

# **EVALUATION OF RECYCLED ASPHALT CONCRETE PAVEMENTS**

**Final Report  
for  
Kossuth County, Iowa  
Project SN-1179(6)  
Research Project HR-1008**

**February 1980**

### Disclaimer

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FINAL REPORT

"EVALUATION OF RECYCLED ASPHALT CONCRETE PAVEMENTS"  
KOSSUTH COUNTY, IOWA  
PROJECT SN-1179(6)

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### Exhibits

- Exhibit A - Project Construction Contract
- Exhibit B - Project Location
- Exhibit C - Typical Cross-Section and Notes
- Exhibit D - Project Pollution Parameters
- Exhibit E - Pavement Test Results
- Exhibit F - Cost Comparision

## INTRODUCTION

After some success with a small asphalt pavement recycling project in 1975, Kossuth County, Iowa programmed a much larger undertaking during the 1976 construction season. The work performed in 1975 indicated that a quality product could be produced with some modifications to conventional equipment. As anticipated, the major problem encountered was the excessive air pollution created during the heating and mixing process.

As part of its 1976 road program, Kossuth County developed plans for recycling sixteen miles of existing asphalt pavements using the "hot mix" recycling process. One project, ten miles in length, was selected by the Federal Highway Authority as part of "Demonstration Project No. 39, Recycling Asphalt Pavements." The FHWA provided a \$29,500 grant to the project to be used for project testing and evaluation.

Cooperation and input into the work proposed for 1976 was received from many sources. The people and organizations contributing were the Federal Highway Authority, the Iowa Department of Environmental Quality, the Federal Environmental Protection Agency, several contractors, and personnel from the Kossuth County Engineer's Office.

To establish some project parameters, the Iowa Department of Transportation Materials Laboratory, as part of the FHWA work plan, evaluated the existing pavement structurally and for existing pavement material properties. Core samples were cut in the old pavement. These samples were analyzed extensively in Iowa Department of Transportation laboratories. The tests indicated that the old pavement contained a high percentage of fine material--ten or eleven percent passing the 200 sieve--and a high shale content. These tests revealed that the asphalt binder

had hardened dramatically over the years with existing recovered residual asphalt penetrations being in the range of sixteen to twenty-eight.

A Road Rater Deflection Survey was performed on the ten mile project prior to salvaging the old pavement on July 13 and July 19, 1976. Old pavement deflections were high as shown below:

<u>Old Pavement Deflection</u>					
	<u>Mean Defl.</u>	<u>Std. Defl.</u>	<u>Coef of Var.</u>	<u>High</u>	<u>Low</u>
NB	5.86	2.065	35.2	13.20	2.70
SB	5.47	1.899	34.7	12.00	3.60
NB & SB	5.73	2.001	34.9	13.20	2.70

Kossuth County asphalt pavement recycling Project SN-1179(6) was awarded to the low bidder, Everds Brothers Incorporated, Algona, Iowa on May 13, 1976, in the amount of \$621,418.71. A copy of the contract as awarded is shown in Exhibit A of this report. Exhibit B, the title sheet, shows the location and length of the project and other relative information. Exhibit C contains the typical cross-section of the roadway before and after construction and special notes which were part of the plans and specifications for the work.

#### Project Design

Kossuth County, Iowa Project SN-1179(6) was originally constructed under a stage construction program between the years 1957 and 1964. The pavement was built on a roadway width of 24 feet. Before the old 7 to 7½ inch pavement was removed this resulted in a travelled way width of 22 feet with no shoulders. A dangerous traffic situation was thus created compounded by very deep road drainage ditches and steep foreslopes. As it existed, maintenance costs of the pavement were very high; and, for the sake of safety, shoulder construction was necessary.

The existing road grade was well above the surrounding farmland, and, if the grade line was lowered uniformly, a snow removal problem would not

be created. After the energy crisis of 1973, truck shouldering costs skyrocketed cutting heavily into the County Road Budget. As a result of these factors, it was concluded that it would be more economical to salvage the old pavement, lower the existing grade line 18 inches uniformly, and rebuild shoulders from excess material within the old road right of way. It was estimated that this method of construction would reduce the amount of truck haul shouldering material from 270,000 cubic yards to 40,000 cubic yards.

It was estimated that about 128,000 square yards of old pavement could be salvaged involving approximately 47,300 tons of bituminous material. Also, it was planned to salvage the existing four inches of chemically treated gravel sub-base and incorporate this old base material in the new sub-base construction. A plan was then developed for a 30 to 34 foot roadway width, six-inch full depth asphaltic concrete pavement, and a pavement width of 22 feet, all constructed on a four-inch prepared soil aggregate sub-base.

From the experience gained from the 1975 recycling project, it was decided to use a 66 2/3% recycled pavement aggregate and 33 1/3% virgin gravel aggregate as the aggregate mixture for the new pavement mix. A 3/4 inch maximum size gravel aggregate was to be combined with recycled material crushed to a two inch maximum size. This mixture of aggregate was proposed with the thought that this mixture might help in getting a handle on the air pollution problem.

From many core samples taken from the old pavement, the Iowa Department of Transportation laboratories determined that 2 1/4% of useful, recoverable asphalt cement existed in the recyclable pavement. It was planned that the bottom four inches of the finished pavement have an asphalt content of 6.75% and the two inch surface coarse have an asphalt content of 7.75%.

Actual trial pavement mixes later proved to require that the final pavement mix should contain 7.75% asphalt content in the lower four inches and 8.25% asphalt content in the surface coarse.

In an effort to "liven up" the asphalt cement in the old pavement and construct a softer more flexible pavement, a 120 to 150 penetration asphalt cement was specified in the contract documents. Previous asphalt pavement work in Kossuth County required the use of 85 to 100 penetration asphalt.

#### Preliminary Construction Work

The first step in the reconstruction of the roadway was the extension of the existing drainage structures to accommodate the new roadway design width. Luckily, all but one of the in-place culverts were reinforced circular concrete culverts and the extension of these was a simple matter. Extension of these culverts was done by County day labor forces and was not a part of the recycling contract.

At a road intersection five miles North from the South end of the project, an existing concrete box culvert was replaced by a twelve foot diameter corrugated metal culvert. Some anticipated settlement was expected in the area of this culvert though a good granular material was used in the backfill operation.

Other preliminary work which was not apart of the contract awarded to Everds Bros., Inc. was furnishing the supply of virgin aggregates to the asphalt plant site. The virgin aggregates were processed under a separate contract, hauled 23 miles, and stockpiled at the plant location. The amount of virgin aggregates used on this project was 13,292 tons at a cost at plant site of \$2.45 per ton. This adds to the cost of the contract awarded in the amount of \$32,565.40. The quality of the virgin aggregates was marginal but was the most convenient available.



### Salvaging Old Pavement

The first phase of the contractor's work was to salvage and stockpile the old pavement. It should be mentioned here that the contractor, on one other recycling project, attempted to scarify and crush the old pavement on the roadway before loading, hauling and stockpiling. This was done employing a Pettibone pulverizing machine. Though the Pettibone machine did pulverize the old pavement to a maximum two inch size, the contractor considered the process too slow and costly.

On this project, all the old pavement was salvaged by first ripping the pavement with two scarifier teeth mounted on the rear of a D-9 tractor. The old pavement broke up easily into chunk sizes which could easily be loaded into ten cubic yard trucks by a three cubic yard rubber-tired loader. To limit the amount of foreign material, such as dirt and grass, being picked up during the loading process, the sod and dirt along the old pavement edges were removed by a motor grader and pushed into the road ditch. The salvaged pavement was then truck hauled an average of three miles to the plant site, stockpiled and made ready for crushing to a two inch maximum size.

Aggregate truck haul distance, employing this salvaging operation, was decreased by twenty miles on 26,622 tons of asphalt mix aggregate on this project. This results in an energy savings of  $5.3244 \times 10^5$  ton miles. Tabulations provided by the Federal Highway Authority<sup>(1)</sup> show that 4270 Btu per ton mile are consumed when three-axle dump trucks are used as hauling units. Thus, an energy savings of  $(5.3244 \times 10^5)$  (2)  $(4.270 \times 10^3) = 45.470376 \times 10^8$  Btu's were realized in the aggregate hauling part of the work.

Using the Asphalt Institute's Publication "Energy Requirements for Roadway Pavements," MISC-75-3, April 1975 and the tables therein, the

energy savings amount to 36,376 gallons of gasoline or 32,712 gallons of number two diesel fuel.

Additional savings occurs in that the salvaged pavement contains a percentage of asphalt cement as it exists on the roadway. This asphalt cement does not require hauling from the refinery. This decreases the haul distance of that portion of asphalt cement which is incorporated in the final recycled pavement mix.

Laboratory tests indicated that the existing pavement contained about 2½% of reusable asphalt. On a project of this magnitude (42,129 tons), this amounts to 950 tons of asphalt cement which could be re-incorporated in the final pavement. Haul distance of virgin asphalt cement was 175 miles from Minneapolis to the plant site. By eliminating a 175 mile haul of 950 tons of A.C.,  $(175 \times 950) = 166,250$  ton miles of haul were not necessary. Again, using FHWA tables for five-axle hauling units, this amounts to an energy savings of  $9.6425 \times 10^8$  Btu's. This converts to 7,714 gallons of gasoline or 6,937 gallons of number two diesel fuel.

More energy savings resulted from the 950 tons of reusable asphalt cement because there was no energy expended for asphalt cement storage. The Asphalt Institute has estimated that 6,400 Btu's per ton are required to heat asphalt cement during storage. Using this criteria, an additional  $6.08 \times 10^6$  Btu's were conserved. Converted to fuel consumptions, it means a savings of 48 gallons of gasoline or 44 gallons of number two diesel fuel. This savings is negligible.

#### Reclaiming Gravel-Clay Base and Roadway Widening

The contract items of salvaging the chemically treated gravel-clay subbase and lowering and widening the roadway were performed jointly. First, four inches of subbase were scarified on one side of the roadway,

then windrowed on the opposite side of the road. Then, with the subbase removed and windrowed, the dirt exposed half of the road was lowered uniformly 18 inches. In the grade lowering operation the excess material was simply pushed over the slope of the road and compacted with a sheeps-foot roller. When the lowering process was completed on one half of the road, it was repeated on the other half. The goal of this operation was to construct a roadway width of 30 to 34 feet; and, also to use the salvaged granular material as temporary surfacing until it was incorporated in the construction of the new soil aggregate subbase.

Normally a project of this magnitude would require 27,000 tons of gravel for temporary surfacing or soil aggregate subbase treatment. With the reclaimed gravel already available on the road, it was not necessary to haul additional temporary surfacing. Average haul distance for temporary surfacing of the project would have been 26 miles from the gravel source to the road. Thus  $(27,000 \times 26) = 702,000$  ton miles of gravel hauling was not necessary.

This operation conserved considerable truck hauling energy and helped retard a rapidly diminishing gravel supply. Referring to FHWA's tables for energy consumed by three axle trucks, we have  $(7.02 \times 10^5)$  (2)  $(4.27 \times 10^3) = 5.99508 \times 10^9$  Btu's conserved by not hauling temporary gravel surfacing. By the Asphalt Institutes' tables this converts to a savings of 47,960 gallons of gasoline or 43,130 gallons of number two diesel fuel.

Prior to 1976, Kossuth County's pavement shoulder construction was done employing truck hauling units. From 1970 through 1975, the cost of truck haul shouldering increased by 125 percent; mostly due to the energy crisis of 1973. If all shoulder work on the project had been done by

truck hauling units, a total of 270,000 cubic yards would have been required to complete the work. Employing a grade lowering process reduced the amount of fill material necessary to 40,000 cubic yards. Thus, a savings of 230,000 cubic yards of shouldering material did not require truck hauling.

Elimination of 230,000 cubic yards of truck haul for shoulder work also conserved energy. In previous work, average truck haul distance for shouldering operations was two miles. Using an excavation shrinkage factor of 30%, shouldering trucks would actually haul  $(230,000 \times 1.3) = 299,000$  loose yardage. If a loose cubic yard of fill material weighs 1.25 tons, then a total, of 373,750 tons would have required hauling. Haul units eliminated by this type of operation would then amount to  $(373,750 \times 2) \approx 747,500$  ton miles.

Again using tables available in The Asphalt Institute's publication, this energy savings in truck haul would amount to  $(3.7375 \times 10^5 \times 2 \times 2 \times 4.27 \times 10^3) = 70,265 \times 10^8$  Btu's. This will convert to a fuel savings of 56.212 gallons of gasoline or 50,550 gallons of diesel fuel.

#### Crushing Recycled Pavement

Contract documents specified that the recycled pavement be crushed to a maximum size of two inches. There was some skepticism as to what problems might be encountered in the crushing operations. Some sources thought that crushing production rates would be diminished substantially due to clogging of the crusher screens. However, crushing of the recycled pavement proceeded with no decrease in the production rate or other serious problems. The only discomfort encountered was the dustiness created due to the extremely dry condition of the material. This situation was partially corrected by continually wetting down the stockpiled material with water.

Crushing of the recycled pavement was sublet by Everds Bros., Inc. to Maudlin Construction Company of Webster City, Iowa. Maudlin Construction performed the crushing operation with a conventional primary and secondary crushing and screening plant. Because of the type of material being crushed, there were no particle size limitations or requirements specified other than all crushed recycled aggregate should pass a two-inch seive.

Though crushed to a two-inch maximum size, the recycled aggregate contained a high percentage of fine material. The existence of these fines probably contributed substantially to the air pollution control problem of the heating and mixing process. The most outstanding characteristic of the crushed recycled aggregate was the dryness of the material. It is thought that the crushed recycled aggregate actually absorbs moisture from the air. In so doing, less heating fuel is required to dry the material in the mixing process.

Probably less energy is consumed when crushing recycled aggregates than in producing virgin aggregates. This would be due to a larger size of particle being produced. Any potential energy savings would be negligible.

#### Construction of Subbase

Some problem was encountered in the preparation of the four-inch soil aggregate subbase. This could be expected because we were constructing the subbase in the same construction season in which the grade lowering operation was performed. Here in Iowa, any new grade is usually very unstable until it has endured at least one winter regardless of the compactive effort provided during construction.

Density requirements for subbase compaction were 95 percent of standard proctor density. Proctor density requirements were, in general,

easy to obtain, but, due to the condition of the subgrade below the subbase, many areas of the subbase were unstable. These areas were scarified and reworked as many as three times. Even then it cannot be said that the subbase constructed on this project was entirely satisfactory.

If this pavement should fail structurally in the future--it hasn't as of the date of this report--said failure will probably be due to the condition of the subbase. In future pavement recycling work, Kossuth County will not do grade lowering work in the same construction season that it does the paving work.

#### Mixing Recycled Pavement

On Kossuth County Project SN-1179(6) a Barber-Greene 10 x 30 drum mixer was used to heat and mix the asphalt cement, recycled aggregates and the virgin aggregate. A wet wash scrubber system of air pollution control was employed in the asphalt plant configuration.

The primary asphalt plant modification was an arrangement whereby the burner flame was backed several feet away from the drum mixer. It was hoped that this modification would eliminate direct flame contact with the recycled aggregate and reduce initial aggregate contact temperatures. Excess air was also introduced into the mixer inlet by a high output air fan hoping to cool the burner gases and thus lower mix contact temperatures. Neither of these modifications helped solve the pollution problem. In fact, introduction of excess air to the drum mixer may have compounded the pollution problem by providing additional oxygen for combustion of the recycled aggregate.

After eight days of operation with the above plant modification, a deflection heat shield was added at the inlet end of the drum mixer. The

heat shield was designed to deflect the burner flame and the flow of hot gases to prevent impingement of these gases on the asphalt and aggregates. This modification had little or no effect in reducing the pollution problem.

At still a later date in the mixing operation, the asphalt plant was further modified by the construction of an aggregate augering system at the rear or outlet end of the mixer. The very fine material of the recycled aggregate was separated from the coarse particles. The fine recycled aggregate was then augered into the rear end of the drum mixer and mixed with the other aggregates and asphalt. There was some visual improvement noticed in the pollution during the time this modification was in operation. However, the augering device was structurally underdesigned and broke down after 30 minutes of operation. There was not enough time of operation to properly test and evaluate air pollution created while this modification was in use.

To provide water for the wet wash scrubber system, the contractor drilled a well. A catch basin was excavated in the area of the scrubber system and filled with water from the well. In a department memorandum, dated January 19, 1976, the Iowa Department of Environmental Quality recommended that a medium energy scrubber be required as the pollution control system. The memorandum established minimum parameters required for the removal of particles of the one micron range. A copy of this memorandum is shown in Exhibit D.

The appearance of the mix produced in the pavement recycling process was that of a conventional asphaltic concrete mix. During the time of the mixing process, the percentage of recycled pavement incorporated was changed and varied from 67% recycled to 30%. Regardless of the percentage being mixed, there was no visible change in appearance. Nor was there any

change or improvement in the pollution problem. To maintain a constant residual asphalt content, the amount of asphalt cement added to the mix was increased as the percentage of virgin aggregate incorporated was increased. Exhibit E documents the changes made in the aggregates on a day to day basis.

Energy was also conserved in the mixing process of asphalt pavement recycling. It is regrettable that Kossuth County did not have the chance to actually monitor the fuel consumption required in the heating and mixing part of the project.

However, in several conversations with Mr. Doug Meyer, President of Everds Brothers, Inc., he emphasized that less fuel was being consumed in heating and mixing of the recycled mix than in conventional mixes. Everds Brothers, Inc. had constructed many miles of asphalt pavement in Kossuth County and were familiar with the aggregate characteristics of this area. Mr. Meyer indicated that the recycled mix was consuming 1.9 to 2.0 gallons per ton of mix whereas a conventional mix had been requiring 2.5 to 2.75 gallons per ton of mix. Without question, it can be assumed that one-half gallon of fuel per ton of mix was conserved.

One reason that the recycled mix required less fuel is the dryness of the crushed material in the stockpile. As mentioned earlier in this report, the recycled aggregate probably absorbed moisture and thus required fewer BTU's in the drying process. Another reason for less energy consumption could be due to the retention of ambient heat of the summer season while in the stockpile.

Number two fuel oil was used for the heating and mixing operation on the project. Assuming that fuel was saved at the rate of one-half gallon per ton of mix and again applying tables provided by The Asphalt Institute<sup>(1)</sup> the amount of energy conserved can be calculated in terms



of Btu's and/or gallons of fuel. Calculations show that  $(42,129 \times 0.5 \times 1.39 \times 10^5) = 2.92796 \times 10^9$  Btu's were conserved or 21,065 gallons of number two diesel fuel.

Mix temperatures on the road were maintained as required by the specifications and generally were in the 250° to 260° F. area. On two occasions the mix temperature dropped to 220° F. but this was only for a short period of time. On other occasions, the mix temperature was 280° F. This fact indicates that the asphalt plant was truly tested in the pollution control experiments.

#### Pavement Laydown

On the road, the recycled pavement mix was as easy to work with as any conventional asphalt mix. A full-width Barber-Greene paver was used in the paving process. Vibratory and pneumatic rollers were employed for compaction. Density requirements were 94 percent of laboratory density. Density was relatively easy to obtain except when the ambient air temperatures dropped in later October.

One noticeable characteristic of the pavement mix was an occasional pulling and gouging under the paver scrid. This was attributed to the fact that the recycled pavement was crushed to a two-inch maximum size. Apparently, the recycled pavement did not break down smaller than a two inch size during the heating and mixing process. Gouging on the surface caused some inconvenience to the contractor in the pavement laydown operation but did not effect ths surface texture or pavement structure. This problem has been corrected on recent Kossuth County projects when recycled material is crushed to a maximum one-inch size.

#### Laboratory and Field Evaluation

Normal asphalt pavement laboratory analysis and field evaluation were carried out during construction. In addition, Barber-Greene engineers

constantly monitored the air pollution characteristics of the heating and mixing process.

In the realm of air pollution analysis it is doubtful if any asphalt paving plant was ever subjected to such rigid testing. The Barber-Greene Company provided their own field laboratory at the plant and constantly observed what was happening inside and outside of the plant configuration. Several temperature measuring devices were located at critical locations inside the drum mixer and the pollution control system. Pressure drop through the scrubber venturi was continually monitored as well as stack emissions. The results of Barber-Greene testing have been restricted by the company and are not available to the public.

One requirement of the specifications was that one air pollution analysis be made within two weeks of plant start up by a qualified, disinterested consultant engineering firm. Entropy Environmentalists, Incorporated, Research Park, North Carolina, performed the specified pollution test according to Environmental Protection Agency Method V. A copy of the test report<sup>(2)</sup> should be available from this organization. Results of the test show that the air pollution standards of the E.P.A. were far from being obtained.

Laboratory analysis, consisting of trial pavement design mixes, laboratory pavement densities, asphalt extractions, viscosities, and residual penetrations were performed by the Iowa Department of Transportation District and State Central Laboratories. Field densities and material testing was done by Kossuth County Engineer's personnel. There was no sieve analysis taken of the crushed recycled pavement other than to be certain that all crushed material passed the two inch sieve. Consequently, it was thought that sieve samples on the cold feed aggregate belt were not necessary.

The Iowa Department of Transportation Central Office also arranged to subject the finished recycled pavement to annual skid resistance and deflection tests. Results of these tests are covered latter in this report. Other characteristics of the finished pavement are shown in Exhibit E.

#### Conservation

Existing asphalt pavements are a constant, endless source of supply of aggregates used in paving. This is particularly important in regions which have a limited or marginal supply of aggregates or where aggregate haul distances are substantial. Eventually, it may also have a decrease in aggregate costs which occur due to the cost of mineral rights and royalties. It is probably one method of creating competition between aggregate producers as well as conserving aggregate supply sources.

Where energy is saved, costs must be saved. Contractors and engineers should be made aware of these savings. Contractors in a competitive market should pass the savings on to the contracting authority. Engineers should analyze each prospective paving or repaving project as to the economics involved when pavement recycling is a potential alternative.

Most of the energy savings in a pavement recycling project results from a substantial decrease in average truck haul distance. In any recycling project, engineers can locate the plant site near to the paving project and where haul distance is at a minimum.

Though it was and is nearly impossible to precisely document the energy savings incurred in a recycling project, it is possible to make an educated estimate of these savings when related factors are known or assumed. The following table will give the reader some indication as to

the potential energy savings estimated on Kossuth County, Iowa Project SN-1179(6) and explained earlier in the report.

Item were energy saved	Estimated Energy Conserved		
	Btu's	Gals. Gas	Gals. #2 Diesel
Reclaim Pavement	$4.5470376 \times 10^9$	36,376	32,712
Reclaim Gravel	$5.99508 \times 10^9$	47,960	43,130
Grade, Lower & Widen	$7.0265 \times 10^9$	56,212	50,550
Asphalt Storage	$6.08 \times 10^6$	48	44
Asphalt Transportation	$9.6425 \times 10^8$	7,714	6,937
Heating & Mixing Asphalt Concrete	$2.92796 \times 10^9$	23,424	21,065
<b>TOTALS</b>	$21.4669076 \times 10^9$	171,734	154,438

The analysis of the above table will reveal that most of the energy savings in a typical asphalt pavement recycling project is attributable to decreased truck haul distance. If, in the above table, only those items related to the recycling operation are considered--not including reclaiming gravel or grade lowering--54% of the energy saved was due to the decrease of truck haul. On the paving portion of this project, there was a savings of 67,562 gallons of gasoline or the equivalent of 60,758 gallons of number two diesel fuel.

#### Costs--Conventional vs. Recycling

Previous to 1976, Kossuth County's conventional method of improving an asphalt road was to resurface with four inches of asphaltic concrete, construct four to six foot shoulders with trucks and other earth moving equipment, and purchase necessary right of way to complete the project. With rising right of way costs, the energy crunch and other inflationary characteristics, we decided to investigate the possibility of using other methods which would give similar results. The result of these considerations is the reason why Kossuth County became so extensively involved in the recycling process.

Exhibit F shows a cost comparison between the conventional method of constructing this type of project previous to 1976 and the actual construction costs of Project SN-1179(6). Upon investigation, Exhibit F will show that the total cost of recycled asphaltic concrete was \$12.03 per ton compared to an estimated \$14.06 per ton for a conventional mix.

On Project SN-1179(6), the cost of salvaging, crushing, and stock-piling recycled pavement was \$3.40 per ton. The cost of the recycled aggregate included a 10% loss of 6" salvaged pavement due to the handling process. Excess recycled material salvaged on this project was used in three other pavement recycling projects. Only 26,622 tons were incorporated in SN-1179(6).

Though the cost of salvaging the old pavement was \$3.40 per ton as compared to \$2.45 for virgin aggregates, we must be aware of the existence of 2 $\frac{1}{4}$ % reusable asphalt cement in the recycled aggregate. When considering an asphaltic concrete cost of \$81.00 per ton, this means that each ton of recycled aggregate contained asphalt cement valued at \$1.82 per ton. At 1980 prices of asphalt cement, which is \$150 to \$160 per ton, the dollars saved by the salvaging process is nearly double that of 1976.

In Exhibit F, the bid items included a mobilization item of cost which Kossuth County has eliminated in its 1978 and 1979 recycling projects. In the infancy of recycling work, this was added as a bid item to help protect the contractor in the event of a forced shutdown by the pollution authorities.

The price structure has changed substantially since 1976 with 1980 price levels being at least 50% higher on most items. Methods of construction have changed and improved since 1976. Now, with the CMI Pavement Pulverizer available, the recycled pavement crushing operation should not be required, thereby saving more energy and costs.

Recycled Pavement Performance

The recycled asphaltic concrete pavement of Kossuth County Project SN-1179(6) is functioning as well as any other conventional asphalt pavement. As of the date of this report, it has been completed three and one half years and has functioned satisfactorily through four rugged Iowa winters.

Like other conventional new or resurfaced pavements, the recycled pavement surface has a substantial amount of pitting of the surface texture. With the gravel aggregates available in Kossuth County, this is a normal occurrence after four or five years. This characteristic is normal for any asphalt work in the County. It is routinely corrected, after the pavement has been in place about seven years, with a limestone chip seal coat. The chip seal coat will then extend the surface life of the pavement for about ten years.

There is no evidence of structural damage on the entire 10.065 miles of the project. The Iowa Department of Transportation has performed Road Rater Deflection Tests on the pavement annually. Road Rater Tests were conducted twice in 1977, twice in 1978, and once in 1979. The theoretical AASHTO Structural Number for the pavement is 2.40 using a coefficient of 0.40 per inch corrected for temperature variations. Road rater test results are as follows:

<u>Deflection</u>		
<u>Date</u>	<u>Mils</u>	<u>SR</u>
5-13-77	3.72	2.25
11-03-77	2.78	2.60
5-30-78	4.25	2.15
11-08-78	2.88	2.45
9-27-79	3.22	2.50

The coefficient of 0.40 per inch is the coefficient used for Type B, Class 2 asphaltic concrete pavement.

Surface friction-skid tests were also conducted annually by the Iowa Department of Transportation. The friction numbers were obtained at 40 and 55 miles per hour and the speed gradients are given below. The friction numbers are considerably higher than recommended minimum friction numbers given in National Cooperative Highway Research Program Report 37, Tentative Skid-Resistance for Main Rural Highways. Speed gradients ranging from 0.3 to 0.7 are common on asphaltic concrete surfaces.

	<u>1977</u>		<u>Speed</u> <u>Gradient</u>
	<u>40 mph</u>	<u>55 mph</u>	
Northbound	61	53	0.5
Southbound	60	50	0.7
	<u>1978</u>		
Northbound	60	54	0.4
Southbound	59	54	0.3
	<u>1979</u>		
Northbound	58	52	0.4
Southbound	58	51	0.3

Laboratory analysis by Lowell J. Zearley, Bituminous Chemist for the Iowa Department of Transportation and his subsequent report entitled "Penetration Characteristics of Asphalt in a Recycled Mixture," November 1979, (3) concluded that "the mixing of the old and new asphalt occurred extensively in the hot recycling process." Mr. Zearley's conclusion substantiates the results shown in Exhibit E of this report. Basically, it proves that the residual asphalt penetration of an old pavement can be substantially increased if a high penetration asphalt cement is used in the pavement recycling process.

### Summary

Kossuth County Recycling Project SN-1179(6) created a lot of interest in the asphalt pavement recycling process. Interest was indicated by the large attendance at the two "open houses" sponsored jointly by Everds Bros., Inc., Barber-Greene Company, the Iowa D.O.T., and the FHWA. Total attendance was well above 200 people. Those in attendance were not only from every area of the United States but also from Canada and Japan.

Several conclusions can be made as a result of the project. Probably the most important is that energy can be conserved and money saved when the recycling process is possible. The project proved that a good quality pavement could be produced even with the use of marginal recycled aggregates. It proved, too, that the physical properties of an old asphalt pavement can be upgraded when a quality virgin aggregate is incorporated in the mix.

The greatest disappointment of the project was the inability of the contractor or the equipment manufacturer to make any noticeable improvement in the pollution control problem. However, the augering device used for a very short time during the plant operation must have given the Barber-Greene Company a direction in which to proceed in its efforts to control pollution. The principle this company uses today is much the same.

From the results of this recycling work, we all realized that there was a lot of work to be done in the area of air pollution control. The equipment manufacturers have attacked this problem with vigor and today pollution standards can be met with little or no problem.

Many organizations and individuals should be thanked and recognized for their contributions to the project. Specifically, the Iowa Department



of Environmental Quality and the Environmental Protection Agency for their interest and patience in letting the project go to completion. The Iowa Department of Transportation and Federal Highway Administration for their input and cooperation; Everds Brothers, Incorporated and the Barber-Greene Company for their pioneering efforts and financial support and cooperation. Individuals who contributed to the success of the project and who should have special recognition are: George Calvert, Charles Huisman and Bernard Ortgies of the Iowa Department of Transportation, and Richard Schiek, Assistant Kossuth County Engineer.

References

- (1) "Energy Requirements for Roadway Pavements," The Asphalt Institute, MISC-75-3, April 1975.
- (2) Source Sampling Report, "Experimental Asphalt Concrete Recycling Plant in Iowa", No. 68-01-3172, October 1976.
- (3) "Penetration Characteristics of Asphalt in a Recycled Mixture," Lowell J. Zearley, Bituminous Chemist, Iowa Department of Transportation.

**CONTRACT**

NO 12323

FORM 883 D 3-74 H-4974

Type of Work ASPHALTIC CONC. PAVEMENT  
Miles 10.065

Project No. SN-1179(B)--51-55  
COST CENTER 801000 OBJECT 860  
County KOSSUTH

ON SECONDARY ROAD FROM THE SW COR. SEC. 3-97-27 NORTH

APPROX. 10 MILES TO IOWA 9

THIS AGREEMENT made and entered by and between the Iowa Department of Transportation, Des Moines, Iowa, consisting of the following members:

ROBERT R RIGLER, STEPHEN GARST, DONALD K GARDNER, ALLAN THOMS,

W. F. MCGRATH, ANN PELLEGRINO, & L. STANLEY SCHOELERMAN, party of the first part, and

EVERDS BROTHERS, INC. OF ALGONA, IOWA

13300

party of the second part.

WITNESSETH: That the party of the second part, for and in consideration of \$ \*\*\*\*651,418.71, payable as set forth in the specifications constituting a part of this contract, hereby agrees to construct various items of work and, or, to supply various materials or supplies in accordance with the plans and specifications therefor, and in the locations designated in the notice to bidders, as follows:

Item No.	ITEM	Quantity	Unit	Unit Price	Amount
1	BASE, RECLAIM, CRUSH & STOCKPILE BITUMINOUS CONCRETE	128.192	SQ. YDS.	1.13	144,856.96
2	RECONSTRUCTION OF SUBGRADE	9.516	MILES	11,347.00	107,978.05
3	SUBBASE, CONSTRUCTION OF SOIL AGGREGATE	9.932	MILES	3,200.00	31,782.40
4	BASE, RECYCLED ASPHALTIC CONCRETE	44.838	TONS	4.85	217,464.30
5	PRIMER OR TACK-COAT BITUMEN	5.196	GALS.	.50	2,598.00
6	ASPHALT CEMENT	1.719	TONS	81.00	139,239.00
7	MOBILIZATION COST		LUMP SUM		7,500.00
				GRAND TOTAL	\$651,418.71

**EXHIBIT "A"**

Party of the second part certifies by his signature on this contract that he has complied with 324.17(8) of the 1975 Code of Iowa as amended. Said specifications and plans are hereby made a part of and the basis of this agreement, and a true copy of said plans and specifications is now on

file in the office of the Iowa Department of Transportation under date of APRIL 22, 1976

That in consideration of the foregoing, the party of the first part hereby agrees to pay the party of the second part, promptly and according to the requirements of the specifications the amounts set forth, subject to the conditions as set forth in the specifications.

The parties hereto agree that the notice and instructions to bidders, the proposal filed herein, the general specifications of the Iowa Department of Transportation for 1972, together with special provisions attached, together with the general and detailed plans, if any, for said project

SN-1179(B)--51-55

, together with second party's performance bond, are made a part hereof, and together with this instrument constitute the contract between the parties hereto.

That it is further understood and agreed by the parties of this contract that the above work shall be commenced on or before, and shall be completed

on or before:	Approx. or Specified Starting Date or Number of Working Days	Specified Completion Date or Number of Working Days
	<u>100 WORKING DAYS</u>	<u>OCT. 15, 1976</u>

That time is the essence of this contract and that said contract contains all of the terms and conditions agreed upon by the parties hereto.

IN WITNESS WHEREOF the parties hereto have set their hands for the purpose herein expressed to this and three other instruments of like tenor, as of

the                      day of MAY 13 1976, 19                     

IOWA DEPARTMENT OF TRANSPORTATION

By *[Signature]*  
Party of the First Part

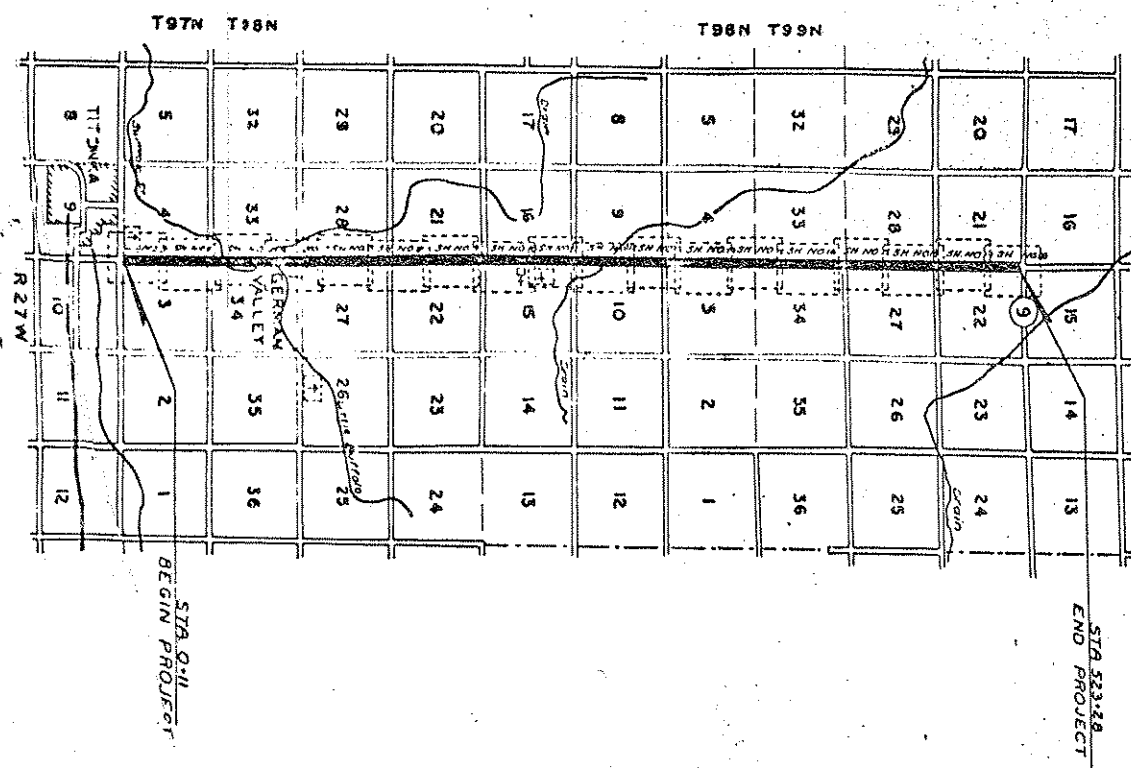
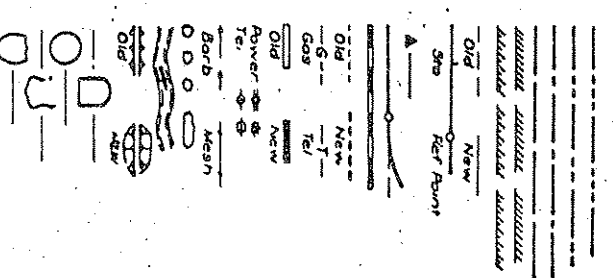
EVERDS BROTHERS, INC. OF ALGONA, IOWA

By *[Signature]*  
Party of the Second Part



CONVENTIONAL SIGNS

- State Line
- Co. Line
- Top Line
- Sec. Line
- Comp. Line
- Utility Right of Way
- Survey Line
- Sec. Corner
- Profile Grade
- Proposed
- Field TA
- Underground Lines
- Catchment
- Utility Poles
- Fence
- Trans. Or. Bush
- Streams
- Dike
- County Road No.
- Primary Road No.
- U. S. Road No.
- Interstate Road No.



IOWA  
 DEPARTMENT OF TRANSPORTATION  
 Highway Division  
 PLANS OF PROPOSED IMPROVEMENT ON THE  
 FARM TO MARKET SYSTEM  
**KOSSUTH COUNTY**  
 SN-1179(6)--51-55

THE STANDARD SPECIFICATIONS, SEES OF 1972,  
 OF THE IOWA STATE HIGHWAY COMMISSION,  
 SHALL APPLY TO CONSTRUCTION WORK ON THIS PROJECT.

SCALE AS NOTED

MILEAGE SUMMARY

Total Length of Project	Sta 0+11 to 53+28 = 53,317.0 FT
Deduct for Bridge	Sta. 60+58 - 55.0'
Deduct for Bridge	Sta. 89+275 - 55.0'
Deduct for Bridge	Sta. 108+01 - 425'
Deduct for Intersection	Sta. 154+94.8 - 22.0'
Net Length of Project	53,142.5 FT = 10.065 Miles

EXHIBIT "B"

Detail Plans  
 reduced in size  
 (Do Not Scale)

INDEX OF SHEETS

SHEET No. 1	TITLE PAGE
SHEET No. 2	TYPICAL CROSS SECTION & ESTIMATE OF QUANTITIES
Printed - SHEET No. 3-20	PLAN & PROFILE OF PROJECT

PLAN & PROFILE AVAILABLE IN COUNTY ENGINEERS OFFICE

APPROVED  
*J. A. Munn*

*Ed J. Wood*

*Wm. R. Ruffel*

*Ray W. ...*

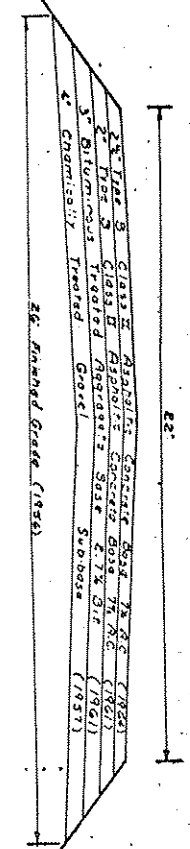
*Dean ...*  
 BOARD OF SUPERVISORS



I HEREBY CERTIFY THAT THIS PLAN WAS PREPARED UNDER MY SUPERVISION AND THAT ENGINEERS MADE BY ME OR BY OTHERS UNDER MY SUPERVISION ARE PROFESSIONAL ENGINEERS UNDER THE LAWS OF THE STATE OF IOWA.  
 DATE: 3/30/76

DEPARTMENT OF TRANSPORTATION  
 IOWA  
 Highway Division  
 APPROVED BY: *J. B. ...*  
 DATE: 3/30/76

**TYPICAL CROSS SECTION**  
Sta 0+11 to 523+28  
(Present Roadway)



**SIEVE ANALYSIS - PERCENT PASSING**

Approximate 100	99	92	82	68	54	39	22	12	8.9
3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	200

Approximate 100 98 94 85 69 46 22 8.8 3.4 2.4

Approximate 100 98 94 85 69 46 22 8.8 3.4 2.4

GRAVIMETRIC: THE FOLLOWING GRAVIMETRIC DATA WERE ACCUMULATED FOR DESIGNING AND ESTIMATING PURPOSES. THEIR APPEARANCE ON THE PLAN SHEETS NOT CONSIDERED A GUARANTEE THAT CONDITIONS OTHER THAN THOSE INDICATED WILL NOT BE ENCOUNTERED.

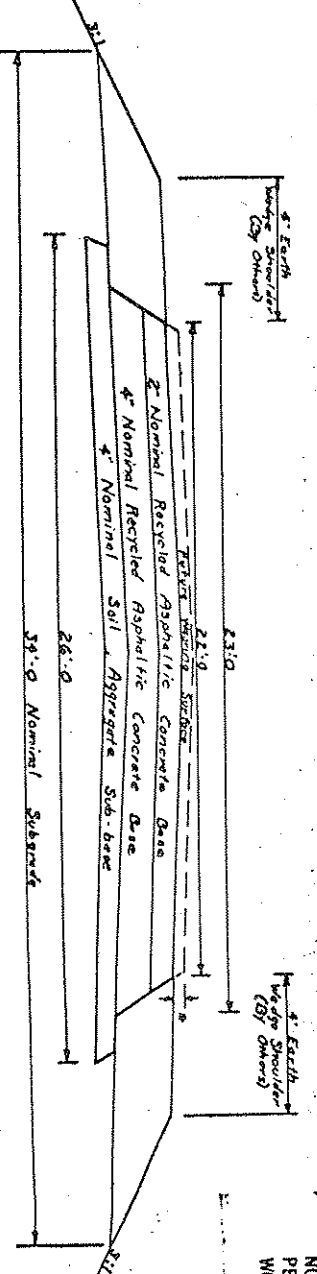
CONTRACTOR WILL SCARIFY EXISTING 7 1/2" NOMINAL BITUMINOUS MATERIAL IN SUCH A MANNER AS TO SALVAGE THE MAXIMUM AMOUNT OF THE BITUMINOUS MATERIAL. THE MATERIAL WILL BE CROSSED OR PULVERIZED TO A 2" MAXIMUM SIZE. NO OTHER GRADATION REQUIREMENTS WILL BE SPECIFIED. THE CONTRACTOR SHALL MAKE ALL NECESSARY PRECAUTIONS TO PREVENT CONTAMINATION AND SEEPAGE AND WILL INCLUDE SALVAGED MATERIAL IN THE BID PRICE. THE CONTRACTOR SHALL INCLUDE ALL COSTS FOR SOIL SOD OFF ROADWAY EDGE BEFORE SALVAGING BITUMINOUS MATERIAL.

THE PLANT SITE WILL BE LOCATED IN THE S.W. 1/4 SECTION 21-98-27 ON PROPERTY OWNED BY KOSSUTH COUNTY. THE CONTRACTOR SHALL HAVE FULL USE OF THIS LOCATION DURING CONSTRUCTION AT NO COST.

AFTER THE BITUMINOUS MATERIAL HAS BEEN REMOVED, THE CONTRACTOR WILL REMOVE THE EXISTING 4" CHEMICALLY TREATED GRAVEL SUB-BASE BY SCARIFYING THE SUB-BASE WITH A 2" MAXIMUM SIZE. THE CONTRACTOR SHALL MAKE ALL NECESSARY PRECAUTIONS TO PREVENT CONTAMINATION AND SEEPAGE AND WILL INCLUDE SALVAGED MATERIAL IN THE BID PRICE. THE CONTRACTOR SHALL INCLUDE ALL COSTS FOR SOIL SOD OFF ROADWAY EDGE BEFORE SALVAGING BITUMINOUS MATERIAL.

THE PRICE BID FOR "CONSTRUCT 4" SOIL-AGGREGATE SUB-BASE" WILL INCLUDE ALL SALVAGING OPERATIONS AS PREVIOUSLY MENTIONED AS WELL AS CONSTRUCTING 4" SOIL-AGGREGATE SUB-BASE (USING SALVAGED MATERIAL).

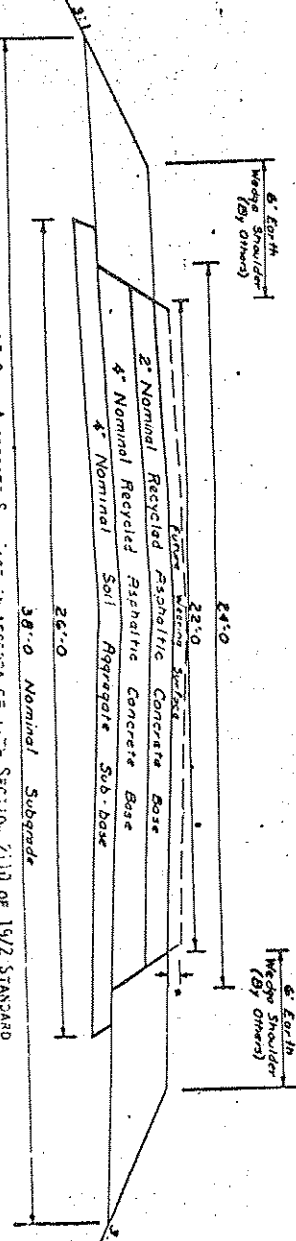
**TYPICAL CROSS SECTION**  
Sta 154+94.8 to 523+28.0  
Reconstructed Grade



NOTE:  
PERMANENT EROSION CONTROL WORK TO BE DONE BY OTHERS.

**EXHIBIT "C"**

**TYPICAL CROSS SECTION**  
Sta 0+11 to 154+94.8  
Reconstructed Grade



CONTRACTOR TO PREPARE 4" SOIL AGGREGATE SUB-BASE IN ACCORDANCE WITH SECTION 2110 OF 1972 STANDARD SPECIFICATIONS.

**POLLUTION TESTS**  
AT THE END OF THE TWO WEEKS OF PRODUCTION OF THE ASPHALT MIXTURE, THE CONTRACTOR SHALL BE PREPARED TO SUBMIT THE PLANT TO THE ENVIRONMENTAL PROTECTION AGENCY (EPA) FOR POLLUTION TESTS TO DETERMINE WHETHER THE ASPHALT MIXTURE MEETS THE COMPLIANCE USING RECYCLABLE AGGREGATES (SMA) METHOD 5 TESTS. COMPLIANCE WITH EPA METHOD 5 TESTS MAY BE REQUIRED BY THE IOWA DEPARTMENT OF ENVIRONMENTAL QUALITY.

Prior to the initial EPA Method 5 Test, and for subsequent tests required, the contractor shall have full use of this location for testing and evaluation for that purpose.

THE CONTRACTOR AWARDED THIS WORK SHALL FURNISH ALL LABOR, EQUIPMENT, SCARIFYING, NECESSARY PULVERIZING AND RECYCLING AND ELECTRICITY REQUIRED TO CONDUCT EPA METHOD 5 TESTS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DELAYS AND EXPENSES INCURRED BY THE CONTRACTOR IN TESTING AND EVALUATION FOR THAT PURPOSE.

**MOBILIZATION**  
PARTIAL PAYMENT FOR MOBILIZATION WILL BE MADE AS FOLLOWS: WHEN 5% OF THE ORIGINAL CONTRACT AMOUNT IS EARNED, THE CONTRACTOR WILL BE PAID 50% OF THE MOBILIZATION AMOUNT. WHEN 10% OF THE ORIGINAL CONTRACT AMOUNT IS EARNED, THE CONTRACTOR WILL BE PAID THE REMAINDER OF THE MOBILIZATION AMOUNT FOR MOBILIZATION.

THE CONTRACTING AUTHORITY RESERVES THE RIGHT TO CANCEL THE CONTRACT OR ANY UNCOMPLETED ITEM OR PORTION THEREOF IF THE CONTRACTOR FAILS TO COMPLY WITH THE TERMS OF THE CONTRACT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DELAYS AND EXPENSES INCURRED BY THE CONTRACTOR IN TESTING AND EVALUATION FOR THAT PURPOSE.

So. Yd.	Miles	Miles	Tons	Gals.	Tons	Lump Sum
487	78.9	7.8	1,217	519.6	337	7500.00
128.92	9.516	9.932	44.938	519.6	171.9	

THE CONTRACTOR AWARDED THIS WORK SHALL COOPERATE WITH THE IOWA DEPARTMENT OF ENVIRONMENTAL QUALITY AND LEND HIS ASSISTANCE IN THE CONDUCT OF THE POLLUTION TESTS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DELAYS AND EXPENSES INCURRED BY THE CONTRACTOR IN TESTING AND EVALUATION FOR THAT PURPOSE.

- FOOTNOTES:**
- Draw Mixing Equipment Complying with Section 2051 MAY BE USED FOR PRODUCTION OF RECYCLED ASPHALTIC CONCRETE BASE.
  - GRAVEL AGGREGATE TO BE ADDED TO THE SALVAGED BITUMINOUS MATERIAL WILL BE FURNISHED COST FREE TO THE CONTRACTOR IN STOCKPILE AT PLANT SITE LOCATED IN THE S.W. 1/4 SECTION 21-98-27.
  - ESTIMATED AT 3 1/2" FOR BOTTOM 4" LIFT. ESTIMATED AT 4 1/2" FOR TOP 2" LIFT.
  - ESTIMATED AT 7,346 TONS SALVAGED BITUMINOUS MATERIAL.
  - CONTRACTOR WILL USE 120-150 PENETRATION ASPHALT CEMENT. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DELAYS AND EXPENSES INCURRED BY THE CONTRACTOR IN TESTING AND EVALUATION FOR THAT PURPOSE.
  - ALL OR ANY PART MAY BE ELIMINATED AT THE DISCRETION OF THE ENGINEER.
  - SECTION 1109.05 OF 1972 STANDARD SPECIFICATIONS SHALL NOT APPLY.
  - GRAVEL CROSSROAD INTERSECTIONS, DRIVEWAYS, BRIDGES, AND FIELD INTERSECTIONS WILL BE SHAPED TO MEET THE NEW ROAD INTERSECTIONS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DELAYS AND EXPENSES INCURRED BY THE CONTRACTOR IN TESTING AND EVALUATION FOR THAT PURPOSE.
  - FINAL PAYMENT WILL BE BASED ON ESTIMATED PLANNED QUANTITIES WITHOUT REMEASUREMENT.
  - ESTIMATED AT 74,975 C.Y. BASED ON AVERAGE CUT OF 18".
  - WEDGE SHOULDERING, AFTER THE ASPHALTIC CONCRETE IS PLACED, WILL BE DONE BY OTHERS AND IS NOT A PART OF THIS CONTRACT.
  - THE CONTRACTOR SHALL AERATE, COMPACT, AND SHAPE ALL UNSTABLE SUBGRADE AREAS PRIOR TO CONSTRUCTION OF THE SUBGRADE. UNSTABLE AREAS THAT DEVELOP DURING SUBSEQUENT CONSTRUCTION OPERATIONS SHALL BE REPAIRED IN ACCORDANCE WITH THE SPECIFICATIONS AND TO THE SATISFACTION OF THE ENGINEER. ALL REPAIR SHALL BE INCIDENTAL TO THE WORK AND NOT MEASURED FOR PAYMENT.
  - GRAVEL CROSSROAD INTERSECTIONS, DRIVEWAYS, BRIDGES, AND FIELD INTERSECTIONS WILL BE SHAPED TO MEET THE NEW ROAD INTERSECTIONS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL DELAYS AND EXPENSES INCURRED BY THE CONTRACTOR IN TESTING AND EVALUATION FOR THAT PURPOSE.

# EXHIBIT "D"

STATE OF IOWA  
DEPARTMENT OF ENVIRONMENTAL QUALITY  
DES MOINES, IOWA 50316

## MEMORANDUM

To: R. A. Walker Date: January 19, 1976  
From: Leo Classen, P.E. LC Re: Recycling Asphalt  
Permits Section Kossuth County

After reviewing Mr. Henely's letter of December 16, 1975, we offer the following comments.

1. We fully endorse the concept and offer our cooperation in solving the problem of meeting air pollution control regulations.
2. Our observations of the experimental run last September as discussed in Mr. Woll's report of September 30, 1975, and Mr. Walker's letter of December 10, 1975, point out that the process used at that time would not meet our existing regulations.
3. We can not offer a solution to the problem but will outline our recommendations for any future experiment.
4. We believe the observed emissions consisted of a high percentage of small particles one micron or less in size. In order to remove an acceptable percentage of these particles, a medium energy scrubber will be required.
5. We have calculated various venturi configurations and believe that the minimum parameters for the removal of particles in the one micron range are:
  - a. A throat velocity of 200 feet per second.
  - b. Water injection rates from 8 to 10 GPM per 1000 CFM
  - c. An air pressure drop through the venturi in the 20 to 25 inch water gauge range.
6. Other types of scrubbers with efficiencies above 95% may be a possible substitute for a venturi. We do not believe fabric filtration or dry collection devices can be used because the asphalt-coated particles would blank-off or clog these devices in a short time.
7. We will evaluate any proposed control device but will not issue a permit other than an experimental permit with the condition that a stack test be made within two weeks of startup.
8. Any contractor who is awarded this contract should be advised of the construction permit requirements and informed to contact us as early as possible on any permit questions.

# EXHIBIT "E"

PROJECT SN-1179(6)--51-55

DATE SAMPLED	MATERIAL	INTENDED % ASPHALT ADDED	TANK MEAS % AC ADDED	% AC EXTRACTED TOTAL	RECOVERED AC PENT.	ABSOLUTE VISCOSITY	KINEMATIC VISCOSITY
9-29-76	67% RECYCLED 33% VIRGIN	4.75	4.88	8.50	51	3775	545
9-30-76	67% RECYCLED 33% VIRGIN	4.75	4.87	7.80	44	5954	658
10-11-76	67% RECYCLED 33% VIRGIN ✓	4.75	4.89	7.10	58	3239	495
10-12-76	67% RECYCLED 33% VIRGIN	4.75	4.96	7.90	47	4975	601
10-13-76	50% RECYCLED 50% VIRGIN	5.75	5.80	7.80	67	2318	440
10-20-76	67% RECYCLED 33% VIRGIN	4.75	4.76	8.00	43	6470	684
10-21-76	67% RECYCLED 33% VIRGIN	4.75	4.78	7.80	41	6740	694
10-22-76	67% RECYCLED 33% VIRGIN	4.75	4.83	7.70	39	8800	772
10-26-76	50% RECYCLED 50% VIRGIN	5.75	5.89	7.30	57	3100	483
10-27-76	40% RECYCLED 60% VIRGIN	6.25	6.39	7.40	71	2210	440
10-28-76	30% RECYCLED 70% VIRGIN	6.25	6.28	7.40	86	1423	351
10-29-76	67% RECYCLED 33% VIRGIN	5.10	5.12	7.60	48	4160	560
11-1-76	50% RECYCLED 50% VIRGIN	5.75	5.87	7.70	62	2772	456

Asy 7.7

# EXHIBIT "F"

COST--ESTIMATED CONVENTIONAL PROJECT VS. ACTUAL PROJECT COST

Item	Unit	Estimated Conventional Cost		Actual Project Cost			
		Unit Cost	Units	Unit Cost	Units		
Asphalt Cement	ton	\$ 81.00	2,259	\$182,979.00	81.00	2,215.03	\$179,417.43
Primer or Tack Coat Bitumen	gal.	0.50	5,196	2,598.00	0.50	5,848.00	2,924.00
Finish Shoulders	mile	2,000.00	10.065	20,130.00	2,000.00	10.065	20,130.00
Base, Asphaltic Concrete, 4"	ton	8.00	30,195	241,560.00			
Construct 4 to 6 Foot Shoulders	mile	31,000.00	10.065	312,015.00			
Additional Right of Way	mile	10,000.00	10.065	100,650.00			
Base, Recycled Asph. Conc., 6"	ton				4.35	42,129	183,261.15
Reconstruction of Grade	mile				11,347.00	9.515	107,978.05
Prepare Soil-Aggregate Subbase	mile				3,200.00	9.932	31,782.40
County Furnish Gravel Aggregate	ton				2.45	13,292	32,565.40
Reclaim and Crush Pavement	ton				3.40	26,622	90,514.80
Mobilization	Lump				7,500.00	One	7,500.00
TOTAL				\$859,932.00			\$656,073.23