RECYCLED ASPHALT PAVEMENTS

Kossuth County
Iowa

By

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Kossuth County Engineer

Sponsored By

Iowa Highway Research Board

Project HR-176

September 1975

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I

INTRODUCTION

Perhaps the best way to begin the report on HR-176 "Recycled Asphalt Pavements--Kossuth County" is to question the "Need," "Why," and "How" for the project. This is best explained by a brief history of the past policies, procedures, and operations of Kossuth County relative to its paving program.

Kossuth County is located in North Central Iowa bordering on the State of Minnesota. It is the largest county in Iowa consisting of 28 congressional townships. The population of the county is 23,000 of which 11,000 people live in the rural area. There are 13 towns located in the county with the county seat, Algona, being the largest with a population of 6,100. Major industry of the area is grain farming with some beef and hog production.

Naturally, where there is good grain farm land it follows that there is poor soil available for road construction and pavements. However, below the 3 to 4 feet of good farm land of Kossuth there is present a good grade of clayey soil which does make an adequate base for surfacing when placed and compacted on top of the roadbed.

Aggregates for pavements in Kossuth County are very limited with the quality of same just average. As an example, the haul distance of the limestone added to the 3" Type B Class I Asphaltic Concrete surface for this project was 53 1/2 miles from the quarry site to the job site. The haul distance from the plant site to project site was 13 1/2 miles.

As early as 1950, the then Kossuth County Engineer, H.M. Smith, embarked on a program of stage construction in building new grades and pavements. The goal of his program was primarily to conserve the county's rapidly dwindling supply of surfacing materials, and also, to realize the side effects of providing smooth and dustless roads for the public. Engineer Smith was fully aware of the poor soils that existed for road construction, but he also knew about the good clay that lay below the farm soil. Consequently, in his grading program he insisted that road ditches be dug deep enough to allow the good clay soil to be compacted on top of the roadbed. The presence of the compacted clay on top of the road resulted in a briding affect over the farm soil.

Mr. Smith's stage construction program involved three different operations which are summarized as follows:

(1) Grading: This was done within 90 feet of right of way, construction 1 1/2 to 1 foreslopes, 1 to 1 backslopes, and generally a 24 foot road top. Minimum ditch depth was 5 feet. Usually, the ditch depth runs 6-7 feet. Sometimes the road ditches seem to act as twin channel changes, but they do keep the water table relatively low under the roadbed. If it were not for the existence of the deep ditches, Kossuth County's present pavements would probably have deteriorated more rapidly and created an impossible financial problem.

(2) Temporary Surfacing and Sub-base Construction: Initially, 1500-2000 cubic yards of crushed 3/4" gravel was placed on new grades as temporary surfacing on roads scheduled for pavement. After one or two years of service in this condition, a gravel-clay calcium treated base, 4" thick, was constructed covering the temporary surfacing. The gravel-clay base consisted of 75% 3/4" maximum size gravel and 25% pulverized clay mixed with 8-10% water, spread and compacted on a 24 foot roadway.

(3) Bituminous Treated Base and Pavements: The year following the construction of gravel-clay clacium treated sub-base, a 3" Bituminous Treated (2.9% Emulsion) Base covered by 1 1/2-2" Type B Class II (4.5% Asphalt Cement) Asphalt Treated Base was constructed. The 1 1/2-2" Asphalt Treated Base was then covered with a seal coat applying 30 lbs. per square yard of 3/8" limestone chips and .30 gallons per square yard of emulsified or cutback asphalt.

The stage construction program satisfied the objectives of aggregate construction and dust control but did generate other problems which we are now trying to solve as economically as possible.

II

ECONOMIC PROBLEMS CREATED

The problems created can readily be catagorized into four areas consisting of: (1) pavement deterioration, (2) excess miles of pavements, (3) design, and (4) costs.

(1) Pavement Deterioration: Pavements are deteriorating at a rapid pace in Kossuth County. Actually, this can be expected because about 60% of them are between 15 and 20 years old. In 1970, the county spent 3/4 million dollars on patching and repairing its 460 miles of pavement. This was a necessary stop gap expenditure, hopefully to allow the county to catch up on an asphalt construction resurfacing program.

Also, as pointed out earlier in this paper, the quality of aggregates used were minimal. Shale content of the gravel is at the upper allowable limit which probably caused excessive oxidation of pavements. Another contributing factor could be the use of 85-100 penetration asphalts which tend to make a flexible pavement more rigid.

(2) Excess Miles of Pavements: Probably due to political pressures and other non-engineered policies, Kossuth County suddenly over-extended its pavement mileage with relation to the amount of funds available. There are 1750 miles of secondary roads in the county of which 460 miles are at some point in the original stage construction program. With the advent of Federal Revenue Sharing Funds and their use on highways, the county has been almost, but not quite, able to keep its pavements in good condition.

(3) Design: The roads designed and constructed in the 1950's and early 1960's suddenly became inadequate in the mid and late 1960's. Federal Aid Funds could not be used for paving unless a proposed project met all the design standards set forth by the Bureau of Public Roads. Kossuth County found itself with many miles of a completed program which did not meet Federal or State guide lines. Nearly all stage constructed roads were too narrow with horizontal and vertical alignment marginal.

From 1968 to 1974 the county constructed 4 and 6 foot shoulders with truck hauled dirt and material from extra right of way widths. This cost is more than the budget will allow and amounts to an average of $36,000 per mile. Normally to preserve and extend the life of the pavement a minimum of 3" of asphalt resurfacing is also required costing an additional $25,000 per mile.

During 1974-1975, the County was ready to try almost anything to decrease this overall cost of construction.

(4) Costs: We all know what has happened to costs of both asphalt cement and portland cement the past two years, and we will not dwell on the subject. We will state that Kossuth County logically was and is committed to some type of pavement program related to asphalt cement. Also, it is hoped that a method can be developed whereby the pavement shouldering costs can also be sharply reduced.

III

WHY THIS PROJECT

The reason for this project can be explained simply. Even before the energy crisis of 1973 the cost of truck shouldering our pavements was becoming prohibitive. The combination costs of shouldering and resurfacing to an adequate pavement thickness was strangling our road budget. At times, consideration was given to the idea of completly destroying the existing pavements, widening the roadbed by lowering the grade line, and then repaving anew.

When the energy crisis swarmed down us--accompanied by increased right of way acquisition costs--the costs of the old method of operation increased 35-40%.

Ironically, it had occured many times in the minds of many people that it would be nice to be able to re-use some of the asphalt materials we dug up and wasted in our pavement repair operations. Everyone realized that if this were possible the amount of asphalt required in reconstruction of pavements might be reduced. This, not to mention the potential saving in costs of truck hauling aggregates and mixes as well as the aggregates themselves.

Had it not been for the energy crisis and the resulting higher costs of construction, Kossuth County probably would not have embarked on this conservation operation. At least not until it was practical and economically feasible.

IV

THE PLANNED PROJECT

After considerable deliberation, it was decided to start experimentations which would involve conservation of the materials presently incorporated in existing asphalt pavements. The plan was to lower, widen, and shoulder the roadbed as part of the same project. Further, it was decided to salvage and re-use the gravel-clay sub-base and reconstruct same and incorporate it as part of the operation.

Project site location was based on the location of other resurfacing projects currently planned for construction. The site selected was located within one mile of the farthest haul point in Kossuth County--being one mile south of the Minnesota State Line and joining an asphalt pavement into Emmet County, Iowa. Length of the proposed project was 0.927 miles and the project number assigned was L-502(2)--73-55.

During the project planning stage, the Iowa State Highway Commission--presently the Department of Transportation--indicated considerable interest in the project through its Highway Materials Engineer, George Calvert, and its Bituminous Engineer, Bernard Ortiges. Mr. Calvert suggested that the Kossuth County Engineer develop plans, specifications, and cost estimates and present same to the Iowa Highway Research Board requesting research funds to cover part of the cost of the experiment. Plans, specifications, and cost estimates were prepared and funds for the project requested in a letter to the Iowa Highway Research Board dated January 16, 1975. At its January 31, 1975, meeting the Research Board agreed to fund one-half the project cost not to exceed $50,000. A breakdown of estimated costs and bid items involved is shown in Exhibit A.

Type of bid item, the requirements therein, and the number of units involved were determined by the Kossuth County Engineer and his staff through their knowledge of what existed on the old roadway and what was demanded in the new project. Several core samples were taken of the old roadway, and these sent to the Ames materials laboratory for analysis. On the basis of the analysis it was planned to add 3% virgin asphalt cement to the recycled material. Core samples also indicated that the 4" of gravel-clay base was re-usable. They also indicated that there was 4 1/2" of recyclable asphalt material available consisting of 1 1/2" Type B Class II Asphaltic Concrete (5% A.C.) and 3" of Bituminous Treated Aggregate Base (2.9% Emulsion). Allowing for handling loss it was decided to reprocess and lay 4 1/2" loose thickness of recyclable material on the new road way. To assure that the end product met pavement full depth requirements the recycled material was covered with 3" of Type B Class I Asphaltic Concrete.

Final plans, specifications, and proposal form were completed and approved by the Iowa State Highway Commission and Iowa Highway Research Board. The project was let by the Iowa State Highway Commission April 1, 1975, and awarded to Everds Brothers, Incorporated, Algona, Iowa. The project funding contract between the Iowa Highway Research Board and the Kossuth County Board of Supervisors was finalized April 24, 1975.

Four bids were received on the construction project ranging from a low of $98,664.20 to $105,407.87. This compared to the Engineer's estimate of $93,053.18. Bid results are shown in Exhibit B.

EXHIBIT A

Cost Estimate

Project No. LRS-502(2)
Kossuth County, Iowa
Length of Project 0.927 Mi.
Location: N. Line Sec. 18-30-100

Item No.	Description of Work	Unit	No. of Units	Estimated Cost per Unit	Total Cost Unit (Est.)
	Salvage, Haul & Stockpile Bituminous Material	Sq. Yds.	11,959	$1.50	$17,938.50
	Salvage, Haul & Stockpile Chemically Treated Sub-base	Sq. Yds.	13,045	$0.50	6,522.50
	Reconstruct Sub-grade	Mile	0.927	$3000	2781.00
	Construct 4" Soil-Aggregate Sub-base	Mile	0.927	$4000	3708.00
	Granular Material	Tons	1391	$2.00	2782.00
	Typ B Class II Asph. Conc. Base (Using salvaged Bit. Mat'l)	Tons	2984	$6.98	20,828.32
	Type B Class I Asphaltic Conc. Base	Tons	2099	$7.98	16,750.02
	Asphalt Cement	Tons	226	$95.00	21,470.00
	Primer or Tack Coat Bitumen	Gal.	1173	$0.50	586.50
					$93,366.84
	Engineering - 5% of Project				$4,668.34
	Total Project Cost				$98,035.18

TABULATION OF BIDS
EXHIBIT B

LOCATION ON SECONDARY ROAD FROM THE SW COR. SEC. 7 - 100 - 30
AT THE EMMET COUNTY LINE EAST APPROXIMATLY 1 MILE

.927 MILES

COUNTY KOSSUTH
TYPE OF WORK ASPHALTIC CONC. PAVEMENT
PROJECT NO. L-502 (2) - 73-55
DATE OF LETTING APRIL 1, 1975

			EVERDS BROS. INC. ALGONA, IOWA		KOMATZ CONST. INC. ST. PETER, MINN.		ROHLIN CONST. CO. INC. ESTHERVILLE, IOWA		W. HODGMAN & SONS INC., FAIRMONT, MINN.	
ITEM	QUANITY	UNIT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT	UNIT PRICE	AMOUNT
BASE, RECLAIM, CRUSH & STOCKPILE BITUMINOUS CONCRETE	11,959	SQ. YDS.	1 60	19,134 40	1 80	21,526 20	1 85	22,124 15	2 00	23,918 00
SUBASE, GRANULAR, RECLAIMING AND STOCKPILING	1,449	CU. YDS.	4 00	5796 00	2 50	3622 50	4 50	6520 50	2 00	2898 00
RECONSTRUCTION OF SUBGRADE	.927	MILES	6000 00	5562 00	8000 00	7416 00	6000 00	5562 00	8000 00	7416 00
SUBBASE CONSTRUCTION OF SOIL AGGREGATE	.927	MILES	3000 00	2181 00	3000 00	2181 00	3000 00	2181 00	3000 00	2181 00
GRANULAR MATERIAL	1391	TONS	3 50	4868 50	3 60	5007 60	3 80	5285 80	3 70	5146 70
BASE, RECYCLED ASPHALTIC CONCRETE	2984	TONS	7 50	23,380 00	6 90	20,589 60	6 70	19,992 80	8 50	25,364 00
BASE CLASS I ASPHALTIC CONCRETE	2099	TONS	7 50	15,472 50	7 83	16,435 17	8 05	16,896 95	7 60	15,592 40
ASPHALT CEMENT	226	TONS	96 00	21,696 00	95 00	21,470 00	93 00	21,018 00	94 50	21,357 00
PRIMER OR TACK COAT BITUMEN	1173	GALS.	60	703 80	52	609 96	50	586 50	49	574 77
TOTAL				98,664 20		99,458 03		100,767 70		105,407 87

V

CONSTRUCTION OPERATIONS

The chronological order of construction operations for the actual work involved in this project can be broken down into seven definite phases. They were as follows:

(1) Salvaging recyclable material

(2) Salvaging gravel-clay sub-base

(3) Widening of roadbed

(4) Constructing Sub-base

(5) Crushing recyclable material

(6) Processing recyclable material

(7) Surfacing-final course

Exhibit C shows a typical cross-section of the old road as it existed before reconstruction and, also, the proposed typical cross-section of the finished product. This exhibit also provided the contractor with the elements of the Iowa State Highway Commission Specifications of 1972 and certain other factors with which he was to comply.

SALVAGING RECYCLABLE MATERIAL

The first step in the construction operation was the salvaging of the recyclable material. This was initiated by using a Cat 14 motor grader with rear mounted ripper attachment to scarify the pavement to a depth of 4 1/2 inches. No problems in this method were encountered except in areas of the pavmement where the pavement had been patched with a 2" hot mix overlay or with full depth asphalt patches. When these area were encountered one of the three ripper teeth was removed from the ripper and the Cat 14 grader was assisted by a loader for additional power. Normally the old asphalt pavement scarified quite easily with pavement section either being pulverized or broken into square sections.

The scarified pavement material was then further broken up by using a Cat DW20 tractor with Hyster compactor wheels. About 95% of the time this operation broke up the old pavement into sections no larger than 4 inches. The difficult areas were still those of the full depth pavement patches. In one area where an emulisified cold mix patch had been placed, the material began to recompact rather than break up and pulverize.

With completion of the road pulverization operation, the next step was to load and haul the material to the plant site and prepare it for crushing. Loading the salvagable material on a narrow grade presented a minor problem. This was solved by using a Cat D8 tractor and 80 scraper to haul the material to entrances or farm driveways where the haul trucks had room to maneuver and be loaded by a rubber tired loader. In some areas the roadway was wide enough to permit windrowing of the salvaged material and then end loading into trucks. A self-propelled windrow loader would probably solve this problem.

SALVAGING GRAVEL-CLAY BASE

This proved to be the least difficult of all the operations connected with the project. This phase was worked jointly with the road widening operation. One half the width of the roadway was worked at a time. First one half the roadway, which now contained only the gravel-clay base, was scarified to a depth of 4 inches. This material was then windrowed, moved, and stockpiled on top of the other half of unscarified gravel-clay base, all with the use of

Cat 14 motor graders. With the gravel-clay base removed from one half the road, the motor grader was then used to excavate that half by cutting the roadway down uniformly one foot and placing the excavated material on the foreslopes. This material was compacted with a sheeps foot roller.

The remaining half of the road was worked in the same manner. The resulting windrow of salvaged gravel-clay base was quite large and amounted to approximately 1500 tons per mile. At this point, it was decided by the County Engineer to eliminate the item of additional granular material for sub-base construction from the contract. The quality of the salvaged gravel-clay base was such that this portion of the contract was not needed.

WIDENING OF THE ROADBED

This part of the construction process is covered under the previous section. It was convenient at this stage to have the windrowed gravel material readily available in the event of wet weather. Even before the project was let, the situation of possible wet subgrades was anticipated which might have given some problems. However, on this project the subgrade was firm as far down as we excavated and never presented a problem.

CONSTRUCTING SUB-BASE

Sub-base construction was a routine operation. The sub-base was constructed over a 26 foot width using the salvaged windrowed gravel base material and according to Iowa State Highway Commission specifications. Field densities ranged from 95-100% of modified proctor with specific gravities being 1.99-2.02.

CRUSHING RECYCLABLE MATERIAL

Specifications for the project required that the salvaged asphalt material be crushed to a maximum size of 2 inches. Practically no difficulty was encountered in this process. A roll type crusher was used with all material passing the 2 inch seive.

The percentage of virgin asphalt to be added to the recycled pavement was determined by the amount of residual asphalt in the old pavement and other inherent properties of the material as shown in Exhibit D. The residual asphalt content of the crushed mat was determined to be 3.7%.

It is well to mention at this point in the report that it is likely that this portion of the recycling process may be eliminated in future projects. This in view of the experience and success obtained in pulverizing the old pavement on the road. Even now there is pulverizing equipment available which can do the job when working with this type of recyclable material. In a future contract this could result in a unit price reduction of $1.25-1.50 per ton in the Item Number 6 of contract--Type B Class II Asphaltic Concrete Base (using salvaged Bituminous Material).

It should be also pointed out that if heavier or thicker layers (6") of hot mix are attempted to be recycled, crushing of the material--probably to a 3 inch maximum size--will be necessary.

PROCESSING RECYCLABLE MATERIAL

The process of handling the recyclable asphalt can be broken into two different operations. They are the <u>Mixing</u> operation and the <u>Lay Down</u> operation.

To obtain some element of experimentation in the project a decision had to be made as to how we would proceed to work the project. Potential variable elements were: (A) using recyclable asphalt aggregates only and adding a variable percentage of virgin asphalt, (B) mixing recyclable asphalt material and adding a percentage of new aggregates to the mix.

Before mixing or recycling began, it was decided to divide the one mile length of the project into 4 variable sections. These sections are catergorized as follows:

Section	Length	Aggregates	Added Asphalt
1	1/2 mile	Recyclable	2.5%
2	1/4 mile	Recyclable	3.5%
3	1/8 mile	Recyclable	4.5%
4	1/8 mile	Recyclable 70% and new 30%	4.5%

Mixing: A Barber Green 10 x 30 drum mixer with a low efficiency wet wash was used in the mixing operation with all other plant equipment being of the conventional type used in any other asphalt paving operation. This plant had been tested by the Iowa Department of Environmental Quality and found in compliance in May of 1975. This drum mixer has an asphalt line inside the drum an introduces the asphalt to the aggregates about 10 feet downstream from the aggregate drying and heating flame.

There was little or no problem in handling the recyclable aggregates to get them to the drum mixer. The only deterrent in this area was an occassional sticking and plugging of the cold feed bins and inlet chute to the drum mixer. This may continue to be a problem after rains or on hot afternoons.

From the start of the mixing process it was evident that it was possible to recycle old asphalt material. It was also apparent that something had to be done to bring the created smoke emission down to an acceptable level. The smoke problem was caused by the ignition of recycled particles when introduced to the hot flame. Two things point to this. One was that smoke was puffing out around the seal at the fire end of the dryer. The other being that the fuel consumption needed for heating and drying was not as high as normal for material containing 5% moisture.

Mixing began at a production rate of 275-300 ton per hour, mix temperature at 300° F, with no water being added to aggregates, and with the wet wash inoperative. Smoke was dense near 100% Ringelmann and very unacceptable. Something had to be done to control the smoke problem.

Several alternatives were available. They were: (a) changing rate of production, (b) changing mix temperature, (c) adding water to aggregates, (d) adding new aggregates to the recyclable aggregates. The chronological order of changes that were made and the emission results are shown in Exhibit E. This exhibit shows when 3% mositure was added to the aggregates, production was maintained at 275-300 tons per hour, mix temperature at 225° F, and with 30% limestone added to mix, the smoke problem was nearly brought to and acceptable level.

Lay Down: The mixing process produced a mix that could be laid and compacted with conventional asphalt equipment. Even at the lower mixing temperatures (225° F) there were few, if any, undisintegrated lumps. The recycled base was laid using a Barber Green full width paver and laying a 4 1/2 inch loose thickness. Rolling was normal but, at the higher mixing temperatures, had to be held up several minutes due to heat retention of the thick mat.

At the very beginning of the lay down operation it was thought by everyone concerned that the mix appeared to be lean on asphalt content. The mix tended to shove under rolling operations and was difficult to handle. After laying 700 feet, it was decided to increase the percent of asphalt added to 3.5%.

When laying the mat with 3.5% asphalt added, the mix looked as though a conventional product were being produced. All of the mix laid well but the densities were low on the first 1900 feet of the project. Ironically, this was true while we were mixing at the higher temperatures. As shown in Exhibit F, the field densities improved and were acceptable for the last 3000 feet of the project. All elements tested improved substantially as the project progressed except the recovered asphalt penetration factor. Regretfully, the recovered asphalt penetration factor was not available when 30% limestone was added to the mix. By extrapolation, however, this could be expected to be 60-65.

It is well to note at this point in the report that when 30% limestone was added to the recycled material and when 4.5% asphalt was added to the mix, the extracted asphalt content was 6.9%, the field specific gravity was 2.25, the field voids were 6.4%, and the smoke problem during the mixing process was almost brought to acceptable limits.

SURFACING-FINAL COURSE

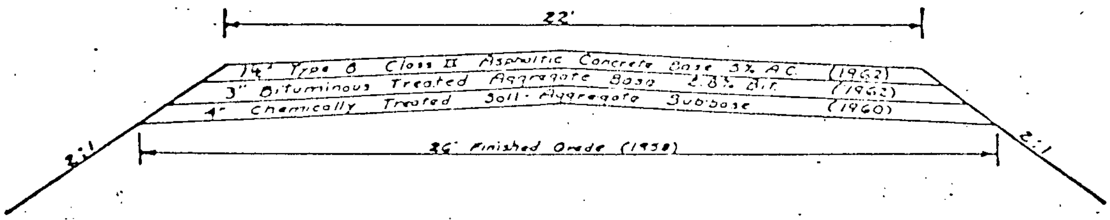
The final surfacing placed upon the recycled base was a standard 3" Type B Class I Asphaltic Concrete according to Iowa State Highway Commission specifications. From the standpoint of future observation and monitoring of the results of the project, it is probably regretable that this phase was necessary to provide adequate pavement thickness. In future recycling projects in Kossuth County, the recycled base will be left exposed-probably for a period of at least five years. Then we will be able to tell how the recycled base performs under the elements of weather and traffic.

EXHIBIT C

TYPICAL CROSS SECTION

Sta 100+00 to 148+92.2

(Present Roadway)



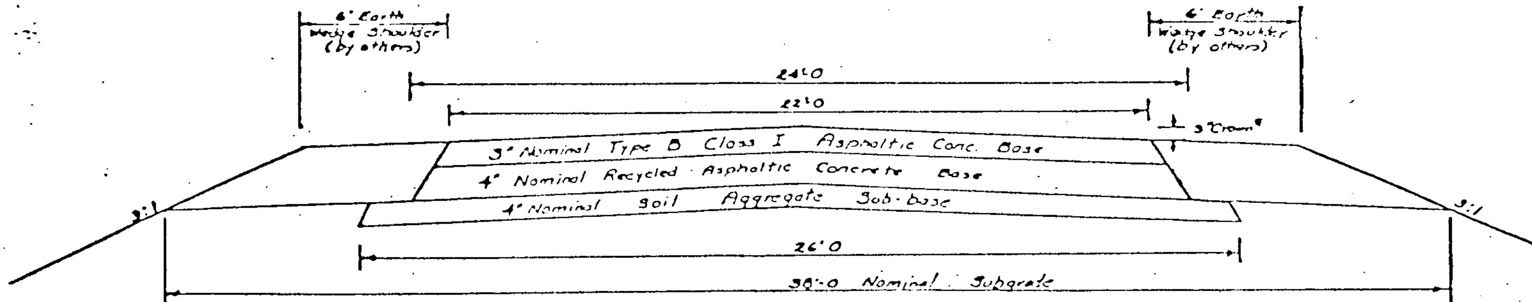
Contractor will scorify existing 4½" nominal bituminous material in such a manner as to salvage the maximum amount of the bituminous material. Contractor will load the bituminous material and haul to the plant site where the material will be crushed to a 2" maximum size. No other gradation requirements will be specified. Price bid will be on a sq. yd. basis and will include all costs for scorifying, salvaging, loading, hauling and crushing.

Contractor to salvage existing 4" Chemically Treated Soil-Aggregate Sub-base and stockpile the material at a location secured by the contractor in accordance with Section 2126 of 1972 Standard Specifications

After the bituminous material and the sub-base material has been removed the contractor will lower the remaining roadbed uniformly, an average depth of 12" and to a nominal width of 38' with 3:1 foreslopes. The sod on the foreslopes, after thorough disking, shall be removed from the area and placed on the area to be occupied by the outer portion of the embankment in layers not over 8" in loose thickness. The existing slopes shall be notched as required by the Engineer in steps as the grade is lowered and widened. The material will be placed on the slopes in layers not over 6" in loose thickness. After the layer has been smoothed and before the next layer is deposited upon it, the layer shall be compacted with a minimum of one rolling per inch of depth of each lift, and it is further required that the roller continue operation until it is supported on its tamping feet or the equivalent.

EXHIBIT C (con't)

TYPICAL CROSS SECTION
Sta. 100+00 to 148+92.2
(Reconstructed Grade)



Contractor to prepare 4" Soil Aggregate Sub-base in accordance with Section 2110 of 1972 Standard Specifications

1500 tons per mile of granular material will be added in the construction of the soil aggregate sub-base as a seperate pay item. The granular material added will be in addition to the so. agad sub-base material.

Contractor will construct nominal 4" Recycled Asphalt Concrete Base using the salvaged material and adding Asphalt Cement as determined by the job mix. Section 2202, 1972 Standard Specifications, shall apply ammended as follows.

1. In any section where Asphalt Treated Base appears it will be assumed to read "Recycled Concrete Base."
2. Delete Section 2202.02B and insert in its place---The Mineral Aggregate used will be the salvaged bituminous material with a maximum size of 2". There will be no other gradation specifications or requirements.
3. Delete Section 2202.02C and insert in its place --- It will be required by the Engr. so that the existing proportions of Type B Class II Asphaltic Concrete Base and Bituminous Treated Aggregate Base be maintained during the salvaging, crushing and placement in the cold feed bins. The additional Asphalt Cement required to be added to the salvaged material will be determined by the job mix. The Asphalt Cement added shall be maintained within plus or minus 0.40 percentage points tolerance of the percent intended.
4. Add the following to Section 2202 --- It is not intended to use an asphalt softening agent, however if the Engineer, at the time of production, determines that a softening is required the contractor will add the prescribed agent and will be paid at invoice price plus 10%.

Contractor will construct Type B Class I Asphaltic Concrete in accordance with Section 2203, 1972 Standard Specifications.

*Subject to Engineers approval 2" crown may be used.

The Engineer may require a tack coat of 0.02 to 0.05 gal per sq. yd.

Reclaim, Crush and Stockpile Bituminous Concrete Base	Reclaiming and Stockpiling Granular Subbase	Reconstruct Sub-grade	Construct 4" Soil-Aggregate Sub-base	Granular Material	Recycled Asphaltic Conc. Base	Type B Class I Asphaltic Conc Base	Asphalt Cement	Primer or Tack Coat Bitumen
Sq. Yd.	Cu. Yd.	Mile	Mile	Tons	Tons	Tons	Tons	Gal.
(5)(10)	(6)	(10)(11)(15)	(10)	(13)(14)	(1)(5)(9)	(1)(2)(9)(13)	(3)(4)(9)	(8)(9)
11,959	1449	0.927	0.927	1391	2984	2099	226	1173

Footnotes:

(1) Drum Mixing equipment complying with Section 2001 may be used for the production of the Recycled Asphaltic Concrete Base and the Type B Class I Asphaltic Concrete Base.

(2) Not less than 30% crushed limestone, graded to meet the requirements of the mix design, shall be incorporated in the Type B Class I upper base course. Cost of the limestone will be incidental to the price bid for the Type B.

(3) Estimated at 5% for Class II

(4) Estimated at 6.5% for Class I

(5) Estimated at 2658 tons salvaged Bituminous Material based on core samples of 5", 5", 4½" & 4½" with an average width of 22' + 130" per co. ft.

(6) Estimated at 1449 Cu.Yds. based on 3" of salvagable sub-base material 24' width.

(7) Contractor shall use 85-100 penetration Asphalt Cement.

(8) All or any part may be eliminated at the discretion of the Engineer

(9) Section 1109.03 of 1972 Standard Specifications shall not apply.

(10) Final payment will be based on estimated planned quantities with out re-measurement.

(11) Estimated at 5000 C.Y. based on average cut of 12".

(12) Wedge shouldering, after the Asphaltic Concrete is placed, will be done by others and is not a part of this contract.

(13) Contractor will furnish the gravel source and crush the gravel to meet specifications

(14) Based on 1500 tons per mile.

(15) The contractor shall aerate, compact, and shape all unstable subgrade areas prior to constructing the soil aggregate subbase. Unstable areas that develop during subsequent construction operations shall be repaired in accordance with the specifications and to the satisfaction of the engineer. All aeration, compaction, shaping and repair shall be incidental to the work and not measured for payment.

EXHIBIT D

Iowa Department of Transportation
Asphalt Concrete Mix Design

Mix, Type and Class: Salvaged Asphalt Concrete. Lab No. ABD5-59

Intended Use:

Size Spec. No. Plans Date Reported: 6/10/75

County: Kossuth Project LRS-502(2)--73-55

Contractor: Everds Brothers, Inc.

Project Location

Agg. Sources The average extraction of the crushed mat was 3.7% of asphalt.
Job Mix Formula Aggregate Proportions: 100% AAT5-186 (Crushed Mat)

JOB MIX FORMULA - COMBINED GRADATION

1-1/2"	1"	3/4"	1/2"	3/8"	No.4	No.8	No.16	No.30	No.50	No.100	No.20
		100	98	93	81	66	50	32	18	12	10

Tolerance:

75 Blow Marshall Density		2.22	
Asphalt Source and Approximate Viscosity		1367 Poises	
Plasticity Index			
% Asphalt in mix	4.50	5.50	6.50
Number of Marshall Blows	50	50	50
Marshall Stability - Lbs.	3530	3797	4267
Flow - 0.01 Inches	10	10	10
Sp. Gr. By Displacement (Lab Density)	2.15	2.20	2.23
Bulk Sp. Gr. Comb. Dry Agg.	2.564	2.564	2.564
Sp. Gr. Asph. @ 77 F.	1.028	1.028	1.028
Calc. Solid Sp. Gr.	2.46	2.42	2.39
% Voids - Calc.	12.4	9.1	6.6
Rice Sp. Gr.	2.50	2.44	2.40
% Voids - Rice	14.0	9.8	7.1
% Water Absorption - Aggregate	1.94	1.94	1.94
% Voids in the Mineral Aggregate	19.9	18.9	18.7
% V.M.A. Filled with Asphalt	37.5	51.8	65.0
Calculated Asph. Film Thickness (microns)	4.2	5.4	6.6

A total content of 6.1% of asphalt is recommended to start the job. This is an addition of 2.5% asphalt to the salvaged concrete.

Copies:

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Roberts
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L. Zearley
J. Stober
Everds
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G. Perrin

Signed: Bernard C. Brown
Testing Engineer

EXHIBIT E

Mix Temp.	Production Rate	Aggregates	% H_2O Added	% Asphalt Added	Remarks
300°	300 TPH	Recyclable	None	2 ½ %	Smoke very dense
260°	300	Recyclable	None	2 ½ %	No change
260°	400	Recyclable	None	2 ½ %	No change
260°	400	Recyclable	1 %	2 ½ %	Some change, 50-80 Ringelmann*
260°	200	Recyclable	3 %	2 ½ %	Little change, 40-60 Ringelmann*
225°	300	Recyclable	1.5%	2 ½ %	Some change, 40 Ringelmann*
225°	300	Recyclable	1.5%	3 ½ %	40 Ringelmann*
225°	300	Recyclable	1.5%	4 ½ %	40 Ringelmann*
225°	300	70% Recyclable 30% Limestone	1.5%	4 ½ %	20-30 Ringelmann*

* Estimated

EXHIBIT F

PAVEMENT TEST RESULTS

Sample No.	Station	Aggregate Used	Mix Temp.	Asphalt Added	% A.C. Extracted	Field Density	% Lab Density	Lab. Voids %	Field Voids %	Recovered Asphalt Penetration	Recovered Viscosity	Marshall Stability + Flow	
77	107+50±	Recycled	275°	2.5%	5.8%	2.04	90.3*	7.7	16.4	N.A.	N.A.	4372	10
78	111+50±	Recycled	260°	2.5%	5.8%	2.02	89.4*	7.9	17.2	37	10,220	4558	10
79	120+50±	Recycled	245°	3.5%	7.5%	1.98	86.1**	3.5	17.6	N.A.	N.A.	3613	13
80	124+50±	Recycled	235°	3.5%	7.0%	2.10	91.3**	3.4	12.7	42	6,040	3262	14
81	126+50±	Recycled	250°	3.5%	7.2%	2.18	94.8**	3.4	9.1	N.A.	N.A.	3808	12
82	138+50±	Recycled	285°	3.5%	7.0%	2.17	94.3**	3.8	9.7	N.A.	N.A.	3900	10
83	143+50±	Recycled	200°	4.5%	8.3%	2.21	94.4***	2.2	8.1	49	3,990	2237	19
84	145+50±	70% Recycled 30% Limestone	200°	4.5%	6.9%	2.25	96.2***	2.3	6.4	N.A.	N.A.	2547	19

N.A. --- Not available

* --- Based on 2.26 Laboratory Density

** --- Based on 2.30 Laboratory Density

*** --- Based on 2.34 Laboratory Density

VI

SUMMARY

The principle question "Can Old Asphalt Pavements Be Recycled?" has been answered by the results of this project. The answer, of course, is "yes, they can!" However, economic and social factors should be given considerable thought. Factors to be considered are: (1) Pavement performance, (2) Economy of process, (3) Environment vs conservation.

PAVEMENT PERFORMANCE

From the results shown and analyzed in Exhibit F, it is possible to assume that the only characteristic widely different in new and recycled pavements is the residual or recovered asphalt penetration factor. On normal projects when new aggregates and virgin asphalt cement are used exclusively, the covered asphalt cement penetration usually is 80-90 when 85-100 penetration is employed in the product. On this project, the recovered asphalt penetration factor was 37-49 which indicates a brittle pavement that should show signs of hair line cracking at an early date. Only the passage of time will verify if this fault develops. All other tests indicate that the recycled material is nearly as good as new material.

The potential problem of the asphalt penetration factor can probably be solved by using a virgin asphalt with a penetration of 120-150, or even of higher value. Another solution could be using a higher percentage of new aggregates in combination with the recycled material.

ECONOMY OF PROCESS

In areas where aggregate sources are plentiful, where haul distances are relatively short, and where roadway widths are adequate, it is unlikely that recycling of pavements would be economical. However, if just one of the above factors is present, recycling should be considered. In Kossuth County, Iowa, all three of these factors exist.

The economics of recycling cannot be judged by the cost of this experimental project. The project was too short and there were too many unknown areas of the costs involved in the process. Bidding contractors had to protect themselves and their financial investment.

Previous to the energy crisis of 1973, Kossuth County had been constructing 4-6 foot shoulders and resurfacing with 3 inches of Type B Class I Asphaltic Concrete. The shouldering operation also required widening the road right of way from 90 to 120 feet. The coast per mile for the entire operation was about $61,000. The cost per mile could be divided as follows: (a) shouldering-$23,000, (b) resurfacing-$33,000, (c) Right of way-$5,000.

With the arrival of the energy cirsis in 1973, the cost per mile increased to $82,000. Shouldering costs increased to $27,000, resurfacing climbed to $45,000, and right of way jumped to $10,000 per mile. As an example, to stay within the 1974 budget, resurfacing projects let for a 4 inch asphalt thickness had to be cut back to 3 inches. Projects planned and budgeted in 1975 were let for a 2 inch thickness realizing that further work would be necessary at a future date.

As construction costs increased and with receipts remaining nearly the same, the volume of construction work had to be decreased.

A five year plan was being "shot out of the saddle". Some different method of construction had to be found.

We can only speculate on the cost of recycling until a much larger project is completed. In Kossuth County we know that costs are cut immediately by $10,000 per mile because additional right of way is not required. The cost of shouldering or widening the roadway could be cut from $27,000 per mile to $6,000. So, before the project starts we have a cost difference in these two items alone of $31,000 per mile. However, this difference in cost savings would be reduced by the amount of: (1) reclaiming recyclable asphalt material, (2) reclaiming the gravel-clay base, (3) and the reconstruction of the sub-base.

Reclaiming 4 1/2 inches of asphalt material, or about 3300 ton per mile should be done at about $2.00 per ton or $6600 per mile. This includes scarifying, loading, hauling 12 miles, and stockpiling. It does not include a crushing cost which it is hoped will be unnecessary.

Reclaiming 1500 cubic yards of gravel-clay base per mile, to be incorporated in the soil aggregated subbase, should cost about $2.00 per cubic yard or $3000 per mile.

On a 10 mile project, construction of a 4 inch soil aggregate subbase should cost $5,000 per mile.

When reclaiming 3300 ton per mile of recyclable material from the old pavement, approximately 10%, or 300 ton per mile will be lost in the handling process. There should remain about 3000 tons per mile (4" compacted) available for the repaving operation.

Assuming the cost of mixing and laying the recycled material to be $3.25 per ton and a haul of $1.25 per ton, we could expect a processing cost of $4.50 per ton, or $13,500 per mile, exclusive of asphalt cement. Assuming further, that 3.5% virgin asphalt cement was added to the mix (cost-$95.00 per ton) the asphalt cost would be $3.33 per ton or about $10,000 per mile.

Logically, the 4 inches of recycled materials should be covered with a minimum 2 inches of new material. Then a 6 inch asphalt pavement would have been constructed. That cost should be about $22,500 per mile.

Earlier it was stated that the total cost of right of way, shouldering, and 3 inch resurfacing project would be about $82,000 per mile according to today's prices. According to what is known now about the recycling operation it is reasonable to assume that the cost can be cut to $60,600 per mile, or a savings of $21,400 (about 35%) per mile.

Exhibit G shows the items of the contract awarded, the contract and actual unit costs, and the contract and actual cost of the project. Final cost of the project was $91,827.66 or about 93% of the contract.

ENVIRONMENT vs CONSERVATION

The only serious problem relative to the project was the smoke or pollution created by the mixing operation. Processing recyclable materials alone will be impossible without developing an adequate pollution control system. Even with the addition of new aggregates, compliance with pollution standards is marginal, but hopefully acceptable, by Iowa standards. If the pollution problem cannot be economically solved, we will not be able to reclaim asphalt materials and re-use and conserve them.

Another conservation item noted in the process was the fact that the best in place pavement results were obtained at the lower mixing (225°) temperatures. It follows then that the heating and drying process requires less fuel per ton of mix processed than conventional mix.

It is timely to note the pavement recycling process could easily be adapted to county pavements where rolled stone bases with asphaltic concrete surfaces exist. In this situation, nearly all the rolled stone base material could be re-used along with the reclaimed asphaltic concrete. In this process, it is likely that there would be little pollution problem and a savings in asphalt cement of one to two percent.

EXHIBIT G

KOSSUTH COUNTY, IOWA.

PROJECT L-502(2)-73-55
0.927 MILES

CONTRACT AND ACTUAL COST

EM NO.	ITEM	UNIT	UNIT PRICE	QUANTITY		AMOUNT	
				CONTRACT	ACTUAL	CONTRACT	ACTUAL
1.	BASE, RECLAIM, CRUSH AND STOCKPILE BIT. CONCRETE	SQ. YD.	1.60	11,959	11,959	19,134.40	19,134.40
2.	SUBBASE, GRANULAR, RECLAIM AND STOCKPILE	CU. YD.	4.00	1,499	1,499	5,796.00	5,796.00
3.	RECONSTRUCTION OF SUBGRADE	PER MILE	6000.00	0.927	0.927	5,562.00	5,562.00
4.	SUBBASE, CONSTRUCTION OF, SOIL AGGREGATE	PER MILE	3,000.00	0.927	0.927	2,781.00	2,781.00
5.	GRANULAR MATERIAL	PER TON	3.50	1,391	NOT USED	4,868.50	0.00
6.	BASE, RECYCLED ASPHALTIC CONCRETE	PER TON	7.50	2,984	2,353.20	22,38.00	17,649.00
7.	BASE, TYPE B CLASS I ASPHALTIC CONCRETE	PER TON	7.50	2,099	2,345.65	15,742.50	17,592.38
8.	ASPHALT CEMENT	PER TON	96.00	226	238.03	21,696.00	22,850.88
9	PRIMER OR TACK COAT	PER GAL.	0.60	1,173	770	703.80	462.00

TOTALS ______________________________ 98,664.20 91,827.66

VI

FUTURE PLANS

Kossuth County is not finished, as yet, with the recycling process. The County's 1976 construction program tentatively will contain 15 miles of this type of construction. The lengths of the projects will be 10 miles, 3 miles, and 2 miles. All the projects will be located within a two township area where normal haul distances are at least 25 miles.

During the progress of these projects pollution problems will hopefully be solved and the asphalt penetration factor of the recovered asphalt raised to an acceptable level. Presently it is intended to add an additional 3.5% asphalt to the reclaimed pavement. Another phase will be a combination of one-third new aggregates mixed with two-thirds recyclable material and an addition of 4.5% new asphalt. All potential variables will be applied at some stage in this work. However, all the surfaces of recycled pavements will be left exposed to weather and traffic for future observations.

Hopefully, this will verify some of the things discovered on Project L-502(2)--53-55.