	40144	8700	Type 1	Washington	62	1	14.37-15.34	0.97	94
	9856	11050	Type 2	Benton	62	2	3.52-8.37	4.85	85
Gravel/ Limestone	9748	400	Type 2	Newton	74	6	14.36-19.79	5.43	87
	9776	1300	Type 2	Newton	7	18	0.00-4.15	4.15	82
	9892	2210	Type 2	Baxter	5	19	6.14-15.41	9.27	90
	9854	2810	Type 2	Carroll	412	5	0.00-10.58	10.58	86
	9724	6000	Type 1	Benton	112	3	1.47-2.50	1.03	91
	9783	6350	Type 2	Baxter/Marion	62	9	9.27-11.82	2.55	89
	9803	16500	Type 2	Baxter	62	11	0.26-2.08	1.72	88

Testing Procedures

- Arkansas maintains the same LA Abrasion requirements (not greater than 40) and Sodium Sulfate Soundness requirement (loss shall exceed 12% after 5 cycles) as for Marshall designs.

- Prior to acceptance Arkansas verifies the initial mix design that is submitted and also verifies other mix designs as well as necessary by utilizing actual materials to be used in production. This work is done in the Department's central laboratory.

Arkansas requires the contractor to develop the mix designs. However, for mixes containing PG 70-22 and PG 76-22 asphalt binders, rolling had to start and finish soon immediately after laydown in order to obtain minimum percent compaction.

Arkansas implemented Superpave as the standard mix design during 1998.

Specifications for all asphalt cement were changed from viscosity gradings to performance gradings in November 1995. A maximum of three grades were established. 64-22 is used on all highways except Interstate; Interstate is specified with 76-22; 70-22 is specified for urban, slow traffic, etc. 64-22 replaced AC-30 or AC-20; 70-22 modified 1.5 to 2% was added; 76-22 modified 3 to 4% replaced our previously modified viscosity grade.

In 1998, the percentage of asphalt binder in Superpave surface course mixes was about the same as conventional Marshall mixes (sp5.46, ml5.35)(?); about 0.50% more in binder course (sp5.00, ml4.44); and about 0.10% less in base courses (sp4.43, ml4.54).

The SM-2E mix developed with generic PG 76-22 binder is used for extreme traffic loading. This binder was available in several forms from a variety of manufacturers, but its use still adds considerably to the cost of the hot-mix asphalt.

Four types of aggregate surfaces were included in the project: limestone, sandstone-limestone, gravel and gravel-limestone. Only those jobs with aggregate cold feed or core sample data are included in the tables below. Included with each of the project jobs are aggregate types, composition, sizes, job mix, specifications and lab tests data where available. Table 2 includes the limestone projects.

Table 2 Limestone

Limestone	Cold Feed	Size	Size	Size	Size	Size	Size	Size	Size	Size				
9823	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2413	Bitumen Sp. Wt.	2.461
STO-532	30		6.7	16.3	28.8	29.2		29.3	29.4	29.5	Voids	3.1	Marshall blows	50
STO-534	10				1.6	7.8		9.5	9.5	9.6	Flow	8.7	Rcmd AC(%)	5
STO-535	38				3.1	18.2		28.7	30.8	32.3	VMA	14.7	Aggregate/ton	$20.38
SA-316	22				0.7	1		3.1	18.9	21.4	Density	148.7		
Job Mix			6.7	16.3	34.2	56.2		70.6	88.6	92.8	Rtned Str.	1288		
Specs			3_15		25_45	45_60		68_80	80_92	92_96	% Rtned Str.	53.4		
9824	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	1658	Bitumen Sp. Wt.	2.471
STO-487	32		5	16.8	30.8	31.5		31.5	31.5	31.6	Voids	3	Marshall blows	50
STO-488	10				9.6	9.8		9.8	9.9	9.9	Flow	8	Rcmd AC(%)	5.2
STO-491	40					12		27.9	32.5	35.2	VMA	15.1	Aggregate/ton	$31.40
SA-275	18							4	15.1	17.9	Density	149.3		
Job Mix			5	16.8	40.4	53.3		73.2	89	94.6	Rtned Str.	1250		
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.	75.4		
9825	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2660	Bitumen Sp. Wt.	2.448
STO-358	39		4.6	16.5	37	37.6		37.9	38	38.2	Voids	2.9	Marshall blows	50
STO-359	43				1.7	14.6		29.2	34.3	37.6	Flow	10.3	Rcmd AC(%)	5.1
SA-179	18			0.4	1.7	2.6		4.7	13.4	15.8	VMA	13.6	Aggregate/ton	$21.62
Job Mix			4.6	16.9	40.4	54.8		71.8	85.7	91.6	Density	149.6		
Specs			3_15		25_45	45_60		68_80	80_92	90_96	Rtned Str.	2063		
9839	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Marshall blows	
											Flow		Rcmd AC(%)	
Job Mix			6	18	38	56		69	87	92.2	VMA		Aggregate/ton	$22.22
Specs			3_15		25_45	45_60		68_80	80_92	92_96	Density			
9841	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Marshall blows	
											Flow		Rcmd AC(%)	5.5
Job Mix			5	16	38	58		72	88	95.2	VMA		Aggregate/ton	$19.45
Specs			3_15		25_45	45_60		68_80	80_92	92_96	% Rtned Str.	77.6		
9847	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Marshall blows	
											Flow		Rcmd AC(%)	
Job Mix			9	17	34	55		72	87	93	VMA		Aggregate/ton	$27.68
Specs			3_15		25_45	45_60		68_80	80_92	90_96	Density			

Sandstone-limestone projects are shown in Table 3.

Table 3 Sandstone-Limestone

SS/LS	Cold Feed	Size	Size	Size	Size	Size	Size	Size	Size	Size				
40144*	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2555	Bitumen(%)	2.451
3/4 SS	20										Voids	4.03	Marshall blows	75
1/2 LS	20										Flow	7.33	Rcmd AC (%)	5.1
DRG SA	9										VMA	15.65	Aggregate/ton	$32.00
SCRNS	36										Density	146.8		
SA	15										Rtned Str	2078		
Job Mix			6.4	16.1	27.7	52.8	66.8	76.4	89.6	95.1	% Rtned Str.	81.3		
Specs			3_15		25_45	45_60		68_80	80_92	92_96				
9844	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Marshall blows	
											Flow		Rcmd AC(%)	
Job Mix			8	16	37	53		73	89.6	96	VMA		Aggregate/ton	
Specs			3_15		25_45	45_60		68_80	80_92	92_96	Density			
9856	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Marshall blows	
											Flow		Rcmd AC(%)	
Job Mix			9	19	42	57		72.4	86.7	92.9	VMA		Aggregate/ton	$27.50
Specs			3_15		25_45	45_60		68_80	80_92	92_96	Density			
9891	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2200	Bitumen Sp. Wt.	2.406
STO-110	23		5.8	12.1	21.4	22.2	22.4	22.4	22.4	22.6	Voids	2.5	Rcmd AC (%)	5.5
STO-111	24			1.7	18.5	22.8	23.1	23.2	23.3	23.3	Flow	11.3	Marshall blows	50
STO-112	15					4	7.6	9.5	11.5	12.8	VMA	15.1	Aggregate/ton	$22.00
STO-113	22					6.5	12.3	15.3	17.9	19.2	Density	146.4		
SA-49	16						0.3	1.6	11.6	15.6	Rtned Str.	1960		
Job Mix			5.8	13.8	39.9	55.5	65.7	72	86.7	93.5	% Rtned Str.	89.1		
Specs			3_15		35_45	50_60		68_76	80_92	92_96				

Gravel projects are shown in Table 4 and gravel-limestone projects are shown in Table 5. Job Number 9724 is a gravel-limestone project and no mix data was found available.

Table 4 Gravel

Gravel	Cold Feed	Size	Size	Size	Size	Size	Size	Size	Size	Size				
2959	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	1460	Bitumen Sp. Wt.	2.372
GR-2	50		6.4	16	34.5	42.5		47.1	48.3	49	Voids	3.2	Rcmd AC (%)	5.5
GR-3	12			0.7	6.6	9.4		11	11.4	11.6	Flow	7.3	Marshall blows	50
SA-5	25				0.2	0.6		15.6	24.8	25	VMA	15.4	Aggregate/ton	$22.00
SA-6	13								2.4	6.8	Density	143.3		
Job Mix			6.4	16.7	41.3	52.5		73.7	86.9	92.4	Rtned Str.			
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.			
30028	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2798	Bitumen Sp. Wt.	2.368
STO-256	64										Voids	3.41	Rcmd AC (%)	5.6
SA-133	27										Flow	9.29	Marshall blows	50
SA-134	9										VMA	15.9	Aggregate/ton	$22.88
Job Mix			10.3	22.1	39.2	54.7	64.4	71	84.8	92	Density	143.7		
Specs			0_15		32_45	51_59		67_75	81_89	90_94	Rtned Str.	1987		
											% Rtned Str.	71		
3797	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2213	Bitumen Sp. Wt.	2.374
GR-281	58		7.4	18.9	37.3	47.9		53.9	55.6	56.5	Voids	4.1	Rcmd AC (%)	5.6
SA-314	10			0.1	0.8	1.1		1.8	4	6.4	Flow	9	Marshall blows	75
SA-315	32				0.2	6.1		16.2	27.2	30.9	VMA	16.2	Aggregate/ton	$19.95
											Density	142.2		
Job Mix			7.4	19	38.3	55.1		71.9	86.8	93.8	Rtned Str.	2028		
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.	91.6		
3858	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	3135	Bitumen Sp. Wt.	2.406
GR-77	50		6.4	18.9	39	44.9		47	47.5	48.3	Voids	3.1	Rcmd AC (%)	5
STO-135	30			0.2	0.4	2.9		14.4	19.3	24.2	Flow	8.9	Marshall blows	75
SA-77	20				0.4	5.8		12.5	19	19.9	VMA	14.5	Aggregate/ton	$16.14
											Density	146		
Job Mix			6.4	19.1	39.8	53.6		73.9	85.8	92.4	Rtned Str.			
Specs			3_15		25_45	45_60		68_80	80_92	90_98	% Rtned Str.			
3875	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2540	Bitumen Sp. Wt.	2.366
GR-709	60		5.9	16.9	35.9	47.8		54.2	56.6	57.6	Voids	3.1	Rcmd AC (%)	5.3
SA-700	35				0.6	8.8		19.4	30.3	33.9	Flow	9.5	Marshall blows	50
MF-4	5									1	VMA	14.7	Aggregate/ton	$19.80
											Density	143.2		
Job Mix			5.9	16.9	36.5	56.6	0	73.6	86.9	92.5	Rtned Str.			
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.			
3898	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	1670	Bitumen Sp. Wt.	2.377
GR-710	35		7.1	15.6	25.3	29.1		30.9	32	32.8	Voids	3.5	Rcmd AC (%)	5.8
GR-712	40				10.1	24.9		35	37.1	38.1	Flow	8.2	Marshall blows	50
SA-646	12					1.6		7.2	11	11.4	VMA	16.7	Aggregate/ton	$20.45
SA-647	13							0.1	5.5	11.4	Density	142.8		
Job Mix			7.1	15.6	35.4	55.6		73.2	85.6	93.7	Rtned Str.			
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.			
3921	C. Fd (%)	3/4"	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2500	Bitumen Sp. Wt.	2.384
GR-875	55		6.5	23	40.6	47		50.8	52.3	53.4	Voids	3.8	Rcmd AC (%)	5.6
SA-798	25				0.6	7.3		14.6	21.4	23.8	Flow	9.7	Marshall blows	50
SA-799	20				0.6	2.2		6.2	11.5	15.4	VMA	16.2	Aggregate/ton	$15.85
											Density	143.2		
Job Mix			6.5	23	41.8	56.5		71.6	85.2	92.6	Rtned Str.			
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.			

Table 5 Gravel-Limestone

GR/LS	Cold Feed	Size	Size	Size	Size	Size	Size	Size	Size	Size				
9748	C. Fd (%)	**3/4"**	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Recmd AC (%)	5.4
											Flow		Marshall blows	
Job Mix			8	18	38	57		74	90	93.8	VMA		Aggregate/ton	$28.00
Specs			3_15		25_45	45_60		68_80	80_92	90_96	Density			
9776	C. Fd (%)	**3/4"**	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	3000	Bitumen Sp. Wt.	2.401
GR-487	27		5.7	11.5	19.8	23.6		25.1	25.9	26.3	Voids	3	Recmd. AC (%)	4.9
STO-1055	17		1.1	5.7	15.2	16.2		16.4	16.5	16.6	Flow	11	Marshall blows	50
STO-1056	40				2	16.2		28.8	32.7	35.3	VMA	14.3	Aggregate/ton	$17.18
SA-763	16				0.1	0.3		1.2	9	13.4	Density	144.4		
Job Mix			6.8	17.2	37.1	56.3		71.5	84.1	91.6	Rtned Str.			
Specs			3_15		25_45	45_60		68_80	80_92	90_96	% Rtned Str.			
9783	C. Fd (%)	**3/4"**	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2278	Bitumen Sp. Wt.	2.44
GR-74	30		4.8	11.7	20.4	23.8	25.3	26.1	27.7	28.5	Voids	3.1	Recmd. AC (%)	5.1
STO-221	10		2.5	6	9.4	9.6	9.6	9.6	9.6	9.7	Flow	8.3	Marshall blows	75
STO-222	39				8.2	21.4	28.3	30.9	33	34.4	VMA	14.9	Aggregate/ton	$26.00
SA-103	21			0.3	1.3	2.1	2.5	4.3	17.5	19.8	Density	143.7		
Job Mix			7.3	18	39.3	56.9	65.7	70.9	87.8	92.4	Rtned Str.	1985		
Specs			3_15		34_44	52_62		68_78	80_92	90_96	% Rtned Str.	87.1		
9803	C. Fd (%)	**3/4"**	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)		Bitumen Sp. Wt.	
N/A											Voids		Recmd. AC (%)	5.44
											Flow		Marshall blows	
Job Mix			10	22	41	60	69	74	88	93	VMA		Aggregate/ton	$27.36
Specs			3_15		25_45	45_65		68_78	80_92	90_96	Density			
9854	C. Fd (%)	**3/4"**	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	2225	Bitumen Sp. Wt.	2.39
GR-66	20		0	1.5	9.4	14		17.3	18.5	19.1	Voids	3.9	Recmd. AC (%)	5.7
STO-162	26		6.8	12.2	21.6	24.1		24.7	24.9	25.2	Flow	8.7	Marshall blows	50
STO-163	34				2	16.6		26.8	29.1	30.5	VMA	16.9	Asph/gal	$1.50
SA-90	20					0.7		3.7	17.7	19.9	Density	143.3	Aggregate/ton	$33.23
Job Mix			6.8	13.7	33	55.4		72.5	90.2	94.7	Rtned Str.	1895		
SPECed			3_15		28_38	50_60		69_77	80_92	93_96	% Rtned Str.	85.2		
9892	C. Fd (%)	**3/4"**	1/2"	3/8"	#4	#10	#20	#40	#80	#200	Stability(lbs)	1867	Bitumen Sp. Wt.	2.362
GR-124	48										Voids	4.27	Recmd. AC (%)	5.5
STO-339	8										Flow	9.17	Marshall blows	50
STO-340	25										VMA	16.28	Aggregate/ton	$19.81
SA-141	19										Density	141.1		
Job Mix			8	19.1	41.3	57.6	65.8	70.5	88.3	93.8	Rtned Str.	1335		
Specs			0_15		34_45	54_62		66_74	84_92	92_96	% Rtned Str.	71.5		

Note-No mix data available for Job Number 9724

Table 6 includes the surface life in years experienced by the project jobs. Among many factors, the average daily traffic (ADTs) can dramatically change over time and are among the major contributors to premature skid test failures.

Table 6 Surface Life and 2004 ADTs

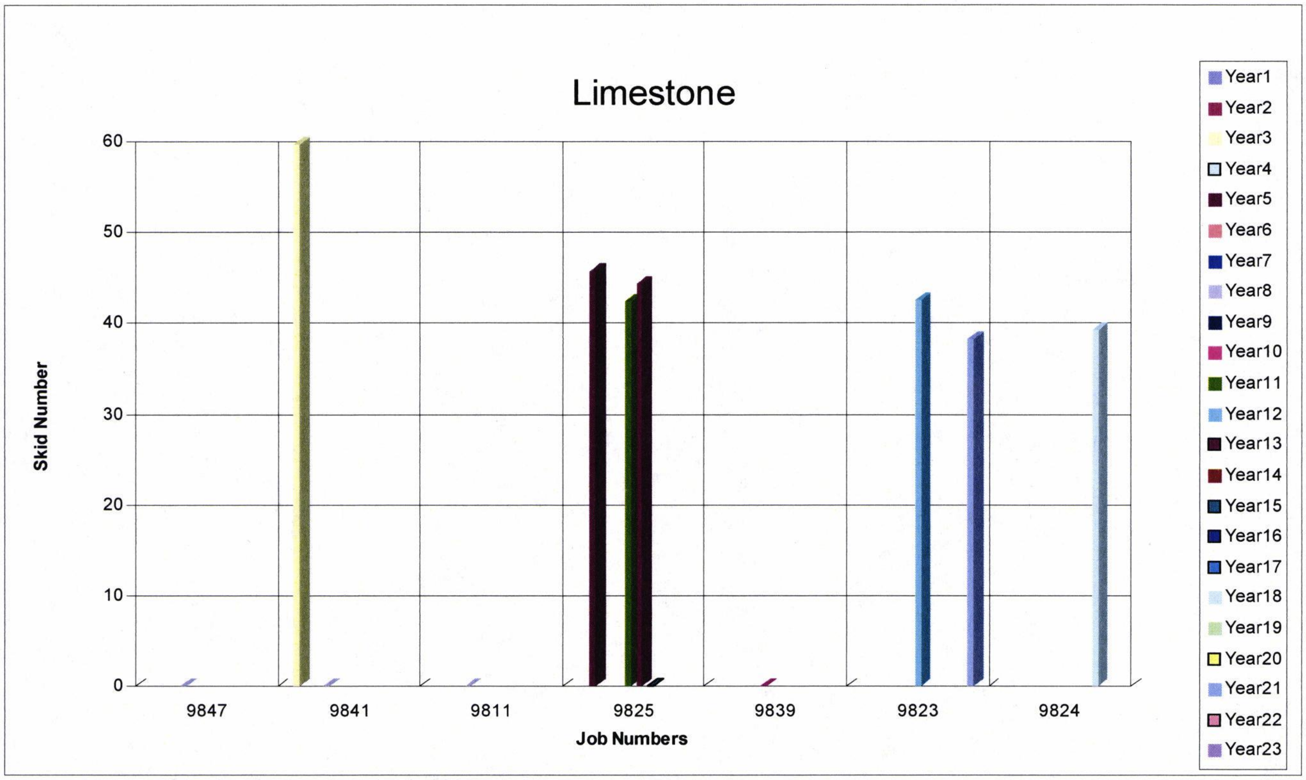
Limestone	Year	Surface Life (Years)	2004 ADT	Job/Year Refurbished (2004 Roadlog)
9847	84	8	2600	9940/1992
9841	85	8	3600	9-753/1993
9811	86	8	3300	9-755/1994
9825	83	15	4900	90112/1998
9839	84	10	12100	9987/1994
9823	84	21	5800	X
9824	83	22	12700	X
Gravel				
3875	82	23	830	X
3898	82	23	1600	X
2959	82	10	2200	20158/1992
3921	82	17	4700	30214/1999
30028	89	10	7500	30068/1999
3797*	83	18	7200	30256/2001
3858	82	9	13300	30062/1991
SS/LS				
9891	88	14	3200	90128/2002
9844	85	14/10	3700	9948/1999 & R90101/1995
40144	94	11	12200	X
9856	85	20	10100	X
GR/LS				
9748	87	18	380	X
9776	82	23	1400	X
9892	90	15	8800	X
9854	86	9	3300	90101/1995
9724	91	14	12800	X
9783	89	16	9900	X
9803	88	10	9600	9774/1997

*No skid data available

X – Original surface

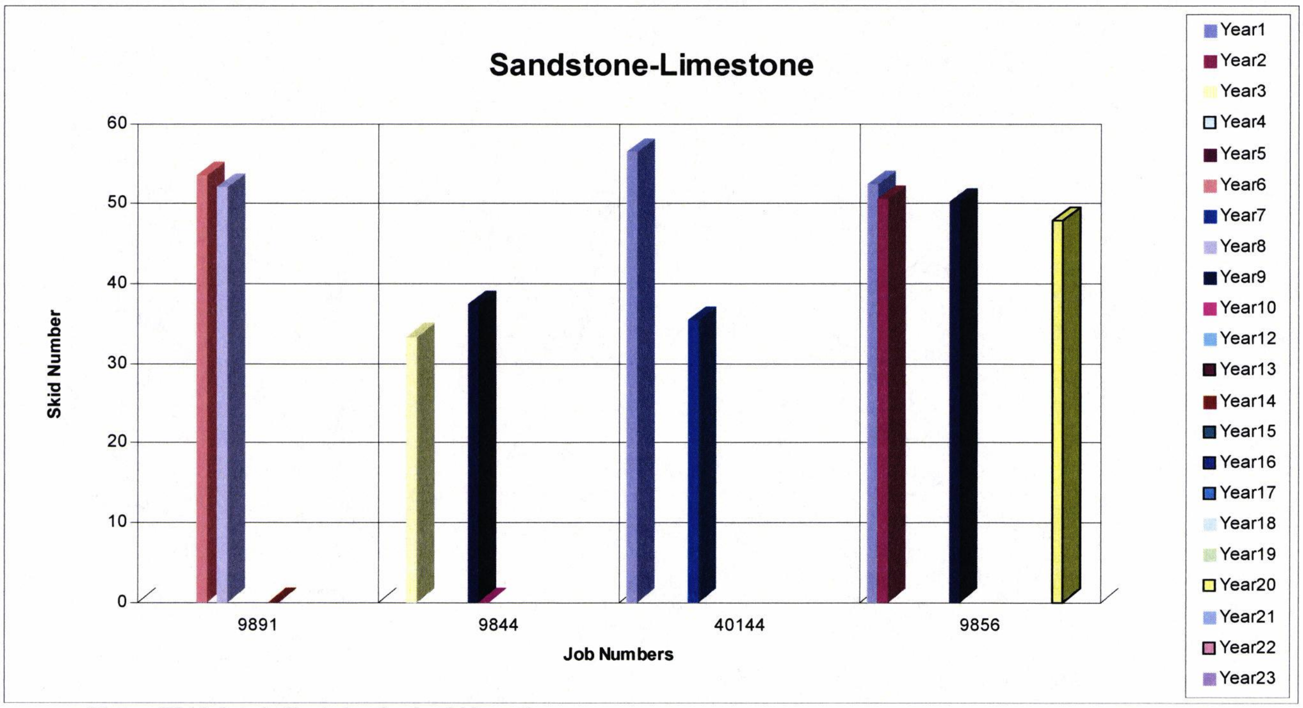
The following four graphs of aggregate surface types display the jobs and averaged test skid numbers with the corresponding year the data was collected. Graph marks indicating a 0 (zero) skid number value is the year that records indicate the surface was replaced. Job Number 3797 (Gravel mix) was not included due to the absence of skid data.

Graph 1 Limestone Surface



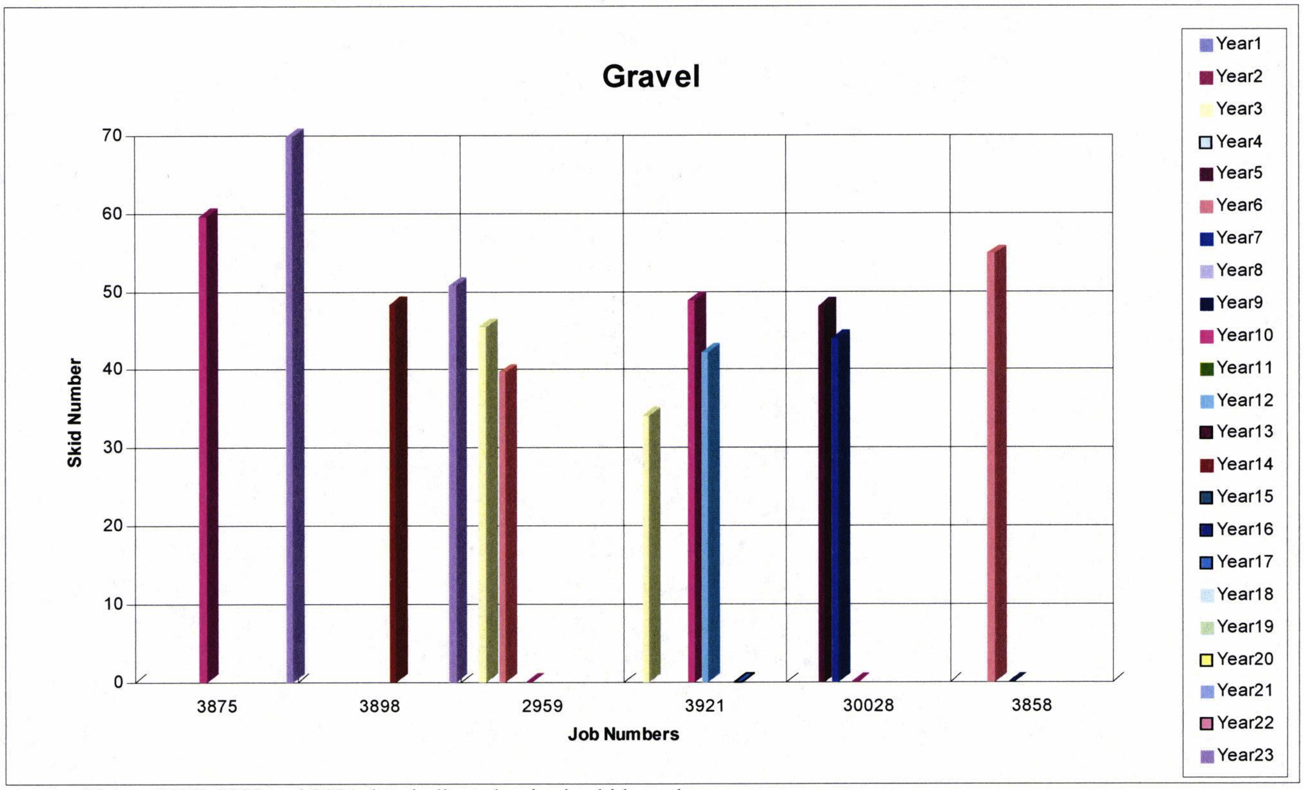
Note – 9825 data indicated a rise in skid number.

Graph 2 Sandstone-Limestone Surface



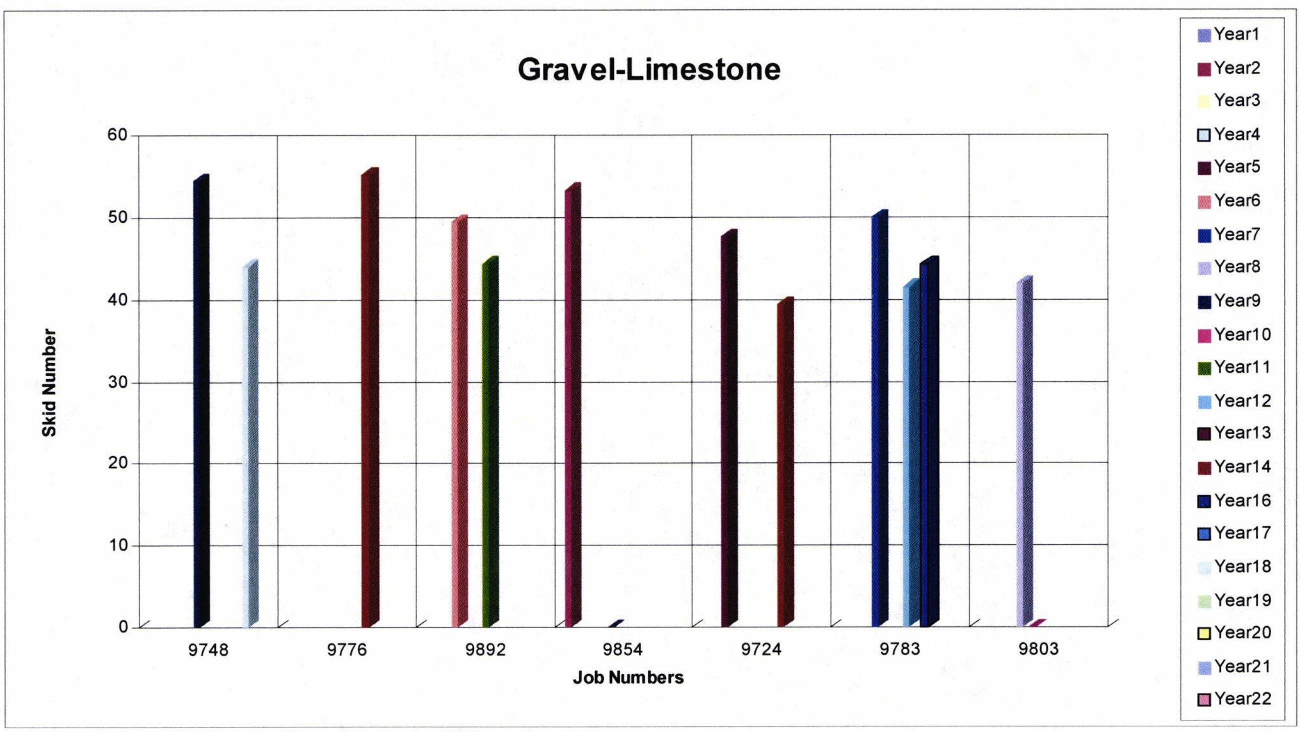
Note – 9844 data indicated a rise in skid number.

Graph 3 Gravel Surface



Note – 3875, 3898 and 3921 data indicated a rise in skid number.

Graph 4 Gravel-Limestone Surface



Note – 9783 data indicated a rise in skid number.

Conclusion

The absence of skid tests and lab results severely limited any conclusive findings throughout this report. Only general observations could be made where no supporting evidence could be produced. No determinations could be made where skid numbers appeared to increase over time although it is suspected the asphalt had gotten harder with age.

1. Limestone surfaces averaged lower overall skid numbers.
2. The sandstone-limestone surfaces having the higher mix percentages of larger aggregates appeared to retain skid numbers longer.
3. Gravel surfaces on the whole had good skid numbers but did not hold up well with medium/heavy traffic conditions.
4. Gravel-limestone surfaces held good skid numbers well with medium/heavy traffic conditions.