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INITIAL REPORT U 2006-8

50 GYRATION SUPERPAVE MIX
ROCHESTER/GRANVILLE, VT 100

REFERENCES:

WP 2005-R-2

INTRODUCTION:

One of the principle outcomes of the Strategic Highway Research Program, or SHRP, was the invention and implementation of a new pavement mix design known as Superpave. This pavement design technique accounts for traffic loading and environmental conditions that were not previously considered during the Marshall mix design process. Additionally, a Superpave gyratory compacter was developed to improve mix design's ability to simulate actual field compaction during laboratory analysis.

Since nationwide implementation in 1993, the Superpave mix design has proven to be successful in delaying the onset and reducing the cumulative rate of rutting, or depression within the wheel paths caused by the passage of vehicles. This is an important design parameter as rutting may cause hydroplaning and has been attributed to improper mix designs that are excessively high in asphalt content, mineral filler and/or an insufficient amount of angular aggregate particles. However, some Superpave mixes have been shown to ravel prematurely at pavement joints, crack and become permeable to water. In order to counteract these premature distresses, many states are beginning to examine the amount of asphalt binder specified within the mix designs.

In accordance with AASHTO R 35-04, "Superpave Volumetric Design for Hot Mix Asphalt", the amount of gyrations, or compaction effort, is governed by the anticipated traffic level on the design lane over a 20 year period. Basically, a higher anticipated traffic loading requires a higher number of gyrations, ranging from 50 to 125 gyrations. Once the number of gyrations has been selected, testing is performed to determine the optimum binder content. Although there are several ways to successfully achieve a lower level gyration mix design, which may be accomplished by varying the gradation of the mix or amount of air voids, the amount of asphalt cement content is typically increased.

The resulting pavement mixture may allow for increased film thickness to surround the aggregates creating a more resilient and flexible material that could reduce the impact of freeze/thaw cycles while maintaining a resistance to rutting. An increase in asphalt cement, otherwise known as binder, should produce a mix that requires less compaction effort in the field. However, lower level gyration mixes are not expected to perform as well as higher level gyration mixes under high rates of traffic loading with regards to rutting.

When Superpave mixes are constructed, the State of Vermont typically utilizes a 75 gyration mix on primary and secondary roads. The objective of this research initiative is to compare the constructability, ease of compaction as well as the overall performance of a 75 gyration Superpave mix versus a 50 gyration Superpave mix on a low volume secondary road. The following initial report outlines the initial observations with regards to preexisting pavement distresses, constructability and performance after one year of service.

PROJECT DESCRIPTION:

The Rochester/Granville pavement project, STP 2124(1)S was constructed during the summer and fall of 2005 and began on VT Route 100 at mile marker (MM) 6.069 in Rochester and continued northerly to MM 2.929 for a total length of 7.749 miles. The project included drainage, guardrail improvements and resurfacing with a leveling and wearing course. The experimental and control sections consisted of a 35 mm overlay with a 50 and a 75 gyration mix, respectively. The performance graded binder utilized within both mix designs was a PG 58-34. This indicates that the binder should perform satisfactory at an average 7 day high temperature of 58°C at 20 mm below the pavement surface and an average one day low temperature of -34°C at the pavement surface. In accordance with the federally approved work plan, 2005-R-2, the control and experimental section were placed as indicated in Table 1:

Rochester-Granville STP 2124 Rehabilitation Project						
Section Type:	**Mile Marker:**	**Town:**	**To**	**Mile Marker:**	**Town:**	**Segment ID:**
Experimental	6.069	Rochester	-	0.000	Hancock	1
Standard/Control	0.000	Hancock	-	2.000	Hancock	2
Experimental	2.000	Hancock	-	2.929	Granville	3

Table 1: Project Limits

As stated within the work plan, six test sites were established throughout the entire length of the roadway segment. Each test site was located in an area with good sight distance on a straight away and consisted of a total length of 100 feet in the direction of travel and are approximately 22' wide encompassing both the north and southbound lanes. Of the six test sites, two were located within the control section and four sites were identified within the experimental sections. Figure 1, provided below, displays a typical test section prior to construction:

Figure 1: Test Site 5

PRECONSTRUCTION CONDITIONS:

Cracking, rutting and IRI values are often utilized to assess the performance and service life of pavement treatments or in this case different pavement mix designs. It has been shown that the surface condition of a pavement is directly correlated to its structural condition. Condition is a non-linear relationship which can be characterized by increasing rates of deterioration. The following is a description of the condition of the roadway prior to construction. All preconstruction surveys were conducted on Thursday, June 23, 2005.

RUTTING

Rutting is generally due to permanent deformation within any of the pavement layers or subgrade and is usually caused by consolidation or lateral movement of the material due to traffic loading. As stated above, this parameter is of special interest throughout the duration of the project as it is anticipated that the 50 gyration mix will rut more readily as compared to the 75 gyration Superpave mix. A rut gauge was utilized to quantify the overall depth of rut within each test section. All rut measurements were collected at 50' intervals from the beginning to the end of each test section. The measurement was collected by extending a string across the width of the road and measuring the vertical length between the string and the deepest depression within all wheel paths identified along the length of the string. All measurements were record onto a standard field form in 1/8" intervals. It is important to note this procedure is highly subjective due to the nature of the data collection procedure. The following table displays a summary of average rut depths within each wheel path for each test site:

Rochester-Granville STP 2124 Rehabilitation Project Preconstruction Rut Depth Summary							
				Rut Depth (in.)			
Test Site ID:	MM Location:	Town:	Section Type:	SB Right Wheel Path	SB Left Wheel Path	NB Left Wheel Path	NB Right Wheel Path
TS 1	6.98	Rochester	50 Gyration	0.42	0.25	0.29	0.29
TS 2	8.08	Rochester	50 Gyration	1.33	0.83	0.96	1.29
TS 3	0.90	Hancock	75 Gyration	0.63	0.29	0.29	0.88
TS 4	1.80	Hancock	75 Gyration	0.38	0.46	0.46	0.08
TS 5	1.15	Granville	50 Gyration	0.50	0.46	0.46	0.71
TS 6	2.52	Granville	50 Gyration	0.67	0.63	0.21	0.42
			Average Rut Depth:	0.65	0.49	0.44	0.61

Table 2: Summary Rut Depths

Currently, there are no industry standards regarding acceptable rut depths. However, the Ohio Department of Transportation has published a report on rut severity based upon rut depth as follows: low – depth less than ¼ inch, medium – greater than ¼ inch and less than 1 inch, high – greater than one inch. At a depth of 1 inch or greater, research has shown a definite effect on vehicle control. In examining Table 2, it appears that the average measured rut depth in all wheel paths is of medium severity. However, the depth of rut within the SB and NB right wheel paths at Test Site 2 are of concern. In general, the rut depths within the right wheel paths are greater in comparison than those within the left wheel paths. This is most likely due to the underlying subgrade and reduced lateral support.

CRACKING

There are several causes for cracking in flexible pavements, including inadequate structural support such as the loss of base, subbase or subgrade support, an increase in loading, inadequate design, poor construction, or poor choice of materials including binder. For this research project, longitudinal, transverse and reflective cracking will be examined. Longitudinal cracks run parallel to the laydown direction and are usually a type of fatigue or load associated failure. Transverse cracks run perpendicular to the pavement's centerline and are usually a type of thermal fatigue that may be induced by multiple freeze thaw cycles. All pavement cracks are visually assessed and recorded onto standard field forms which contain a 1' by 1' grid encompassing the entire limits of the test site. All cracks are then counted and divided into their respective categories as described below.

I. Fatigue Cracking

As indicated by the "Distress Identification Manual," fatigue cracking occurs in areas subjected to repeated traffic loading, typically the wheel paths, and may be a series of interconnected cracks in early stages of development that progresses into a series of chicken wire/alligator cracks in later stages. For this investigation, the wheel paths were determined to be three feet in width with the center of the left wheel path 3.5' from the centerline and 8.5' from the shoulder for the right wheel path on either side of the roadway. An important parameter considered during the pavement design process is a wheel load characterized as an ESAL, or equivalent single axle load. An ESAL is defined by Clemson University as "the effect on pavement performance of any combination of axle loads of varying magnitude equated to the number of 80-kN (18,000-lb.) single-axle loads that are required to produce an equivalent effect." Basically, pavements are designed to structurally support traffic loads which are often calculated by ESAL's with regards to roadway use.

II. Thermal Cracking

The formation of transverse cracking is largely due to climatic conditions and is often induced by freeze-thaw cycles or by maximum low temperature shrinkage cracking. These cracks allow for water infiltration causing additional pavement distresses. Thermal cracking is directly attributed to the type of asphalt cement within the pavement's composition. For this investigation, all cracks perpendicular to the pavement's centerline will be examined regardless of whether or not they are continuous from edgeline to centerline.

A summary of the total length of fatigue and thermal cracking is indicated in Table 4 provided below:

Rochester-Granville STP 2124 Rehabilitation Project Summary of Preconstruction Pavement Distress					
Test Site ID:	**MM Location:**	**Town:**	**Section Type:**	**Fatigue Cracking (LF):**	**Thermal Cracking (LF):**
TS 1	6.98	Rochester	50 Gyration	87	8
TS 2	8.08	Rochester	50 Gyration	156	0
TS 3	0.90	Hancock	75 Gyration	163	20
TS 4	1.80	Hancock	75 Gyration	363	13
TS 5	1.15	Granville	50 Gyration	219	92
TS 6	2.52	Granville	50 Gyration	203	18
			Average LF of Cracking:	**199**	**25**

Table 4: Preconstruction Crack Summary

In examining Table 4, it is clear that insufficient lateral support appears to be a larger problem as opposed to pavement distresses caused by environmental conditions due to the greater occurrence of fatigue cracking noted at each test site. From this information and given the location of the roadway, it is surmised that local and cost effective materials were utilized to construct the underlying subbase and base. Increases in load weight and load frequency since the original road-section design have generated an insufficient load carrying capacity. Please note however, that each test site was established at random locations which may not fully depict the frequency of roadway distresses.

IRI

IRI, or the International Roughness Index, is utilized to characterize the longitudinal profile within the wheel paths and constitutes a standardized measurement of smoothness. According to Better Roads Magazine, "pavement's IRI in inches per miles measure the cumulative movement of the suspension of the quarter-car system divided by the traveled distance. This simulates ride smoothness at 50 miles per hour." IRI values are directly correlated to pavement distresses. IRI values were collected in 1/10 mile increments on Monday, May 22nd, 2005 through the Pavement Management Section of VTrans utilizing a road profiler. Table 5 displays the average IRI values for each wheel path. In addition, the Federal Highway Administration, or FHWA, has published a conditional rating scale of a roadway segment based upon IRI results as shown in Table 6.

Rochester-Granville STP 2124 Rehabilitation Project Summary of IRI Data						
		IRI Values (in./mile)				
Section Type:	**Segment ID:**	**SB Right Wheel Path**	**SB Left Wheel Path**	**NB Left Wheel Path**	**NB Right Wheel Path**	**Average:**
Experimental	1	193	140	148	212	**173**
Standard	2	232	193	177	215	**204**
Experimental	3	232	188	192	263	**219**

Table 5 – Preconstruction IRI Values

IRI Pavement Condition Scale		
Condition Term Categories	**Interstate**	**Other**
Very Good	<60	<60
Good	60-94	60-94
Fair	95-119	95-170
Mediocre	120-170	171-220
Poor	>170	>220

Table 6: FHWA IRI Condition Scale

In examining Table 5, the average IRI values increase steadily heading north along VT 100. Additionally, the IRI values collected from the right wheel path of both the north and southbound lanes were found to be consistently greater than those within the left wheel path, roughly 50 inches per mile on average, which supplies additional evidence to suggest a pavement response from insufficient subgrade support. As a final aside, the average IRI values for both the control and experimental sections indicate that the preconstruction condition of the roadway was found to be mediocre in accordance with the IRI Pavement Condition Scale.

MIX DESIGN AND CONSTRUCTION:

As stated previously, although there may be many ways to produce a 50 gyration mix in comparison to a 75 gyration mix, the only variable that was altered for this experimental research project was the amount of binder in the mix. According to the "Superpave Bituminous Concrete Mixture Design" produced by Pike Industries, the amount of binder utilized within the 75 gyration mix was 5.6% while the amount of binder utilized within the 50 gyration mix was a total of 6%, an increase of 0.4% in total mix weight. This represents a 14% increase in asphalt mass. Everything else remained a constant, including the sources and gradation of the stone mix as well as the performance graded asphalt binder, a PG 58-34. Additionally, both the experimental and control mixes contained 12% natural sand and 15% RAP, or Recycled Asphalt Pavement. However, in order to compensate for the increased binder content within the 50 gyration mix, the amount of aggregate was reduced from 3274 Kg within the 75 gyration mix to 3257 Kg within the 50 gyration mix, for a total reduction of 17 Kg of aggregate per batch weight. A copy of the mix designs is provided in Appendix A.

For this investigation it will be important to compare the anticipated traffic level on the design lane over a 20 year period to the number of gyrations (50 or 75), otherwise known as N design, with regards to the overall performance of each mix. In accordance with the AASHTO R 35-04, a 50 gyration mix should be constructed on a roadway with a design ESAL of 0.3 million or less. Conversely, a 75 gyration mix should be applied in locations of a design ESAL equal to or greater than .3 million and less than 3 million. If a road is constructed with a lower level gyration mix than suggested by AASHTO it may be hypothesized that the pavement may not provide enough structural support and premature pavement distresses in the form of fatigue cracking and rutting are likely to occur. Table 7 provides a summary of the Design ESALs calculated by the Technical Services Division in association with the number of gyrations and suggested AASHTO specifications. Please note that a mix design exceeding the suggested vehicular loading is highlighted in red.

Rochester-Granville STP 2124 Rehabilitation Project Mix Design Comparison to Predicted 20 Year Design ESALs							
Limits				Design ESAL (millions)	N Design	Suggested AASHTO Design ESAL (millions)	Magnitude out of Suggestion
Begin MM	Town	End MM	Town				
6.069	Rochester	7.130	Rochester	1.0	50	<0.3	3.36
7.130	Rochester	0.000	Hancock	0.7	50	<0.3	2.34
0.000	Hancock	1.200	Hancock	0.7	75	0.3 to <3	-----
1.200	Hancock	2.000	Hancock	0.5	75	0.3 to <3	-----
2.000	Hancock	2.929	Granville	0.5	50	<0.3	1.63

Table 7: Mix Design Comparison

The construction project began on Friday, August 11th, 2005. Prior to the production of the respective wearing courses, a shim or leveling course was applied to the uneven surface of the road. Shimming was performed over the course of four nonconsecutive days, three of which were within the limits of the 50 gyration sections. The same mix type was used for shim as wearing course. A site visit was conducted on August 23rd to observe the application of the leveling course. During the site visit, Tony Coarse, the

Resident Engineer, expressed concerns related to the excessive amount of hot mix asphalt that was needed for the leveling course most likely resulting from deep ruts. It was also noted that the leveling course was applied in one lift. This combination may result in premature rutting as the leveling course may continue to consolidate within the wheel paths under continuous traffic loading.

The application of the wearing course began on September 22nd, 2005 with the application of the 75 gyration Superpave Mix in the town of Hancock and was constructed in thirteen nonconsecutive days. No significant observations were recorded by the Resident during this timeframe with the exception of the difficulty experienced by the Contractor, Pike Industries, in achieving the specified compaction of the 75 gyration mix on September 23rd. A site visit was conducted on October 10th, 2005 in order to assess the ease of compaction with regards to the 50 gyration mix. While onsite, Tony Coarse explained that little compaction effort was needed for the 50 gyration mix in comparison to the 75 gyration mix.

According to the "2006 Standard Specifications for Construction", "the density of the compacted pavement shall not be less than 92.5% nor more than 96.5%." In order to verify field compaction, a minimum of six cores must be extracted from the constructed pavement for each day of production. Once extracted, each core is tested in accordance with AASTHO T166-00, "Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens." All results for one day's production is entered into a spreadsheet and assessed for compaction values that may be outside of the specification. Table 8, provided below, contains a summary of compaction results for the duration of the project in addition to how many cores were out of spec. Please note that there was an even distribution of cores below and above the specification for both mix types.

Rochester/Granville STP 2124 Rehabilitation Project Summary of Compaction Results					
Mix Type:	**Average:**	**Standard Deviation:**	**Count:**	**Number out of Spec:**	**Percent out of Spec:**
75 Gyration Mix	94.07	1.15	18	3	16.67%
50 Gyration Mix	94.84	1.49	60	11	18.33%

Table 8 – Compaction Results

COST:

The bid price associated with the 50 and 75 gyration mix was $54/ton. This should represent the total cost for production, application and compaction. However, when computed by production quantities placed, the total cost for the 50 gyration Superpave mix was $656,772 or $114,620 per mile. While the total cost for the 75 gyration Superpave mix was $194,637 or $97,319 per mile for a total difference of $17,301. Overall, this is a small discrepancy most likely attributed to the amounts of Superpave mix required for shimming.

PERFORMANCE:

The first of the annual inspections was carried out in June of 2006. In general, the pavement was in good condition as little cracking or rutting was noted. All test sites were reestablished in the original locations. Any cracking or rutting was recorded onto the appropriate data sheets. In addition, IRI data was collected on September 28th, 2006. Table 9 through Table 11 provides a summary of each type of distress following one year of performance. Please note that another parameter under evaluation is the onset and rate of reflective cracking, or the propagation of the cracks from the existing pavement into the layer of pavement added during rehabilitation. This will be directly impacted by the flexibility of the pavement overlay. A summary of reflective cracking is furnished within Table 10.

Rochester-Granville STP 2124 Rehabilitation Project Summary of Rut Depth Following One Year of Service							
				Rut Depth (% of Preconstruction)			
Test Site ID:	MM Location:	Town:	Section Type:	SB Right Wheel Path	SB Left Wheel Path	NB Left Wheel Path	NB Right Wheel Path
TS 1	6.98	Rochester	50 Gyration	31%	52%	86%	45%
TS 2	8.08	Rochester	50 Gyration	32%	30%	22%	16%
TS 3	0.9	Hancock	75 Gyration	21%	59%	86%	38%
TS 4	1.8	Hancock	75 Gyration	66%	46%	46%	263%
TS 5	1.15	Granville	50 Gyration	26%	17%	37%	24%
TS 6	2.52	Granville	50 Gyration	25%	27%	81%	40%
Percent of Preconstruction:				31%	35%	48%	33%

Table 9 – Rut Summary

Rochester-Granville STP 2124 Rehabilitation Project Summary of Pavement Distress						
Test Site ID:	MM Location:	Town:	Section Type:	Fatigue Cracking (LF):	Thermal Cracking (LF):	Reflective Cracking (LF)
TS 1	6.98	Rochester	50 Gyration	0	0	15
TS 2	8.08	Rochester	50 Gyration	5	0	0
TS 3	0.90	Hancock	75 Gyration	0	0	0
TS 4	1.80	Hancock	75 Gyration	14	0	14
TS 5	1.15	Granville	50 Gyration	0	0	0
TS 6	2.52	Granville	50 Gyration	0	0	0
Average LF of Cracking:				3	0	5

Table 10 – Crack Summary

Rochester-Granville STP 2124 Rehabilitation Project Summary of IRI Data						
		IRI Values (in./mile)				
Section Type:	Segment ID:	SB Right Wheel Path	SB Left Wheel Path	NB Left Wheel Path	NB Right Wheel Path	Average:
Experimental	1	96	70	72	91	**82**
Standard	2	88	69	76	98	**83**
Experimental	3	90	79	85	102	**89**

Table 11 – IRI Summary

At this point it is too early to make any conclusions. However, it is interesting to examine the summary of rut depth. As stated previously, the rut depth prior to construction was greater within the right wheel path of the north and southbound lanes. However following one year performance average rut depth was found to be relatively consistent in both the right and left wheel paths throughout the project. This is somewhat surprising as it would be anticipated that greater rutting would have been found within the right wheel paths based on preconstruction conditions and the application of leveling course in one lift. According the IRI Pavement Condition Scale, the current state of the roadway would be characterized as good to fair condition.

DISCUSSION:

The Agency is interested in implementing a Superpave mix that is both flexible and resilient with regards to freeze/thaw cycles and resistant to rutting. It has been observed that some higher level gyration mixes such as 75 and 100 gyration Superpave mixes ravel prematurely at pavement joints, crack and become permeable to water. In order to counteract these pavement distresses, many states are beginning to examine the amount of asphalt binder specified within the mix designs. It is anticipated that a lower level gyration mix, containing additional asphalt binder, would alleviate premature pavement distresses related to cracking or raveling. However, they are not expected to perform as well under high rates of traffic loading and fatigue cracking is anticipated.

In order to evaluate the constructability and performance of a lower level gyration mix, a 50 gyration mix was constructed on VT 100 between the towns of Rochester and Granville. A control section, consisting of a typical 75 gyration mix, was also constructed to provide a comparison. Prior to construction, pavement condition surveys were conducted at six test sites established throughout the limits of the project. In addition, IRI values were also collected. Insufficient subgrade support is suspected given the amount of rutting and fatigue cracking throughout each test site as well as increased IRI values within the right wheels paths.

The project was constructed during the summer and fall of 2005. In accordance with the mix designs, the 50 gyration mix contained a greater amount of asphalt cement, 0.4% on average, and a lesser amount of aggregate by weight. All else remained a constant, including the amount of sand mix and RAP incorporated into the mix during production.

A leveling course was applied in one lift prior to the application of a wearing course. A higher rate of rutting is anticipated throughout the project regardless of mix due to the potential for reduced compaction of the leveling course coupled with the depth of rutting noted prior to construction. According to the Resident, less compaction effort was required for the 50 gyration mix as compared to the 75 gyration mix in order to meet the compaction specification.

An annual pavement condition survey was conducted following one year of performance. While it is too early to draw any conclusions, results thus far have been promising. Pavement distresses to date are consistent with preconstruction pavement conditions with the exception of rutting which appears to be more uniform across all wheels paths. However, increased rutting within the right wheel paths is anticipated. It will also be important to consider ESAL loading in conjunction with potential limitations of the 50 gyration mix. The project will provide a wonderful opportunity to evaluate the capabilities of the experimental mix as there is a good spread with regards to order of magnitude beyond the recommended vehicular loading rate as furnished by AASHTO.

FOLLOW UP:

Pavement condition surveys will be conducted on an annual basis as well as the collection of IRI values. A report will be published following five years of service and will compare the onset and rate of rutting, IRI values, fatigue, thermal and reflective cracking over time between the control and experimental pavements.

Report References:

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Ruth W. Stidger. "Diagnosing Problem Pavements." Better Roads. June 2002. 15 Nov 2004 <http://www.betterroads.com/articles/jun02b.htm>.

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Appendix A

VERMONT AGENCY OF TRANSPORTATION

SP05 - 339

PROGRAM DEVELOPMENT DIVISION - MATERIALS & RESEARCH SECTION

SUPERPAVE BITUMINOUS CONCRETE MIXTURE DESIGN

DISCLAIMER — Revision 2.0 March 17, 2005

The calculated data and transferred information within this spread sheet are for verification and informational purposes only. While care was used in preparing and formulating the equation formulas and resultant data, no guaranty or representation is made as to its accuracy. Anyone choosing to use this spread sheet to verify Superpave mix design data does so at his/her own risk.

Project Name:	**Master**	Project Number:	**Master**
Mix Type:	**Type IV (S) w/RAP**	Gyrations, N_{ini} / N_{des} / N_{max}:	**7/75/115**
Produced By:	**Pike Industries, Inc.**	Plant Number & Location:	**Plant 736, New Haven Vt.**

Stockpile Gradations - % Passing (WET Sieve Analysis)

Size (mm)	% Used	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075	RAP % AC
Essex	12	100	100	100	100	100	100	97	82	62	42	18	3.4	2.5	
W.S.S.	37	100	100	100	100	100	100	95	59	29	14	7	5	3.5	
9.5	36	100	100	100	100	100	98	28	6	4	2	2	2	1.8	
RAP	15	100	100	100	100	100	95	75	57	44	33	22	13	6.8	5.20
Resultant	**100.0**	**100**	**100**	**100**	**100**	**100**	**99**	**68**	**42**	**26**	**16**	**9**	**5**	**3.3**	

Hot Bin Gradation - % Passing (WET Sieve Analysis)

Bin	% Used	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075	RAP % AC
DRUM	100.0	100	100	100	100	100	99	68	44	28	19	11	6	3.8	
Mfg. Fines															
RAP															5.20
Resultant	**100.0**	**100**	**100**	**100**	**100**	**100**	**99**	**68**	**44**	**28**	**19**	**11**	**6**	**3.8**	

Design Blend HMA Plant's Fine Adjustment Factor = 0.5

Batch Weight (Kg)	DRUM						RAP	Performance Graded Binder: Virgin	RAP	Total	Total
	3274						612	196	32	228	4082
	84.3						15.0	Rap can be no more that 15.0% of Total			

% PG Binder Content	Sieve (mm)	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075
	Job Mix Formula	**100**	**100**	**100**	**100**	**100**	**99**	**68**	**44**	**28**	**19**	**11**	**6**	**3.8**
	Job Aim	100 / 100	100 / 100	100 / 100	100 / 100	100 / 100	93 / 100	62 / 74	40 / 48	24 / 32	15 / 23	7 / 15	2 / 10	2.8 / 4.8
Virgin 4.8 / Total 5.6	Spec. Limits	100 / 100	100 / 100	100 / 100	100 / 100	100 / 100	90 / 100	/ <=90	32 / 67					2 / 10

Source of Materials

Aggregates			Performance Graded Binder		
Fine:	Saxon Hill Pit Essex, VT	PG Grade:	58-34	58-34	58-34
	Pike Industries, Inc. New Haven, Vt	Other:			
Coarse:	Pike Industries, Inc. New Haven, Vt	Manufacturer:	**Shell**	**Bitumar**	**Petro- Canada**
		Mixing Temp.:	159 °C ± 11 °C	157 °C ± 11 °C	155 °C ± 11 °C
RAP:	PII New Haven	Comp. Temp.:	145 °C ± 5 °C	142 °C ± 5 °C	145 °C ± 5 °C

Mixing Times: Dry: Wet: Total:

Submitted By: **Thomas A. Custeau** Title: QC Engineer

Company: **Pike Industries, Inc.** Date: 7/18/2005

Job Mix Formula			
VMA	15.7	+/- 1%	
VFA	74.5	+/- 5%	Max 80%

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PROGRAM DEVELOPMENT DIVISION - MATERIALS & RESEARCH SECTION

SUPERPAVE BITUMINOUS CONCRETE MIXTURE DESIGN

DISCLAIMER **Revision 2.0 March 17, 2005**

Project Name:	**Master Rochester-Granville (8/15/2005)**	Project Number:	**Master AC STP 2124 (1)S**
Mix Type:	**Type IV (S) w/RAP**	Gyrations, N_{ini} / N_{des} / N_{max}:	**6/50/75**
Produced By:	**Pike Industries, Inc.**	Plant Number & Location:	**Plant 736, New Haven Vt.**

Stockpile Gradations - % Passing (WET Sieve Analysis)

Size (mm)	% Used	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075	RAP % AC
Essex	12	100	100	100	100	100	100	97	82	62	42	18	3.4	2.5	
W.S.S.	37	100	100	100	100	100	100	95	59	29	14	7	5	3.5	
9.5	36	100	100	100	100	100	98	28	6	4	2	2	2	1.8	
RAP	15	100	100	100	100	100	95	75	57	44	33	22	13	6.8	5.20
Resultant	**100.0**	**100**	**100**	**100**	**100**	**100**	**99**	**68**	**42**	**26**	**16**	**9**	**5**	**3.3**	

Hot Bin Gradation - % Passing (WET Sieve Analysis)

Bin	% Used	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075	RAP % AC
DRUM	100.0	100	100	100	100	100	99	68	44	28	19	11	6	3.8	
															5.20
Resultant	**100.0**	**100**	**100**	**100**	**100**	**100**	**99**	**68**	**44**	**28**	**19**	**11**	**6**	**3.8**	

Design Blend HMA Plant's Fine Adjustment Factor = **0.5**

Batch Weight (Kg)	DRUM	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	Bin Mfg. Fine	RAP	Performance Graded Binder: Virgin	RAP	Total	Total
	3257						612	213	32	245	4082
	84.2						15.0	**Rap can be no more that 15.0% of Total**			

% PG Binder Content	Sieve (mm)	50.0	37.5	25.0	19.0	12.5	9.5	4.75	2.36	1.18	0.600	0.300	0.150	0.075
	Job Mix Formula	**100**	**100**	**100**	**100**	**100**	**99**	**68**	**44**	**28**	**19**	**11**	**6**	**3.8**
	Job Aim	100 / 100	100 / 100	100 / 100	100 / 100	100 / 100	93 / 100	62 / 74	40 / 48	24 / 32	15 / 23	7 / 15	2 / 10	2.8 / 4.8
Virgin 5.2 / Total 6.0	Spec. Limits	100 / 100	100 / 100	100 / 100	100 / 100	100 / 100	90 / 100	<=90	32 / 67					2 / 10

Source of Materials

Aggregates			Performance Graded Binder		
Fine:	Saxon Hill Pit Essex, VT	PG Grade:	58-34	58-34	58-34
	Pike Industries, Inc. New Haven, Vt	Other:			
Coarse:	Pike Industries, Inc. New Haven, Vt	Manufacturer:	**Shell**	**Bitumar**	**Petro- Canada**
		Mixing Temp.:	159 °C ± 11 °C	157 °C ± 11 °C	155 °C ± 11 °C
RAP:	PII New Haven	Comp. Temp.:	145 °C ± 5 °C	142 °C ± 5 °C	145 °C ± 5 °C

Mixing Times: Dry: Wet: Total:

Submitted By: **Thomas A Custeau** Title: QC Engineer

Company: **Pike Industries, Inc.** Date: 7/20/2005

Job Mix Formula			
VMA	16.5	+/- 1%	
VFA	75.8	+/- 5%	Max 80%

FOR STATE OF VERMONT USE ONLY

Comments: ______

Signature: ______

Title: ______ Date: ______

Date & Time Received Stamped Below