PENETRATION CHARACTERISTICS OF ASPHALT IN A RECYCLED MIXTURE

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PENETRATION CHARACTERISTICS

OF ASPHALT

IN A RECYCLED MIXTURE

by

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SUMMARY

Samples of both recycled and nonrecycled asphaltic concrete were extracted in increments by the Abson Recovery Method and the penetration of the asphalt from each increment determined. The recycled projects were plantsite operations containing various amounts of virgin gravel. Cored samples were taken from the pavements on Kossuth County roads that were constructed as recycled projcts in 1975, 1976, and 1977. Also cored samples were taken from a Kossuth County paving project done in 1975, that was not recycled. Comparison mix samples from 1978 construction projects in Marshall and Woodbury Counties of nonrecycled projects are included.

CONCLUSION

The test data from the penetrations of the recovered asphalt indicates that mixing of the old and new asphalt occurs very extensively in the hot recycling process. In laboratory controlled conditions it is difficult to coat aggregates with different penetration asphalts and prevent them from mixing.

INTRODUCTION

Recycling of asphalt concrete began in Iowa in 1975 with a project in Kossuth County. Recycling projects have continued in the same county during 1976, 1977, and 1978. Kossuth County has stockpiled 80,000 tons for recycling during 1979. During the 1975 project, 85-100 penetration asphalt was used as the additional binder. In 1976, it was 120-150 penetration asphalt and in 1977, 200-300 penetration was used. For the construction during 1978, the penetration was restricted to 250-300. The addition of softening agents was never tried because it was believed the use of higher penetration asphalts would accomplish the same results as the softening agents.

An obvious question arose as to whether the new asphalt added to the recycled material actually mixed with the old asphalt, which had a penetration of about 20, or whether the old asphalt resisted mixing and more or less acted as an extension of the aggregate.

Our approach for attempting to solve this problem was to use the Abson Recovery and remove the asphalt in increments.

A sample of the recycled mixture was soaked in trichloroethylene for a short period, decanted and centrifuged and the Abson Recovery Procedure followed. New solvent was then used on the mixture and the procedure repeated. Each extraction removed about one half of the total asphalt so it can be concluded that the first extraction contained the outer portion of the asphalt film and the second extraction the inner portion.

From previous work, it was shown that the asphalt films coating the large and small aggregates are approximately the same. Table 1 shows the results of two samples of a 3/4" aggregates size mix that was screened while hot on the 4" sieve. The coarse and fine fractions were extracted separately for asphalt content and a sieve analysis run on the aggregates. From this information, the film thicknesses were calculated with the results as shown.

Table I

Film Thickness Calculated from Asphalt Content and Surface Area

Sieve No. / Sample	Sieve Analysis % Passing									
	3/4	1/2	3/8	4	8	16	30	50	100	200
No. 1 (Fine)				100	84	68	50	28	18	12
No. 1 (Coarse)	100	78	62	23	16	16	15	12	8.4	5.7
No. 1 (Coarse & Fine Combined)	100	90	82	3	52	43	34	20	13	9.0
No. 2 (Fine)				100	84	69	49	28	12	12
No. 2 (Coarse)	100	76	63	26	17	16	15	12	8.7	6.1
No. 2 (Coarse & Fine Combined)	100	88	82	64	52	44	33	21	14	9.3

	%Asphalt Content	Surface Area Sq. Ft./Lb.	Film Thickness in Microns
No. 1 (Fine)	6.78	56.3	6.3
No. 1 (Coarse)	2.99	24.0	6.2
No. 1 (Coarse & Fine Combined)	5.03	42.1	
No. 2 (Fine)	6.79	56.9	6.2
No. 2 (Coarse)	3.11	25.4	6.2
No. 2 (Coarse & Fine Combined)	5.05	42.8	

LABORATORY PROCEDURE

Our normal method for asphalt removal from the mixture is by a reflux extractor. Since our interest was to remove portions of the asphalt film, it was necessary that the solvent be in complete contact and for the same period of time with the entire sample during extraction. We found the variation of time for this contact to be considerable at different locations in the sample for our regular method. The procedure that satisfied the above needs was to place about 1500 grams of the sample in a two liter beaker and completely cover the same with reagent grade trichloroethylene. The solution was decanted and centrifuged and the Abson Recovery Method followed. Several trial runs were necessary to establish the time required for this initial soak to remove about one half of the asphalt from the mix. It was found that the time varied from about 3-1/2 to 5 minutes for the different mixes. Fresh solvent was then poured over the sample and allowed to stand for twenty minutes and the Abson Recovery Procedure repeated on this portion of the sample. Examination of the aggregate then indicated all the asphalt had gone into solution and only stain from the solution remained.

SCOPE

The Marshall and Woodbury County mixes were included to show deviation of test results from the same samples, and to eliminate the influence of shale in the aggregate upon the penetration results. The Marshall County project was a high type mix using a good quality of crushed limestone. The Woodbury mix was comparable in quality, but used Quartzite as the principal aggregate. The asphalts used in these projects were from different sources. The average penetration results from these two projects showed the first and second increment extractions to be essentially the same.

The Kossuth County projects include a recycled and a non-recycled project both constructed in 1975. Recycled projects from Kossuth County done in 1976 and 1977 are included. High shale contents in the gravel aggregates from this area of the State are common.

Little information is available on the initial composition of these Kossuth County pavements, but it seems reasonable to assume they were constructed with locally available gravels and have been seal coated at various times throughout the years.

RESULTS

Table II is a listing of the projects included in this report along with the average penetrations for the first and second increments of the extractions.

Normally, if the asphalt is recovered in two increments from a new non-recycled mix, the penetrations of the two portions would be expected to be the same. Table II shows this to be the case with the Marshall and Woodbury projects.

Table II

Average Penetration Results

	Average Penetration of 1st Extraction	Average Penetration of 2nd Extraction
Kossuth Co. 1975 - recycled	41	38
Kossuth Co. 1975 - non-recycled	31	46
Kossuth Co. 1976 - recycled	31	56
Kossuth Co. 1977 - recycled	37	54
Marshall Co. 1978 - non-recycled	63	62
Woodbury Co. 1978 - non-recycled	48	51

If mixing of the old and new asphalt in a recycled project was not obtained, it would be expected that a higher penetration would result from the first increment, because the old asphalt would remain essentially in contact with the aggregate and the new asphalt would merely coat the old asphalt. The 1976 and 1977 recycled projects and the 1975 non-recycled project has this condition reversed. The explanation for this being, the virgin gravels added to the recycled mix for these projects contained a large amount of shale, and resulted in selective absorption of the lighter fractions of the asphalt. The lighter fractions from within the shale are removed in the second extraction increment and account for the high penetrations.

The recycled project in Kossuth County done in 1975, showed essentially the same penetrations for both increments. The shale content in this project was the lowest for the recycled jobs and probably was not high enough to interfere with the penetrations.

To validate the procedure we were using, we attempted to coat a hard asphalt with a soft asphalt and not have them mix. An aggregate was coated with 60 penetration asphalt at a temperature of 163° C (325°F). This mixture was then age hardened by an additional 24 hours in an oven at 149°C (300°F). The penetration of the asphalt of this mixture was not determined but by observation the asphalt had become brittle at room temperature. The mixture was then heated to the lowest possible temperature to allow coating of an additional asphalt of 200 penetration. The results of three extraction increments are shown in Table III and demonstrate the readiness in which hard and soft asphalts mix. The penetrations of the first extraction increment, which should consist of the 200 penetration asphalt if mixing had not occurred, was 31. The penetration of the third extraction increment was 18 which would represent the heat embrittled asphalt. In explaining the low penetrations of the recovered asphalts, we have found that a straight line relationship does not exist for the resultant penetration when combining very hard asphalts with normal penetration grades of asphalt.

Table III
Penetration Results

	Penetration @ 77°F 100 gms 5 sec.
1st extraction increment	31
2nd extraction increment	25
3rd extraction increment	18

The old rule from Chemistry that "like dissolves like" is in reference to solubility of compounds of similar molecular structure. This is especially appropriate in recycling of asphalt concrete where we are dealing with molecules of the same structure. Here we are dissolving asphalt in asphalt with the aid of the high shear forces furnished by the aggregate and the mixing process.

The individual test results for penetration and shale contents are shown in Appendix A. The percentage shale is calculated as that amount retained on the #16 sieve in comparison to the total amount of sample retained on the #16 sieve.

CLOSURE

Different approaches are certainly possible in solving this most important problem. Hopefully, this report will stimulate others in a search for a better understanding of the physical and chemical characteristics of the asphalt in the recycling process.

ACKNOWLEDGMENT

The author would like to thank Mr. Charles Huisman, Materials Engineer and Mr. Robert Shelquist, Bituminous Engineer of the Iowa DOT, for their contribution toward the project. Appreciation is extended to the Laboratory personnel, especially Clarence Jones and Robert Starr for their efforts in the Laboratory testing. Appreciation is also extended to Mr. Richard Henely, Kossuth County Engineer and Philip Hassenstab, District Materials Engineer-Iowa DOT, for their cooperation and assistance.

APPENDIX A

TEST RESULTS

Form 208 Special
6-72

IOWA DEPARTMENT OF TRANSPORTATION
Office of Materials
Highway Division

TEST REPORT — MISCELLANEOUS MATERIALS
AMES LABORATORY

Material Asphalt Concrete Cores **Laboratory No.**

Intended Use

County Kossuth (SN-1179(6)--51-55) **Proj. No.** Department Information

Producer **Contractor**

Source

Unit of Material Cores taken from Kossuth County project constructed in 1976 as a recycled material.

Sampled by **Sender's No.**

Date Sampled 6-14-78 **Date Rec'd** **Date Reported**

RECOVERED ASPHALT

	Penetration @ 77°F. 100 gms. 5 sec. First increment extracted	Penetration @ 77°F. 100 gms. 5 sec. Second increment extracted	% shale in extracted aggregate
	31	73	
	36	63	4.8
	33	48	4.9
	30	57	
	33	38	
	29	53	3.9
	28	59	3.9
Average	31	56	

DISPOSITION:

Signed
Testing Engineer

Form 208 Special
6-72

IOWA DEPARTMENT OF TRANSPORTATION
Office of Materials
Highway Division

TEST REPORT — MISCELLANEOUS MATERIALS
AMES LABORATORY

Material: Asphalt Concrete Cores Laboratory No.:

Intended Use:

County: Kossuth (SN-745(9)--51-55) Proj. No.: Department Information

Producer: Contractor:

Source:

Unit of Material: Cores taken from Kossuth County project constructed in 1975. This was a non-recycled project.

Sampled by: Sender's No.:

Date Sampled: 6-14-78 Date Rec'd: Date Reported:

RECOVERED ASPHALT

	Penetration @ 77°F. 100 gms. 5 sec. First increment extracted	Penetration @ 77°F. 100 gms. 5 sec. Second increment extracted	% shale in extracted aggregate
	24	52	10.6
	25	33	15.3
	26	56	
	26	52	
	25	50	
	36	43	
	46	37	
	34	41	
Average	31	46	

DISPOSITION:

Signed
Testing Engineer

Form 208 Special
6-72

IOWA DEPARTMENT OF TRANSPORTATION
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Highway Division

TEST REPORT — MISCELLANEOUS MATERIALS
AMES LABORATORY

Material Type B Surface **Laboratory No.**

Intended Use

County Woodbury (FN-141-1(10)--21-97) **Proj. No.** Department Information

Producer **Contractor**

Source

Unit of Material Box sample of new mix from Woodbury County project constructed in 1978. This was a non-recycled project.

Sampled by **Sender's No.**

Date Sampled **Date Rec'd** **Date Reported**

RECOVERED ASPHALT

	Penetration @ 77°F. 100 gms. 5 sec. First increment extracted	Penetration @ 77°F. 100 gms. 5 sec. Second increment extracted
	44	41
	42	59
	49	67
	52	57
	43	48
	46	37
	48	64
	45	46
	48	47
	64	47
Average	48	51

DISPOSITION:

Signed
Testing Engineer

Form 250 Special
6-72

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Highway Division

TEST REPORT — MISCELLANEOUS MATERIALS
AMES LABORATORY

Material Asphalt Concrete Cores **Laboratory No.**

Intended Use

County Kossuth (L-502(2)--73-55) **Proj. No.** Department Information

Producer **Contractor**

Source

Unit of Material Cores taken from Kossuth County project constructed in 1975 as recycled material.

Sampled by **Sender's No.**

Date Sampled 6-14-78 **Date Rec'd** **Date Reported**

RECOVERED ASPHALT

	Penetration @ 77°F. 100 gms. 5 sec. First increment extracted	Penetration @ 77°F. 100 gms. 5 sec. Second increment extracted	% shale in extracted aggregate
	35	35	
	45	48	3.2
	29	35	1.8
	46	50	
	38	33	2.7
	47	30	2.8
	46	38	
Average	41	38	

DISPOSITION:

Signed
Testing Engineer

Form 656 Sheet 6-77

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TEST REPORT — MISCELLANEOUS MATERIALS
AMES LABORATORY

Material: Asphalt Concrete Cores Laboratory No.:

Intended Use:

County: Kossuth (L-RS-329--73-55) Proj No.: Department Information

Producer: Contractor:

Source:

Unit of Material: Cores taken from Kossuth County project constructed in 1977 as a recycled material.

Sampled by: Sender's No.:

Date Sampled: 6-14-78 Date Rec'd: Date Reported:

RECOVERED ASPHALT

Penetration @ 77°F. 100 gms. 5 sec. First increment extracted	Penetration @ 77°F. 100 gms. 5 sec. Second increment extracted	% shale in extracted aggregate
34	53	
36	58	
37	61	
35	45	
41	62	
37	46	
37	41	15.0
37	66	15.3
Average 37	54	

DISPOSITION:

Signed _____
Testing Engineer

Form 1-Special
5-72

IOWA DEPARTMENT OF TRANSPORTATION
Office of Materials
Highway Division

TEST REPORT — MISCELLANEOUS MATERIALS
AMES LABORATORY

Material: Type A Surface Laboratory No.

Intended Use

County: Marshall (M-4664(1)--81-64) Proj. No. Department Information

Producer Contractor

Source

Unit of Material: Box sample of new mix from Marshall County project constructed in 1978. This was a non-recycled project.

Sampled by Sender's No.

Date Sampled Date Rec'd Date Reported

RECOVERED ASPHALT

	Penetration @ 77°F. 100 gms. 5 sec. First increment extracted	Penetration @ 77°F. 100 gms. 5 sec. Second increment extracted
	62	59
	62	71
	61	76
	58	58
	58	52
	76	54
	56	64
	58	66
	66	53
	77	68
Average	63	62

DISPOSITION:

Signed
Testing Engineer