



Research Using Waste Shingles for Stabilization or Dust Control for Gravel Roads and Shoulders

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Thomas J. Wood, Primary Author
Office of Materials and Road Research
Minnesota Department of Transportation

January 2014

Research Project
Final Report 2014-06



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Final Report

Prepared by:

Thomas J. Wood
Eddie N. Johnson
Melissa K. Cole

Office of Materials and Road Research
Minnesota Department of Transportation

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Executive Summary

Recycled Asphalt Shingles (RAS) include both manufacture waste scrap shingles (MWSS) and post-consumer tear-off scrap shingles (TOSS). It is estimated that Minnesota generates more than 200,000 tons of shingle waste each year. Recently, a portion of this waste has been incorporated into hot-mixed asphalt (HMA) pavement mixtures. The current technology limits the amount of RAS in HMA to no more than five percent by weight. This leaves a lot of underutilized shingle waste material throughout the state. This has prompted MnDOT to investigate other potential uses RAS. One potential use is to improve the performance of gravel surfacing and reduce dust by replacing common additives such as calcium chlorides with RAS. This is especially relevant as gravel sources in Minnesota have been depleted and/or have declined in quality, which has affected the performance of gravel surfacing. These poorer quality fines can increase the amount of dust generated and increase the difficulty of keeping the roadway smooth. Some agencies have used dust-control additives to help the performance of these lower-quality gravels. Successful implementation has the potential of removing valuable RAS materials from the waste stream to supplement the use of more expensive virgin materials and improve the performance of local roads.

Chapter 1. Introduction

Objectives of Research and Methodology

This report represents Task 6 – Draft Final Report of Local Road Research Board (LRRB) project number 914, Research Using Waste Shingles for Stabilization or Dust Control for Gravel Roads and Shoulder.

Currently in Minnesota, most research in regard to the use of Recycled Asphalt Shingles (RAS) has been for use in Hot Mixed Asphalt (HMA) mixtures. There are two types of RAS shingles; manufacture waste scrap shingles (MWSS) and tear-off scrap shingles (TOSS). This study expanded on the current uses for RAS by exploring uses for gravel roads. The hypothesis for this study is adding RAS to the gravel will improve stabilization, i.e. reduce wash boarding effect and help control the dust. If the study proves the hypothesis, not only will the surfacing of gravel roads and shoulders be improved, but it will also have the potential to remove large amounts of RAS from landfills. Only TOSS was used during this study.

The research efforts were made up of the following tasks:

- Task 1 Laboratory Testing to Determine Physical Characteristics of RAS and How They Interact with Gravels.
- Task 2 Construct Test Sections.
- Task 3 Test Sections Evaluation.
- Task 4 Develop Special Provision and Guidelines for Use of RAS.
- Task 5 Develop Draft Outline for Implementation Plan from Finding of Study.
- Task 6 Draft Final Report.
- Task 7 Final Report.

Background

MnDOT has teamed up with Jackson County and Goodhue County for this study. In Jackson County, the effect of gravel stabilization using the TOSS was studied. In Goodhue County, dust control using TOSS was studied.

Chapter 2. Research Methodology

Task 1

Samples of TOSS were obtained from Dem Con. Class 5 natural gravel from Jackson County and Class 6 limestone from Goodhue County were also used in this research. Using these samples the following testing was completed:

1. Loose Unit Weights
2. Proctors
3. Modified Indirect Tensile Strength (IDT)
4. Tri-axial Shear Test

Analysis of the data from the laboratory testing determined the best strength of the gravel / shingles at approximately four (4) parts TOSS to 10 parts Class 5 gravel, by volume, for use in Jackson County. For the work with Goodhue County with the Class 6 limestone the analysis determined a blend at rate of one (1) part TOSS to one (1) Class 6 limestone, by volume, for the dust control section. See Appendix A for more complete details.

Task 2

This task was to build test sections to monitor how the TOSS affected performance of surfacing gravel used. In Jackson County three (3) test sections were built. The first one, CR 70 east from junction with TH 68, was a blend of four (4) parts TOSS to 10 parts Class 5 gravel. Based on observations during placement the Jackson County personnel recommend increasing the blend to one (1) part TOSS to one (1) part gravel. Two (2) more test sections were built with the increase blend on the intersection of 520th Avenue and CR 81 and 750th Street and CR 81. All three (3) test sites are located on roadway with a stop sign from an uphill slope.



Figure 1 – Test Section Construction in Jackson County

Goodhue County used Class 6 crushed limestone for their surfacing gravel. Wash boarding or corrugations are not as big of an issue as it was in Jackson County. The most prominent issue is dust control for Goodhue County.

October of 2012 Goodhue County personnel built a short test section on CR 6 to see how the shingles performed when mixed with limestone Class 6. In the summer of 2013 they extended the test section to allow for dust collection. See Appendix B for complete details of Task 2.



Figure 2 – Test Section Construction in Goodhue County

Task 3

In Task 3 evaluation on the performance of test sections built in Task 2 was conducted. Two (2) methods were used for evaluation; interviews with County personnel and dust collection using the Colorado Dust Collection Method.

Based on interviews with Jackson County personnel it was believed that the TOSS gravel blends greatly reduce or eliminated corrugation and appeared to reduce dust generation. The test sections in Jackson County are too short to use the Colorado dust collector on. They stated that they did not have to re-shape or blade the test section as often as control sections which were located next from test section on a level section of roadway. They also believed that TOSS section recovered from spring thaw faster than the un-treated sections.

Interviews with Goodhue County personnel state that they did not see any differences between test sections and control section as far as the smoothness, i.e. corrugation. Class 6 Limestone tends to bind together reducing chances of corrugation. Visual observations showed a reduction in dust generated on TOSS treated sections as compared to control sections. The visual evaluation was followed up with dust collection done with the Colorado Dust Collector.

The table below has dust collection data. The section placed in the fall of 2012 still shows a 34% reduction in dust generated after 298 days in service. From previous work done on effectiveness of dust control treatment show that on average the effectiveness after one (1) year in place is close to zero (0) percent.

Table 1 - Dust Collection Results in Goodhue County

Test Section	Run No.	Test date	Dust Avg (g/mile)	Age at Test (days)	Dust % Reduction
TOSS/CL6 LS 2012	1	7/26/2013	4	298	34%
CL6 LS 2012	1	7/26/2013	6.1	298	
TOSS/CL6 LS 2013	4	8/15/2013	3.2	14	61%
CL6 LS 2013	4	8/15/2013	8.2	14	

Based on the interviews and dust collection the use of TOSS blended with local surfacing gravel appears to improve the performance of the surfacing gravels. See appendix C for complete details for task 3.

Task 4

In Task 4 was to develop draft special provision for preparing waste shingle for use on gravel roadways. Here is proposed special provision.

Special Provision 2118.1 Recycled Asphalt Shingles (RAS) for surfacing gravels

Provide recycled asphalt shingles from tear-off scrap asphalt shingles or manufacture wastes shingles.

RAS Gradation.....MnDOT Laboratory Procedure 1801

Provide RAS in accordance with the following gradation requirements:

Table 2118-1 RAS Gradation	
Sieve size	Percent passing
½ in [12.5 mm]	100

Waste Materials

Do not allow extraneous materials including metals, glass, rubber, nails, soil, brick, tars, paper, wood, and plastics greater than 0.5 percent by weight of the graded aggregate as determined by material retained on the No. 4 [4.75 mm] sieve as specified in MnDOT Laboratory Procedure 1801.

Task 5

Task 5 was to develop draft implementation plan outline for use to promote the findings of this study. The plan suggests venues, i.e. conferences, workshops, to present the findings of this study. Methods to encourage implementation, and resources to help local agencies use TOSS in gravel surfaces. See Appendix D for a copy of this plan.

Tasks 6 and 7

Tasks 6 and 7 involved developing the draft final report and a final report of the findings from Tasks 1-5.

Chapter 3. Conclusions and Recommendations

Conclusions

The addition of TOSS to surfacing gravel does improve the performance of the surfacing gravel. It appears that fibers in ground shingles help to bind the materials that pass the 100 sieve in a sieve analysis in the gravel. This binding effect helps to limit corrugation caused by acceleration and deceleration of vehicles. In one of the limestone sections there appeared to be less float of larger aggregate particles. The binding of limestone does reduce the amount of dust produced. The TOSS material is easy to handle. It can be blended uniformly with a loader or motor grader. The less than ½ inch particles do not appear to have any issues during handling and placement. It is the opinion of the researchers that the additional cost to grind the TOSS to less than ¾ inch material is not justified.

Recommendations

The following areas should be worked on to help the successful implementation of the use of TOSS in surfacing gravels.

1. The use of TOSS to improve performance of surfacing gravels should be encouraged.
2. For rural counties that do not produce a large amount of tear off shingle each year, a plan should be developed to combine shingles from surrounding counties at one location until enough are gathered to justify bringing in a processing plant.
 - a. Work with MPCA on how to store un-processed shingles so as not to create environmental issues.
 - b. The processing company would like a minimum of 2,000 tons to move in and process the waste shingles.
3. Continue evaluations of test sections to see how long they perform.
4. Try blending TOSS with other gravel types to see what affect it has on performance
 - a. Granite.
 - b. Trap rock.
 - c. Quartzite.
5. Build test section comparing TOSS treated roadways for dust control against commonly used dust treatments.

Appendix A: Task 1 Report

Minnesota Local Road Research Board Investigation 914:
Research Using Waste Shingles for Stabilization or Dust Control
for Gravel Roads and Shoulders

Task 1 Summary Report:
Laboratory Testing and Test Sections Designs

Submitted to the LRRB: February 2012

Thomas J. Wood
MnDOT Office of Materials
1400 Gervais Avenue
Maplewood, Minnesota 55109

Melissa K. Cole
Mn/DOT Office of Materials
1400 Gervais Avenue
Maplewood, Minnesota 55109

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Introduction

Currently in Minnesota, most research about use of Recycled Asphalt Shingles (RAS) has been for use in Hot Mixed Asphalt (HMA) mixtures. There are two types of RAS shingles; manufacture waste shingles (MW) and tear-off scrap shingles (TOSS). This study will expand on the current uses for RAS by exploring its use for gravel roads. The hypothesis for this study is adding RAS to the gravel will improve stabilization, i.e. reduce wash boarding effect, and help control the dust. If the study proves the hypothesis, not only will the surfacing of gravel roads and shoulders be improves, this has the potential to remove large amounts of RAS from landfills.

Background

This report represents Task 1 of the Local Road Research Board (LRRB) project number 914 entitled, “Research Using Waste Shingles for Stabilization or Dust Control for Gravel Roads and Shoulders”. This report will summarize the laboratory testing completed to determine the blends of TOSS RAS to use for stabilization and dust control. Test sections recommendations will be given based on the testing and will be built in Task 2 of this study.

MnDOT has teamed up with Jackson County and Goodhue County for this study. In Jackson County, the effect of gravel stabilization using the TOSS will be studied. In Goodhue County, dust control using TOSS shingles will be studied.

Materials

Recycled Asphalt Shingles

Dem-Con, a large RAS processor in Minnesota, supplied shingles for the laboratory testing. A fine ground RAS was used for the testing (100% passing the #4 sieve).

Aggregates

Jackson County provided a sand and gravel Class 5 aggregate, typical to what is used in their county for gravel roads. Goodhue County provided a crushed limestone Class 6 aggregate.

Testing Procedures and Results

Unit weight

Following MnDOT 1211 – Unit Weight Determination (AASHTO T19), we obtained unit weights of the RAS, Jackson County gravel, and the Goodhue County.

Loose Unit Weights

Material	Top size	Volume, cf	Wt, g	Loose Wt, pcf	Average Loose Unit Wt, pcf
DemCon RAS	#4	0.1	2279	50	50
	#4	0.1	2270	50	
Goodhue Cl6	3/4"	0.1	3969	88	96
	3/4"	0.1	4518	100	
	3/4"	0.1	4416	97	
	3/4"	0.1	4457	98	
Jackson Cl5	3/4"	0.1	4100	90	92
	3/4"	0.1	4153	92	
	3/4"	0.1	4235	93	

Table 2 Loose Unit Weights of Materials

Proctors

The Moisture-Density Relations of Soils Using a 2.5kg (5.5 LB) Rammer and a 305mm (12 INCH) DROP - MnDOT 1305 (Modified AASHTO T99) was used to determine the optimum moisture. Samples were prepared using 50 cycles on the Gyratory Compacter versus the specified 5.5 lbs. Rammer.

The results of these tests are as follows:

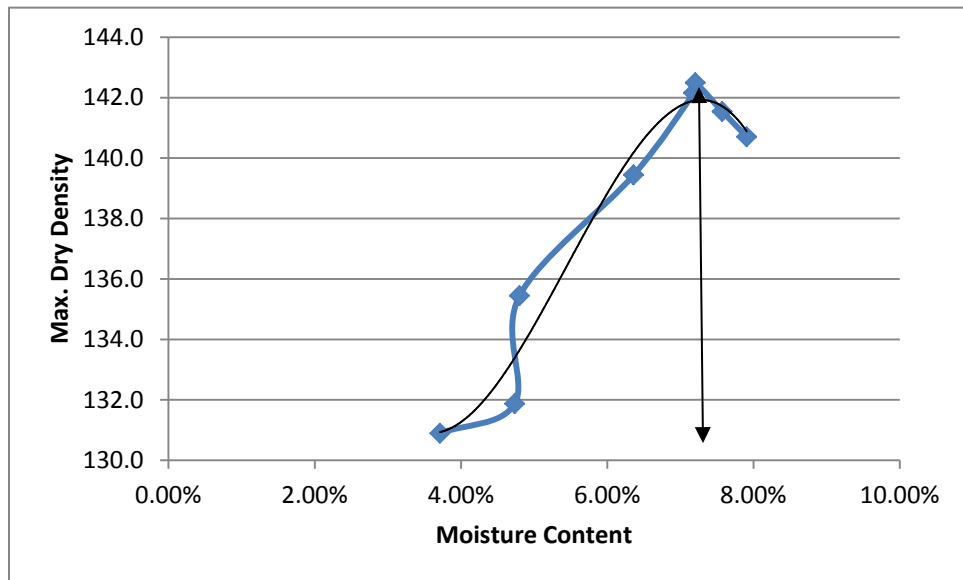


Figure 1 Optimum Moisture for Goodhue County Class 6 Aggregate

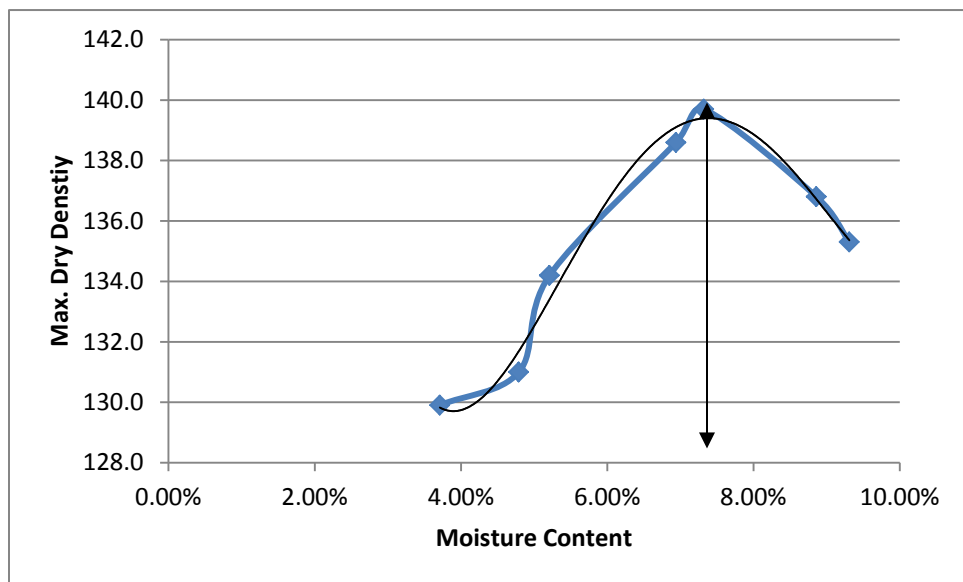


Figure 2 Optimum Moisture for Jackson County Class 5

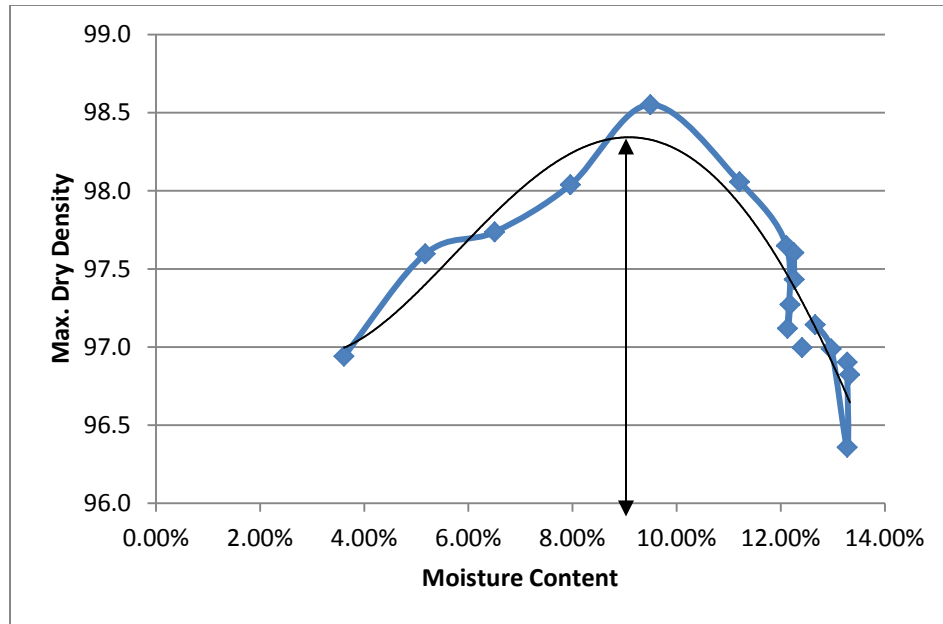


Figure 3 Optimum Moisture Content for Dem Con RAS

Optimum moisture based on these graphs was found to be about 7.5% for both Goodhue and Jackson County. The Dem Con RAS TOSS optimum moisture was found to be about 9%.

Indirect Tensile (IDT) Strength

Preparation of Bituminous Specimens Using Marshall Apparatus - ASTM 6926 modified was used in the preparation of the samples to be used for the Indirect tensile (IDT) Strength test. This standard was modified because bituminous was not being used, we compacted aggregate and aggregate/shingle samples using the procedures outlined in this specification, i.e. using the Marshall Hammer. Samples were mixed using a bucket mixer and moisture added to samples to bring total moisture close to optimum moisture as determined above. Samples were then oven dried at 55° C (131° F) until all moisture was removed from the samples. Please note that the samples were not heated prior to compaction using the Marshall Hammer.

Once samples were compacted and dried, ASTM 6931, Indirect Tensile (IDT) Strength of Bituminous Mixtures was modified and used to test the tensile strength of the samples. This procedure was performed using the Jackson County Class 5 material as the objective of this study was to determine the use of TOSS for stabilization of the gravel roadway.

Blend	Water Content	Average Water content	Strength (IDT) lbs.	Average IDT Strength (lbs.)
0% S	5.53%	5.73%	382	336
0% S	5.86%		216	
0% S	5.79%		411	
10% S	4.93%	4.77%	305	289
10% S	4.52%		256	
10% S	4.86%		305	
20% S	7.94%	7.79%	420	436
20% S	7.80%		401	
20% S	7.63%		486	
40% S	7.63%	7.64%	572	587
40% S	7.80%		655	
40% S	7.49%		534	
60% S	8.74%	8.75%	411	449
60% S	8.84%		401	
60% S	8.68%		534	

Table 3 Tensile Strength of Jackson County Class 5 Mixed with TOSS

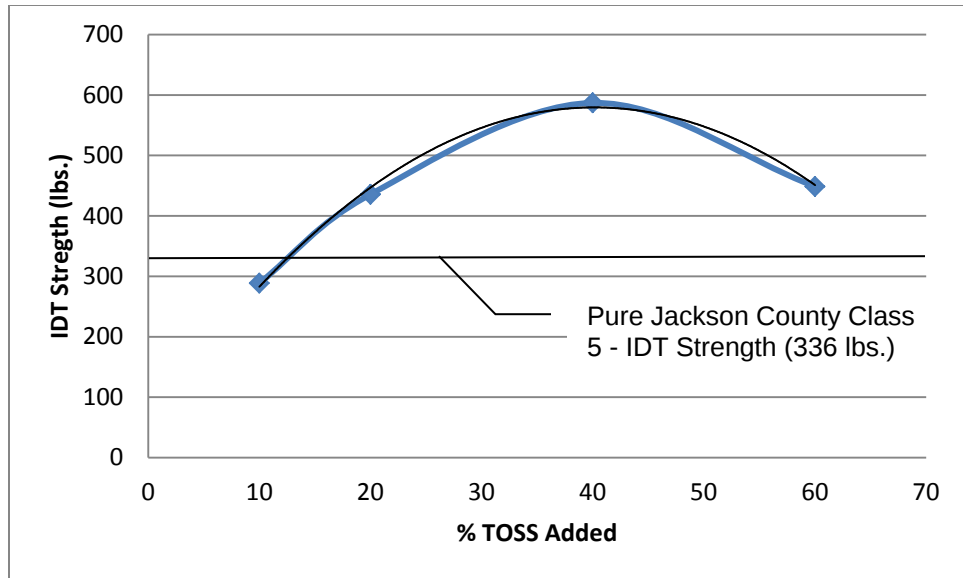


Figure 4 IDT Strengths Jackson County Class 5 + 10-60% TOSS

Based on the data presented above, when virgin aggregate was tested the IDT strength was 336 lbs. All but the 10% TOSS obtained IDT strengths higher with the maximum strength reached at 40% TOSS added.



Figure 5 Jackson County and 20% added TOSS



Figure 6 Jackson County and 60% added TOSS

Observations

Observations made during the testing were as the TOSS content increased; the more cohesive the samples were during the IDT testing. Meaning when the 60% TOSS sample failed in testing, it did not break through as observed in the lower percentages of TOSS. It adhered together, but a crack was visually observed. Figure 6 is a picture of 60% samples after testing. The top sample in the picture was physically broken in half along the observed crack after testing was completed; the two samples below failed and a crack appeared. The samples tested at lower %TOSS failed in a more volatile manner. Meaning during the testing process the samples broke in half. Figure 5 shows samples at 20% after testing.

Tri-axial Shear Test

Testing was performed using ASTM D2166-06 for Unconfined Compressive Strength of Cohesive Soil, modified using the testing methodology in Chapter 8 of the publication "Principles of Geotechnical Engineering, Second Edition" by Braja M. Das, specifically Section 8.3 - Triaxial Shear Test.

A sample consists of two gyratory pucks of 5.9 inch diameter approximately equal to 6 inches in height (minimum 6 inches to maximum 6.1 inches) stacked on top of each other. The gyratory samples were prepared in accordance to ASTM??

After testing the samples were oven dried at 58° C (136.4° F). The sample material was rehydrated and reused for subsequent tests at each percent of TOSS.

Rehydrated material was allowed to “soak” in a sealed container (5 gallon pail) a minimum 24 hours for pure granular and minimum 48 hours for TOSS/granular mixture to permit the moisture to disperse through the material before testing.

A mini-maul was used to break-up the pucks, with care being taken to not apply a force that the aggregate would break.

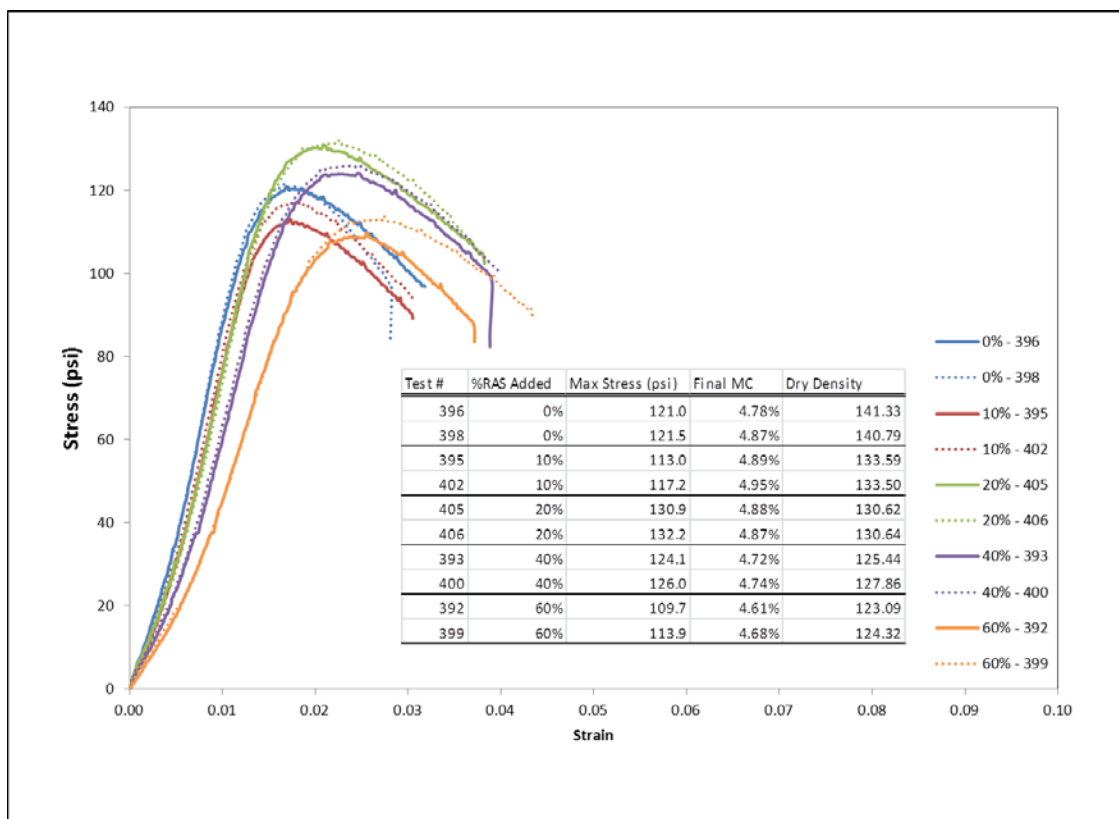


Figure 7 Jackson County Class 5 with TOSS - Shear Strength 4 psi

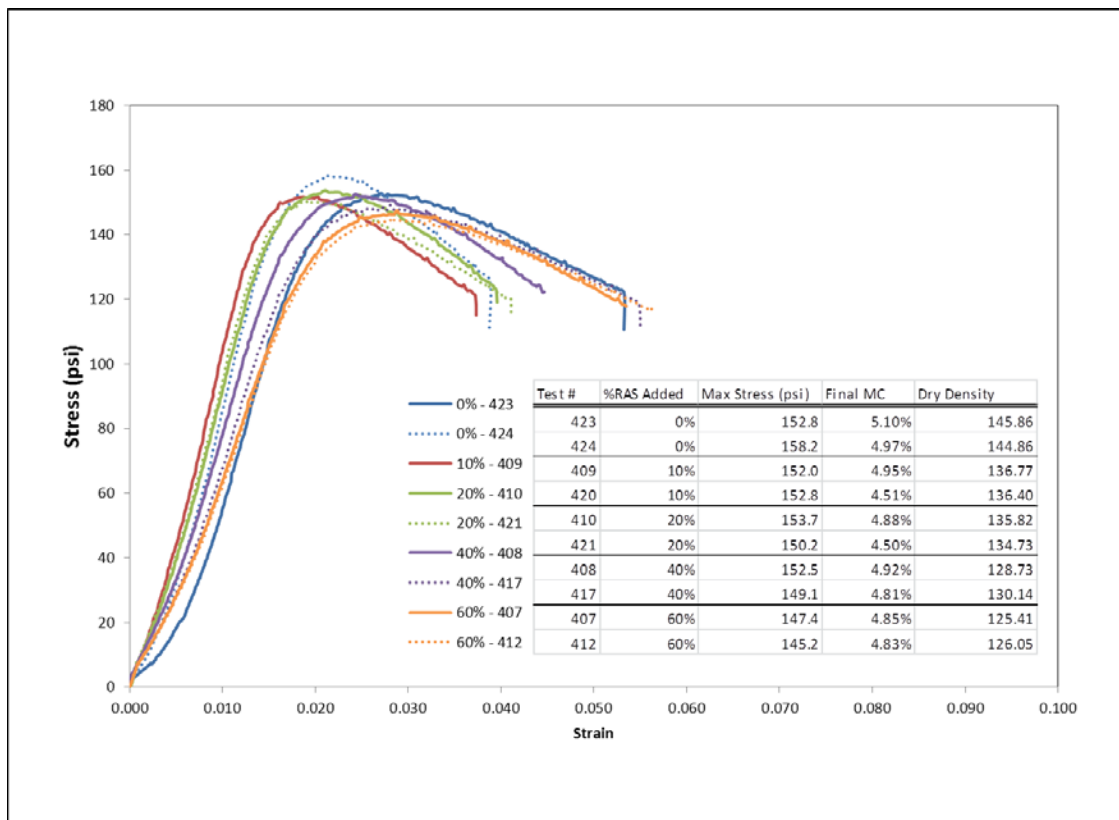


Figure 8 Jackson County Class 5 with TOSS - Shear Strength 4 psi

Observations

Each subsequent fabrication of pucks from oven dried material required slightly more material to maintain puck height. It is hypothesized that this phenomenon is due to micro formation of clay “clumps” within the material during compaction (puck fabrication) with oven drying “hardening” them (as oven dried material feels more “gritty” than virgin material - except for pure TOSS). When material is re-hydrated these micro clumps break down during compaction allowing aggregate to more easily slide by each other (a lubricating effect). This phenomenon diminishes after approximately after the 3rd re-heat in mixed material and approximately the 5th reheat in pure granular material. Pure TOSS did not demonstrate this phenomenon.

Pure granular pucks were easily broken apart into large pieces and then easily crushed into loose aggregate. Any clumps not broken down during prepping for oven drying easily crush apart with finger pressure after oven drying and or when blending in the bucket mixer.

At 10% and 20% TOSS the material behaved very similar to the pure granular. The only difference noted was that water did pool slightly when first added to the oven dried material to re-hydrate it.

Samples all failed in a typical shearing pattern (shear starting approximately 2 inches from the top of sample and then running approximately diagonally thru the sample). It is very apparent in the material as to where the energy from the test went through the sample diagonally, i.e. the sheared material could be easily crumbled by hand when prepping for the oven drying.

Material becomes much more cohesive as the TOSS content increases. The pure TOSS pucks were as smooth with minimal surface permeability to water. The pure TOSS material lost approximately 10% in strength with each re-heat and re-fabrication of samples.

Approximately 1/4 inch to 3/8 inch size globular “marbles” of extremely cohesive material formed during compaction at the 40% TOSS test and increased in number as the content of the TOSS increased. It was noted that the 40% test had minimal amounts of globular marbles, the 60% test had moderate amounts, and prevalent in the pure TOSS material.

The globular marbles of material were extremely difficult to manually break-up. The pure TOSS pucks could only be broken into loose material with aggressive use of the 3 lbs. mini-maul and the globular material would only deform rather than break apart. Even after oven drying to 0% moisture content the globular material would deform rather than break apart when attempting to crush them with the mini-maul. It should be noted that an increase in the amount of globular material did not seem to occur with each reuse of the material.

The upper limits, 40% - pure TOSS, samples exhibited markedly different behaviors while testing versus the pure granular, 10%, and 20% tests. The sample would start to shear at the typical 2 inches from the top of the sample but would almost immediately stop diagonally shearing and then would compress (bulge) with the force spreading throughout the sample. The change in how the forces of the test transmitted through was also apparent while breaking up the samples to prepare them for oven drying. In the 40% test, and 60% test, the top quarter and bottom quarter of the sample required significant effort with the mini-maul to crush it apart into pieces. The pure TOSS could only be reduced down to loose material by using the mini-maul.

Conclusions / Design Recommendations

Based on the data present above, the addition of TOSS up to a rate of 40% performs as well as or better than the virgin class 5 material from Jackson County. The recommend range of addition of TOSS for improving surfacing Class 5 would be between 30 and 40% by weight. Based on the unit weights of the TOSS and the Class 5 gravel, the recommend addition rate of TOSS would be in 10 cubic yards gravel, add 7 cubic yards of TOSS (31,000 lbs. of gravel and 9,450 lbs. of TOSS).

The test section to be constructed in Jackson County will be constructed using a 1½ inch layer of 30-40% shingles and gravel section. It will then be compacted in place and monitored. This section monitoring will be visual to see if there is a marked difference in the amount of wash boarding between the test section and the control sections.

No testing was completed using the Goodhue County Class 6 aggregate. This study is a dust control study only, therefore it is recommended that a layer approximately 1/2 in. thick be placed over the top of the gravel road and compacted using rubber tire (pneumatic) rollers. By capping the gravel road, dust should be controlled for a period of time. After placement, we will monitor the dust on this section in comparison to other sections.

Appendix B: Task 2 Report



Minnesota Department of Transportation

Memo

Office of Materials

1400 Gervais Avenue, Mail Stop 645
Maplewood, MN 55109

Office Tel: 651/366-5573

Fax: 651/366-5461

TO: Tim Stahl

DATE: December 19, 2012

SUBJECT: Task 2A & 2B memo for LRRB 914: Research using waste shingles for stabilization or dust control for gravel roads and shoulder.

This memo documents the work completed in Task 2A & B of the LRRB Research Project INV 914 Research using waste shingles for stabilization or dust control for gravel roads and shoulders.

Recycled Tear off Salvage Shingles (TOSS) were purchased to complete Task 2A. Dem-Con Company Shakopee, MN was contacted for a quote to supply 600 tons of ground tear off shingles to MnDOT. A draft of special provisions for TOSS is found in Appendix A. The TOSS shingles were purchased and Dem-Con Company delivered 300 tons to both Jackson County and MnDOT in Zumbrota, (Goodhue County) for construction of the test sections in Task 2B.

Dem-Con Company quoted \$18.00 per ton for ½” minus ground TOSS plus trucking and fuel surcharge (Appendix B). Total cost for the TOSS and trucking was \$23,673.28 (Appendix C).

Test sections were built in Task 2B using a blend of TOSS and local surfacing gravels. On October 11th, 2012 Jackson County re-graveled C.R. 70 east from TH 86. Approximately 1½” of a blend of Jackson County class 5 and TOSS. The ratio used on this section was four (4) loader buckets of TOSS to ten (10) loader buckets of class 5 (Figure 1) This section was approximately 1500 feet from intersection of C.R. 70 and TH 86. There is a slight up grade which has suffered from severe wash boarding from accelerating and stopping traffic.



Figure 1 Jackson Co. 4 part shingles to 10 parts gravel blend, by volume

The material appeared to be segregated in the stockpile. Once it was placed and shaped on the roadway the segregation was eliminated (Figures 2 and 3).



Figure 2 Jackson Co. shaping of 4/10 blend on CR 70



Figure 3 Jackson Co. shaping of 4/10 blend CR 70

Jackson Co. Personnel suggested increasing the amount of TOSS blended into the Class 5 gravel based on the observations during the placement of the first test section. A ratio of approximately 1 part TOSS to 1 part Class 5 gravel by volume was used. On October 12th, 2012 two (2) more segments were built. These sections are at the intersection of 520th Avenue and CR 81 and 750th Street and CR 81. Both intersections have an upgrade change from the stop sign (Figure 4 & 5).



Figure 4 Jackson Co. Looking toward CR 81 on 750th Str. 1 part shingle to 1 part gravel blend



Figure 5 Jackson Co. Looking up grade on 520th Ave. from CR 81 1 to 1 blend

On November 20, 2012 a site visit was made to review the constructed sections. Early reviews show that both blends of TOSS to class 5 have reduced or eliminated wash boarding with the one (1) to one (1) blend performing the best.

Another test section was constructed in Goodhue County on October 18, 2012. This county was chosen because Class 6 Limestone is used for surfacing gravel. The study for this County was to determine if TOSS blend will help reduce dust. Since it was late in the season when this test section were constructed the County built a short test section in to see how the material would withstand snow plowing. The ratio was one (1) part TOSS to one (1) part Class 6 Limestone by volume. See Figure 6, 7, & 8 below.

A ½ mile long test section will be built on CR 6 to allow dust testing to be completed in the summer of 2013.



Figure 6 Goodhue CR 6 placing shingles on Cl 6 limestone



Figure 7 Goodhue CR 52 Finished blend of TOSS and Cl. 6



Figure 8 Goodhue CR 52 November 1, 2012

Appendix C: Task 3 Report



Minnesota Department of Transportation

Memo

Office of Materials

1400 Gervais Avenue, Mail Stop 645
Maplewood, MN 55109

Office Tel: 651/366-5573

Fax: 651/366-5461

TO: Tim Stahl

DATE: September 4, 2013

SUBJECT: Task 3 memo for LRRB 914: Research using waste shingles for stabilization or dust control for gravel roads and shoulder.

This memo documents the work completed in Task 3 of the LRRB Research Project INV 914 Research using waste shingles for stabilization or dust control for gravel roads and shoulders.

As part of Task 2A & B, test sections were built in Jackson County and Goodhue County (See Task 2A & 2B memo for details). The method for evaluation of performance of the test section was: follow-up interviews with County personnel to discover their opinions of overall performance of gravel modified with tear off salvaged shingles (TOSS). The test sites were also observed, and a comparison was made between treated and non-treated gravel for wash boarding, roughness' overall appearance and amount of dust.

June 12th, 2013 Mr. Ed Johnson and Mr. Thomas Wood met with Mr. Bob Hummel Jackson County Highway Superintendent to interview him and review the Jackson County test sections. Mr. Hummel stated that the test sections were performing better than the control sections. The performance of two (2) of test sections now not performing as well as they had been before this spring. Mr. Hummel stated that maintenance forces had taken an aggregate re-claimer and pulled in large amount of untreated gravel from the ditches that greatly reduced the concentration shingles in the surfacing gravel. He stated that his motor grader operators were very satisfied with results and recommend using shingles in all of the surfacing gravel for Jackson County. They notice less wash boarding, and less dust from shingle treated sections. See figure 1 below.



Figure 1 CR 70 from MN 86

During spring thaw the roadways treated with TOSS seemed to be more stable than control sections. One observation was that some of the larger ground shingle particles appear to have been displaced by traffic to the shoulder area of the roadway. This loss does not seem to effect the overall performance of the shingle treated section. It is hard to estimate accurately amount of loss of the $\frac{3}{8}$ inch plus TOSS materials. By weight it appears to be a very small percentage of added ground shingles. See Figure 2 below.



Figure 2 Float of larger shingle particles

June 13, 2013 Johnson and Wood meet with Mr. Ron Scripture Goodhue County Maintenance Supervisor to review Goodhue County's test section. Mr. Scripture stated that they did not see too much difference in performance between the limestone class 6 with shingle or without shingles as related to wash boarding, and roughness. Both are performing acceptably. See Figure 3 below. In the picture in figure 3 the shingle section stops at the cross roads behind the pickup truck.



Figure 3 Goodhue County Shingle Section

When the researcher asked Goodhue County to help out with this project they had the belief that the class 6 limestone surfacing gravel used by the County has less issues with wash boarding and roughness than normal class 1 or 5 sand and gravel would. The area that the researchers were most interested in Goodhue County was what effect on dust does adding of the shingle have if any.

Starting on July 22, 2013 Mr. Eddie Johnson and Mr. John Pantelis did dust collection testing using Colorado dust collection methods describe in report linked here. On Goodhue County Road 52 test section.

<http://www.mrr.dot.state.mn.us/research/pdf/200904.pdf>

Mr. Johnson and Mr. Pantelis commented that they thought the surface was tighter with less float on the shingle section than the control section.

City and Date: Former site of Clay Bank, Minnesota 7/22, 8/8, and 8/15/13

Location:

Project: Goodhue County Road 52, 3 miles north of the city of Goodhue, Minnesota. Test sections were located on County Road 52 east from the intersection of County Road 52 and County Road 6 to 0.2 miles east of the intersection of County Road 52 and 205th Avenue.

Roadway description:

Current records show that County Road 52 receives an Average Annual Daily Traffic (AADT) volume of 110 vehicles¹. Goodhue County personnel participated in LRRB Investigation 914 by installing three test sections along 1.2 miles of County Road 52. See Figure 4

¹ Minnesota Department of Transportation, 2011 Publication Traffic Volumes - Goodhue County - Sheet 2 of 2. <http://www.dot.state.mn.us/traffic/data/maps/trunkhighway/2011/counties/goodhue2.pdf> accessed 8/16/2013.

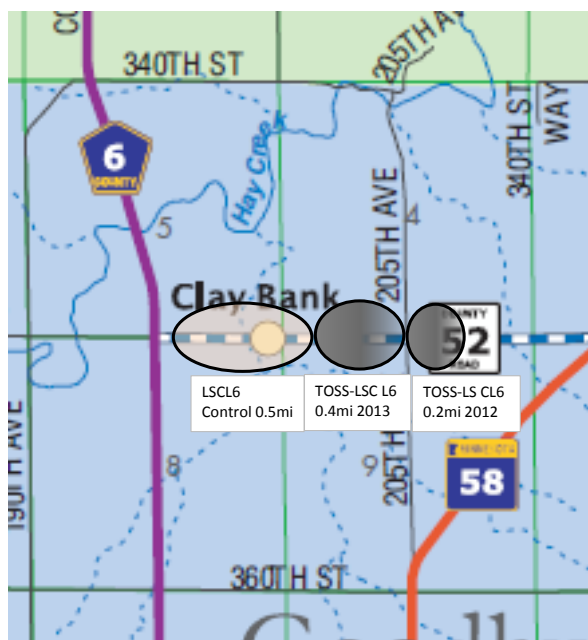


Figure 4 Test section layout Goodhue CR 52

Sections included:

- Control Section, a limestone Class 6 aggregate surface. The section begins at County Road 6 and continues east for 0.6 miles to the driveway for address number 20062.
- 2012 Shingles Section, a 1:1 blend of limestone Class 6 aggregate and 0.5-in. minus ground tear off salvage shingles (TOSS). The section begins at 205th Avenue and continues east for 0.2 miles. Shingle stabilization was performed in October, 2012.
- 2013 Shingles Section, a 1:1 blend of limestone Class 6 aggregate and 0.5-in. minus ground TOSS. The section begins at address number 20062 and continues east for 0.4 miles to 205th Avenue. Shingle stabilization was performed in August, 2013.
 - o Note: A resident routinely contracted for chloride-type dust control along an intermediate 0.1 mile in this section. The chloride area was excluded from dust measurements.

Condition:

The roadway was generally in good overall condition, with good drainage, appropriate crown, no rutting, and no measurable corrugations. TOSS and aggregate sections appeared uniformly blended.

Aggregate float of the control section contained powdery and coarse material, and the surface appeared loose. The control section traffic produced a dense dust cloud.

Aggregate float of the 2012 section was sandy, and the surface appeared tightly bound. Aggregate float of the 2013 section was observed on 8/8/2013 and 8/15/2013, and found that the road had progressed from coarse aggregate plus shingle pieces to a bound condition with sandy float.

Measurement Results:

Sections were measured for dust production using a Colorado State Dustometer that was built by MnDOT's Office of Materials and Road Research². Three collection runs of one mile comprised a dust production rating per section. Ratings are reported in grams per mile. Dust control efficiencies were reported in percent reduction as compared to a corresponding control section.
$$\text{Dust CE} = 100 \left(1 - \frac{D_t}{D_c} \right)$$

Equation 1

Initial reductions were measured near 61 percent. It was found that a control efficiency of 34 percent was possible after nearly one year of service (Table 1, Figure 5).

Test Section	Run No.	Test date	Dust, g/mile	Dust Avg g/mile	Dust Std g/mile	Moisture %	Age, days	Dust CE
TOSS/CL6 LS 2012	1	7/26/2013	3.7	4.0	1.041	0.10%	298	34%
TOSS/CL6 LS 2012	2	7/26/2013	3.2					
TOSS/CL6 LS 2012	3	7/26/2013	5.2					
CL6 LS	1	7/26/2013	6.4	6.1	0.252	0.90%	298	
CL6 LS	2	7/26/2013	5.9					
CL6 LS	3	7/26/2013	6.1					
CL6 LS	4	8/15/2013	8.6	8.2	0.321	1.00%	14	
CL6 LS	5	8/15/2013	8.1					
CL6 LS	6	8/15/2013	8					
TOSS/CL6 LS 2013	4	8/15/2013	3.4	3.2	0.153	0.84%	14	61%
TOSS/CL6 LS 2013	5	8/15/2013	3.1					
TOSS/CL6 LS 2013	6	8/15/2013	3.2					

Table 4 Goodhue CR 52 Dust Control Results

² E.N. Johnson and R.C. Olson, *Best Practices for Dust Control*. Minnesota Department of Transportation, St.Paul, MN, 2009. <http://www.mrr.dot.state.mn.us/research/pdf/200904.pdf> accessed 8/16/2013.

Control efficiencies for chloride-type dust control agents are given in Figure 6. The figure shows that effectiveness on Minnesota test sections was generally lost as the service life approached one year. Comparison of chloride to the 2012 application of 1:1 TOSS/limestone showed that the TOSS stabilization performed better than expected through one year of service.

Additionally, the moisture content values show that dust control effectiveness was obtained without the aid of moisture retention.

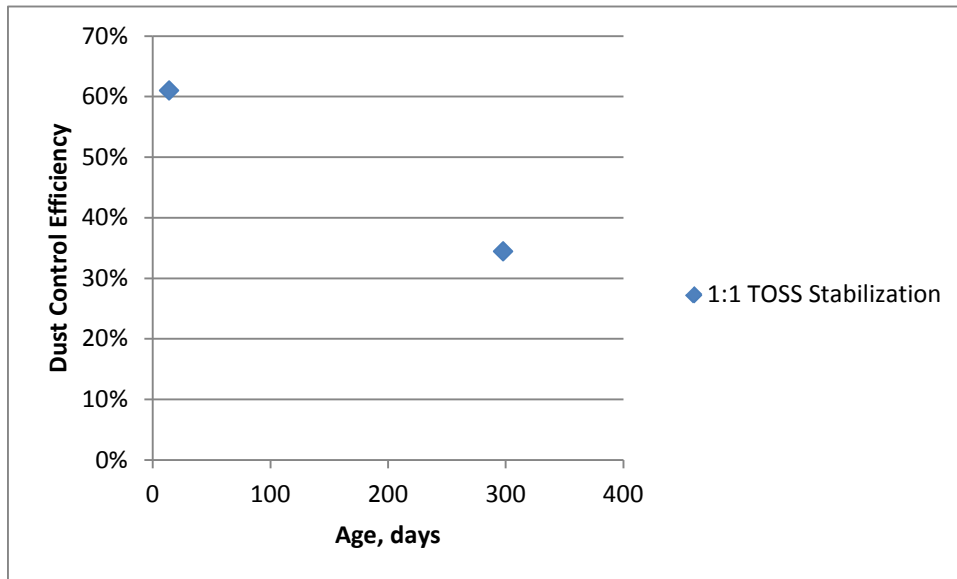


Figure 5 Dust control efficiency on Goodhue CR 52 Shingle Stabilization – 2013.

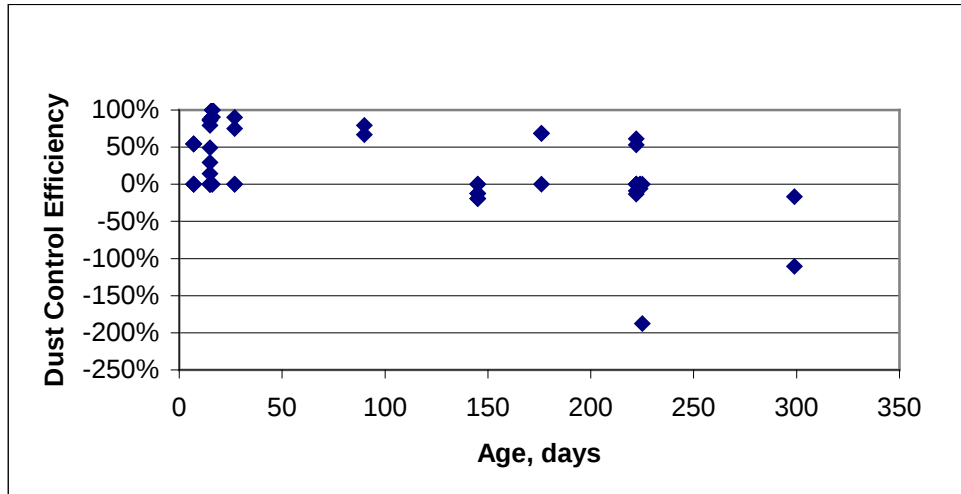


Figure 6 Dust control efficiency vs. treatment age during year one, various Chloride treatments - 2009. ³

Conclusion and Recommendation:

Based on interviews with county personnel, field reviews and dust collection, all the test sections are performing better than the control sections. The reduction in roughness and wash boarding on Class 5 sand and gravel sections in Jackson County has been remarkable. Based on the performance of test sections the Jackson County personnel are currently working on methods to stock pile tear off shingles generated in their county to be ground and incorporated into their surfacing gravel.

The gradation that TOSS was ground to was ½ inch minus (see appendix 1). Based on observations there is no need to grind the shingle to the finer gradation required for use in hot mix asphalt. The finer grind average cost was \$27.00 a ton verses \$18.00 ton for the ½ inch minus grind used. The approximately \$9.00 a ton more to meet the finer gradation requirement does not appear to had any benefit over the coarser grind.

The reduction in dust on limestone Class 6 aggregate used in Goodhue County appears to be very effective without inducing chlorides in to water shed. It would be interesting to apply a test section with a higher ratio of TOSS to gravel then what was done. Maybe something in line of two (2) part TOSS to one (1) part Class 6 gravel instead of the one (1) to one (1) ratios used to see what the increased amount of TOSS would do to reduce dust. MnDOT will continue to do dust collection testing on test sections to try to determine how long the TOSS blend is effective at reducing dust.

Appendix D: Task 4 Report



Minnesota Department of Transportation

Memo

Office of Materials

1400 Gervais Avenue, Mail Stop 645
Maplewood, MN 55109

Office Tel: 651/366-5573

Fax: 651/366-5461

TO: Tim Stahl

DATE: September 17, 2013

SUBJECT: Task 4 memo for LRRB 914: Research using waste shingles for stabilization or dust control for gravel roads and shoulder.

This memo documents the work completed in Task 4 of the LRRB Research Project INV 914 Research using waste shingles for stabilization or dust control for gravel roads and shoulders.

Task 4 was to develop draft special provisions for recycled asphalt shingles for use to modify surfacing gravels. Attached is a copy of draft special provisions. Based on discussions with MnDOT's Bituminous Office, Grading and Base Office and local suppliers of ground waste shingle the attached special provision was developed. The idea of using ½ inch minus in place of ¾ inch minus was determined based on laboratory testing and cost different. The finer grind cost on average \$9.00 more to product without any laboratory data showing improvement over coarser grind.

Appendix E: Task 5 Report



Minnesota Department of Transportation

Memo

Office of Materials and Road Research

1400 Gervais Avenue, Mail Stop 645

Maplewood, MN 55109

Office Tel: 651/366-5573

Fax: 651/366-5461

TO: Tim Stahl

FROM: Thomas J. Wood

DATE: September 11, 2013

SUBJECT: Final Implementation Plan (Task 5)

The LRRB Project 914 Research using Waste Shingles for Stabilization or Dust Control for Gravel Roads and Shoulder. Task 5 of the project was to develop Plan for Implementation of the findings of this study. Below are the steps for implementation for this project:

1. Recommend presenting finding at TERRA Pavement Conference and Road Dust Institute Conference and other conferences.
2. Recommend hosting a webinar to share information locally and nationwide.
3. Recommend a video be produced of interviews of County Personnel about the project and performance.
4. Produce two (2) pager outlining the findings of the project and to be available as handout at conferences, etc.
5. Seek out opportunities to meet and share information with effected agencies.

We are available to help with any implementation of this project.

CC: Jerry Geib, Ed Johnson, File