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Research Update

50 Gyration Superpave Mix
Rochester-Granville, VT 100

<u>**References**</u> – **Work Plan No. WP-2005-R-2**
Initial Report U2006-8

INTRODUCTION:

One of the principal outcomes of the 1987 Strategic Highway Research Program (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 the 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 research update outlines measurements and observations through nine years of age and provides comparison with preexisting pavement distresses.

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^{o}C at 20 mm below the pavement surface and an average one day low temperature of -34^{o}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:

Table 1 Rochester-Granville STP 2124 Rehabilitation Project Limits

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

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. Since the publication of the initial report, it was decided that due to extensive alligator cracking that was present during preconstruction, making it impossible to accurately count, test site 5 (in the experimental section) would be discontinued from data collection efforts and not be included in analysis.

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% Recycled Asphalt Pavement (RAP). 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. Further information related to mix design and construction can be found in the initial report, U2006-8.

PERFORMANCE:

Table 2 and Table 3 show the amount of cracking, on average, in the control (75 Gyration) and experimental (50 Gyration) test sites. Fatigue cracking is the amount of longitudinal cracking in wheel paths, which is caused by repeated traffic loadings. Thermal cracking is transverse cracks and caused mainly by freeze-thaw cycling. Reflective cracking is cracking that has come up through the new pavement structure, mirroring cracking that was pre-existing on the previous pavement treatments. Table 2 represents the level of cracking as a percent of the amount of preconstruction cracking and Table 3 the actual amount of cracking in linear feet per each 100 foot test section. To this point the numbers indicated that the two treatments have performed fairly equal, with the 50 gyration mix showing slightly more distress when compared to the pre-existing conditions. Both pavement treatments have performed very well for nine years of age.

Table 2. Amount of year 9 cracking as a percent of original cracking. Reflective cracking is a percent of total preconstruction.

Mix	Fatigue	Thermal	Reflective	Total
75 Gyration	33	61	12	46
50 Gyration	53	64	14	55

Table 3. Amount of year 9 cracking in linear feet per 100 foot test section.

Mix	Fatigue	Thermal	Reflective	Total
75 Gyration	110	10	50	175
50 Gyration	78	5	43	178

Table 4 and Table 5 show the amount of rutting, on average, in the control (75 Gyration) and experimental (50 Gyration) test sites. Table 4 represents the level of rutting as a percent of the amount of preconstruction rutting and Table 5 the actual amount of rutting in inches of depth. Rut depths are shown by southbound (SB) and northbound (NB) lanes and inside and outside wheel paths (IWP and OWP respectively). Again, both treatments have performed similarly through the nine years of service life so far. The 50 gyration mix has performed better as a function of pre-existing rutting, but mainly due to a probably outlier on the northbound outside wheel path in one 75 gyration test site. For actual depths in inches the 75 gyration has performed better 0.40 inches to 0.44.

Table 4. Amount of year 9 rutting as a percent of original rutting.

Mix	SB OWP	SB IWP	NB IWP	NB OWP	Average
75 Gyration	89	96	108	235	94
50 Gyration	92	73	104	88	86

Table 5. Amount of year 9 rutting in inches.

Mix	SB OWP	SB IWP	NB IWP	NB OWP	Average
75 Gyration	0.42	0.33	0.38	0.48	0.40
50 Gyration	0.63	0.35	0.36	0.43	0.44

International roughness index (IRI) values were obtained from the Vermont Agency of Transportation's roadway profiling van. IRI is a ride index that is measured within all wheel paths and is recorded as the number of inches the profiler would fluctuate (up and down) per mile. Measurements have been calculated based on the entire length of the pavement treatments within the construction project, not just the referenced research test sites. Values as of 2013 (year 8) for this project are 117 in/mi for the 50 gyration section and 124 in/mi for the 75 gyration, meaning the 50 gyration is very slightly smoother to this point of the study. For this type of roadway, values between 95 and 170 are considered in fair condition. Preconstruction IRI values were 204 in/mi for the 75 gyration pavement and 196 for 50 gyration.

FOLLOW-UP:

To date this project has performed very well, both the experimental 50 gyration pavement and the control 75 gyration pavement. Site visits will be made on a yearly basis, to document the condition of the asphalt for both cracking and rutting. The duration of the study will be until adequate conclusions can be made or until the project receives new pavement or preventative maintenance treatments.