Demonstration Projects Program
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DEMONSTRATION PROJECT NO. 39

RECYCLING ASPHALT PAVEMENTS

Springfield, Missouri

Prepared for
and
Distributed by

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
REGION 15
DEMONSTRATION PROJECTS DIVISION
1000 NORTH GLEBE ROAD
ARLINGTON, VIRGINIA 22201

INTERIM REPORT
1980 PAVEMENT RECYCLING PROGRAM
DEMONSTRATION PROJECT NO. 39
SPRINGFIELD, MISSOURI

PREPARED FOR

CITY OF SPRINGFIELD, MISSOURI
DEPARTMENT OF PUBLIC WORKS
830 NORTH BOONVILLE
SPRINGFIELD, MISSOURI 65802

PREPARED BY

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SPRINGFIELD, MISSOURI 65802

JANUARY 9, 1981

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INTRODUCTION

In January, 1980 the City of Springfield, Missouri, through its Director of Public Works, Mr. David G. Snider, P.E., began planning for the execution of a hot mix recycling project. This project was hopefully to be performed as a Demonstration Project No. 39 program under the auspices of the United States Department of Transportation, Federal Highway Administration.

The project as then visualized and as now generally completed, consisted of the removal of one-half (1/2) to one (1) inch of existing asphaltic concrete wearing surface from twenty-six (26) streets within the city limits, then replacing one (1) to two (2) inches of recycled asphaltic concrete mix on those same areas. An additional thirty-three (33) streets were selected to receive overlays of one (1) to one and one-half (1 1/2) inches of the recycled mix. The project scope included the removal of 11,022 tons of existing asphaltic concrete from an area of 209,620 square yards on the first twenty-six (26) streets, and the replacement of 22,360 tons of recycled hot mix on 310,010 square yards of area on the fifty-nine (59) street locations. The total length of the project was 68,070 feet (12.9 miles) of removal and replacement and 39,595 feet (7.5 miles) of replacement only.

During February and March, 1980, a work plan describing the proposed work to be performed by the consultant to the City was prepared, as was a proposal by Anderson Engineering, Inc., in response to the work plan. A copy of the work plan is included in this report as Appendix I. A condition of the proposal limited the major portion of the consultant's work to the first group of twenty-six (26) streets where both removal and replacement were to be performed. Appendix II contains Exhibit A, which is a list of the streets and

the initially proposed quantities to be included in the Demonstration Project.

In May, 1980, bids were obtained from at least three (3) contractors. A contract was awarded to the successful low bidder, the Midland Paving Company of Springfield, Missouri. The specifications upon which the bid was based are included in Appendix III. The contractor performed this work during the summer of 1980. The first replacement was on July 24, 1980, although removal and scarification had preceeded this date by several weeks. The bulk of the replacement was performed in July and August, 1980. All work under the contract was completed on October 10, 1980. The remainder of this report documents the work performed by Anderson Engineering, Inc., and presents recommendations and opinions by the authors concerning future projects of this type.

PRELIMINARY INVESTIGATION

The initial step in the preliminary investigation was to walk the length of the twenty-six (26) streets selected for removal and replacement making schematic diagrams of the cracking and patching pattern, which had developed on the pavement surface. To facilitate this work, a form drawing was prepared for a three (3) block long segment of each street. A sketch was then prepared showing the approximate amount and extent of surface cracking, ravelling, rutting and patching. A typical copy of one of these sketches is included as Appendix IV. The remainder are on file with the consultant. Locations for Benkleman Beam testing and subsequent photographs were selected during this portion of the investigation. Areas which were both visually good and bad were located and marked. These sketches are not graphically accurate

to allow for the reestablishment of individual cracks. However, they do provide the same general type of information as low level aerial photographs, and will be of value when compared to the crack patterns observed during the annual reinspections to be performed in the summers of 1981, 1982, and 1983.

Following the visual examination, Benkleman Beam Determinations were performed at eighty (80) locations. A single axle, dual tired truck with a rear axle weight of 22,400 pounds was used for this test. This load, rather than 18,000 pounds, was selected because city ordinances permit the heavier load particularly for trash and garbage trucks on City streets. The deflection values ranged from low values of 0.007 to 0.120 inches. Twenty-seven (27) or 33 percent of the values exceeded 0.040, which is generally taken as the maximum summer deflection for an acceptable pavement section. As the test locations were somewhat weighted towards the visually poorer areas, it appears that 70 percent or more of these areas have good to fairly good base and subgrade conditions. The use of a replacement overlay approximately equal to the removal depth should produce a pavement section with acceptable deflection values. On the remaining 30 percent or less of area tested, an overlay thickness greater than the removal thickness would be required to produce a pavement section which would remain relatively crack free for several years.

The results of the Benkleman Beam tests and detailed descriptions of the test locations are included in Appendix V. Photographs were obtained at each of the eighty (80) locations. Eight (8) of these, generally the poorer appearing areas, are included in Appendix VII.

In conjunction with the deflection testing, core samples were obtained at

four (4) locations. Several six (6) inch diameter cores were taken at each location so that a sufficiently large sample could be obtained from the upper one (1) inch of the core samples. The sample representing the set of cores of each location was tested for extraction gradation and asphalt content. The bituminum was extracted by the Abson method, and both penetration and ductility tests at 77° F were performed. The results of these tests have been summarized and are included in Appendix VI.

PROPOSED RECYCLED MIX

The project quantities, 11,022 tons of removal and 22,360 tons of replacement, strongly suggested a mix consisting of 50 percent of recycled material and 50 percent virgin aggregate and new oil. Previous Demonstration Project 39 reports also suggested that this mix would be feasible. Several samples of the planed asphaltic concrete were tested for extraction gradation and asphalt content. Gradation tests were performed on various stockpiles of virgin aggregate at the contractor's plant. The proposed mix was selected to conform to the requirements of Section 401, Plant Mix Bituminous Pavement, of the Standard Specifications for Highway Construction, 1973 Edition, published by the Missouri State Highway Commission. Copies of the proposed mix and specification limits given in Section 401 are included in Appendix VIII.

CONSTRUCTION PHASE

The construction phase consisted of the removal and transportation of the material to be recycled to the contractor's plant which is located in Christian County, and the replacement of the recycled mix. A subcontractor, Dustrol, Inc. of El Dorado, Kansas, was employed to perform the planing and

loading of the existing wearing surface material. Two planing machines were employed. The first was a crawler mounted planer with a 350 HP engine and a 6.5 foot wide cutting drum, manufactured by the Barber Greene Company. This machine generally removed 1 1/4 to 1 1/2 inches of asphalt per pass. Being crawler mounted, it had to be hauled from site to site. This was a disadvantage on this project because there were twenty-six (26) individual sites. The second was a rubber tired planer mounted on a motor grader frame, manufactured by G. J. Payne Company of Los Angeles, California. This planer was a more mobile machine than the Barber Greene, and was utilized on the thinner cuts. The planer had a 5.0 foot wide cutting drum.

As may be seen from Exhibit A in Appendix II, the majority of removal depths were 0.5 inches. This contributed considerably to the project because the planed material was finer and contained fewer large lumps than the material for which removal depth approached 1.5 inches. One of the contractor's observations was that requiring two passes of the planer for the deeper depths would have eliminated most of the problems associated with large lumps of old material appearing in the finished product.

The asphalt mix was produced in a new plant. This plant was a UMD 700 Drum Mixer with a 70 ton storage silo manufactured by CMI. The paving machine used for hot mix placement was a Model BSF2 paver manufactured by the Cedar Rapids Corporation and was crawler mounted with a 10 foot wide vibrating screed. The roller was a Hyster Model C350B 8 to 10 ton vibrating, steel wheeled machine.

Delivery of the recycled hot mix was by both gas and diesel powered tandem axle trucks, several with pups. For the most part, these trucks were hauling on a contract basis, being individually owned and operated. This caused certain

problems in the beginning of the project with foreign materials in the bed such as large (1 inch ±) stones left from other projects. These stones were thicker than the overlay and caused tears and scratches in the screeded surface on the first day's placement. Additional problems were caused by the individual ownership of these trucks in that they also hauled for other projects. They fueled at various locations and times. Collection of consumption records was difficult to maintain, and in some cases had to be estimated.

Placement of the recycled asphalt hot mix began on July 24, 1980, and continued through August 15, 1980, on the first group of twenty-six (26) streets. Twenty-two (22) sets of tests were performed on samples from the recycled mix during this period. Each set consisted of an extraction gradation test, an asphalt content test, and a Marshall stability test obtaining Marshall density, percent total voids, percent voids filled, Marshall stability numbers and flow values. In addition three core samples were taken from each day's placement and measured for thickness and percent compaction. The results of these twenty-two (22) sets of tests are included in Appendix XI.

The contractor maintained good control over his mix as may be seen by inspection of the test results. In all cases, the characteristics measured meet the specification values, although the asphalt content and flow values were lower than desired on July 29 and 31, 1980. Coordination with the City's resident inspector and the contractor's batch men quickly took care of this problem. While not a specification item, it was desired to have the total voids from 3.5 to 5.0 percent and the percent voids filled from 75 percent to 85 percent. The total voids values were in this range on twenty (20) of

the tests. The percent voids filled generally ran around 70 percent, which was lower than desired but not lower than encountered on many other conventional material projects.

COSTS OF ALTERNATE METHODS

The cost of this project, based on the original bid quantities, was $740,433.60. The comparable alternate method of construction would include the removal and delivery of material to a designated storage site because the project requirements included the maintenance of existing curb heights insofar as possible. The adjustment of the many utility manhole covers was also to be avoided because standard practice in the Springfield area has been to locate sanitary sewers beneath street pavements. This project was bid on the basis of (a) using the recycled mix and (b) performing the same items of work with the substitution of a conventional mix for the overlay. The low bidder bid $1.05 per ton less for the recycled mix alternate for a cost savings of $23,475.90. One of the other two bidders bid equal amounts for each alternate for no cost savings, and the third bidder bid $1.00 per ton less for the recycled mix for a cost savings of $22,358. This savings is approximately 3.17 percent of the contract price.

ENERGY CONSUMPTION

The energy consumption of the recycling alternate versus conventional design is based on the fact that removal of 11,022 tons of material was required in either event. The maintenance of curb heights and elimination of manhole adjustments was one requirement of the project.

The energy calculations for both a conventional mix placement and a 50 percent recycled mix placement are given in Appendix XII. On the basis of

these calculations, 424,288 BTU per ton of conventional mix would have been required, compared to 335,623 BTU per ton for the recycled mix. This represents a savings of 97,665 BTU per ton, or an equivalent 0.781 gallons of gasoline per ton. For this project the total savings would be 18,899 gallons of gas. The market value of this savings compares favorably with the savings indicated by the alternate cost method as bid by the contractor.

CONSERVATION OF NATURAL RESOURCES

The conservation of natural resources can best be represented by the amount of conventional asphaltic concrete which was not used. On this project, this amounts to approximately 11,022 tons, consisting of some 606 tons of asphalt cement amounting to 143,400 plus or minus gallons. Additionally 10,415 tons of natural aggregates were saved. No conservation in the sense of disposal sites applies because the City of Springfield has made some use of this type material for several years.

ENVIRONMENTAL CONSIDERATIONS

The emission testing was to have been performed by the Division of Health of the City of Springfield on a one-time basis during the project. However, due to difficulties caused by the plant's being outside the political jurisdiction of the Department of Health, no emission tests were performed.

SUMMARY

The interim analysis of this project is that recycling projects with small quantities on scattered sites are feasible. At least under the market conditions of the summer of 1980, they are economically favorable. Because this was the first major hot mix recycling project in the local area, the

experience gained may decrease future bid prices. A second, smaller project performed in the area in the fall of 1980 experienced difficulty with large lumps of recycled material passing through the drum. This emphasizes the need for thin planing and milling, or the additional processing of the recycled material.

Handling and blending the recycled material with the virgin components proved to be less of a problem than otherwise thought, and the placement characteristics were similar to conventional hot mix. With the exception of one street, the completed surface appearance and smoothness were comparable to the conventional overlay.

Whether the possible extension of time before cracking occurs develops on this project as has been reported on others remains to be seen. Subsequent reports over the next three (3) years may indicate this.

The collection of energy consumption data was difficult on this project. It would be far easier where all equipment was contractor owned and operated, and where the plant was producing mix for one project during the entire contract time.

APPENDIX I

WORK PLAN
ASPHALTIC CONCRETE PAVEMENT RECYCLING
CATAGORY 3

WORK PLAN

PROPOSED DEMONSTRATION PROJECT

NO. 39

RECYCLING

OF

ASPHALT PAVEMENTS

PROPOSED BY

DEPARTMENT OF PUBLIC WORKS

DAVID G. SNIDER, P.E.
DIRECTOR

CITY OF SPRINGFIELD, MISSOURI

VI. PRELIMINARY INVESTIGATION

A preliminary investigation based on performance testing, initial design/construction/maintenance records, analysis of samples, and visual observation will be performed to evaluate the existing pavement structure.

The following effective means of evaluating the existing pavement will be included in the initial condition survey.

1. Examination of the types and probable causes of distress which have occurred.
2. Accumulation of any pertinent data such as traffic volumes, initial design/construction/maintenance records, etc.
3. Performance tests such as deflections and serviceability ratings such as psl or psr.*

After the analysis of a representative number of crushed cores, and/or scarified samples has been completed, the recoverable resources, material properties (Penetration and viscosity of the recovered asphalt, gradation of the aggregates, plus any other chemical or physical tests which may be useful in future analysis of the pavement performance), and structural characteristics of the existing pavement will be reported.

VII. DESIGN CRITERIA/PROCEDURE

All design test results and analyses of the material properties of the recycled design mix, in addition to data obtained relating to the proportions and individual properties of its components and

*It is our intent to provide skid resistant tests but we are having difficulty in securing test equipment to provide these tests. If test equipment is secured, skid test will be taken, otherwise only engineering opinion will be used.

their effects on the mix, will be reported. The effects of water on the stability of the recycled mixture, as designed in the laboratory, will be determined.

The percentages and properties of reclaimable materials will be obtained from the data collected during preliminary investigation. The properties of all additives, such as fresh asphalt cement, rejuvenating agents, and virgin aggregates, if required, will be reported. To the extent possible, the combined effects of the additives and reclaimed materials should be designed to meet the minimum requirements for a new mix.

VIII. CONSTRUCTION CRITERIA/PROCEDURE

This section of the evaluation encompasses the hot-mix recycling method selected, contract specifications, required equipment and productivity of the equipment used during the operation.

Standard project job control and testing procedures, such as materials and compaction testing, temperature measurements, etc., will be employed and documented during the construction of the project. The structural characteristics and material properties of the mat will be determined by the analysis of a representative number of samples. Performance test results will be compared to those values obtained on laboratory prepared specimens.

IX. COSTS OF ALTERNATE METHODS

This analysis will include an evaluation of the suitability and economic feasibility of the reconstruction method and a comparison

asphalt as required to meet our resurfacing specifications and then relay on the previously milled streets first and then as far as material is available resurface unmilled streets. All of this will be accomplished by contract through competitive bidding. The width of streets will remain basically the same except minor adjustments to provide straighter roadway edges.

IV. EVALUATION:

The Evaluation and Control will be performed by contract with Anderson Engineering, a locally based engineering consulting firm with asphalt laboratory facilities.

V. SCOPE OF PROJECT:

The fundamental objective of this project is to evaluate hot-mix asphalt pavement recycling processes on various city streets in Springfield, Missouri, as shown on Exhibit A by collecting data pertaining to the following:

Preliminary Investigation

Design Criteria/Procedure

Construction Criteria/Procedure

Costs of Alternate Methods

Energy Consumption

Environmental Considerations

Conservation of Natural Resources

Post-Construction Performance

of the costs (dollars per ton) of recycling to that of conventional resurfacing.

X. ENERGY CONSUMPTION

A breakdown of the total energy input (BTU per ton) to the recycling operation (including energy required to manufacture the asphalt at the refinery, but not energy inherent in the asphalt) will be documented by recording fuel consumption, electric power usage, etc. Conclusion of energy savings realized through the use of reclaimed materials will be reported. This analysis will compare the total energy input for the recycling method to an estimate of the energy which would have been expended on a conventional equivalent construction method.

XI. ENVIRONMENTAL CONSIDERATIONS

The City's Air Pollution section will try to monitor one time during full plant operation the particulate and hydrocarbon emissions from the asphalt plant. Because of equipment and configuration of the plant, results may be non-conclusive but an attempt will be made to secure reliable information.

XII. CONSERVATION OF NATURAL RESOURCES

Savings in aggregates and asphalt will be determined as compared to equivalent pavement section with conventional construction methods.

XIII. The performance of the recycled pavement will be evaluated on an annual basis for a minimum of 3 years after project completion.

This evaluation will include documentation of surface condition, patching and cracking, and other pertinent test data as determined desirable for evaluation.

XIV. REPORTING

It is anticipated that an interim report encompassing Sections V-XII will be completed in approximately 90 days after project completion. A report in letter form will be submitted annually during the follow-up period. This report should include an evaluation of the existing condition of the recycled pavement.

APPENDIX II

EXHIBIT A

LIST OF STREETS AND QUANTITIES
PROPOSED FOR ASPHALT
RECYCLING/RESURFACING

Exhibit A

CITY OF SPRINGFIELD, MISSOURI

PUBLIC WORKS DEPARTMENT

PROPOSED ASPHALT RECYCLING-RESURFACING

1980

STREET	LOCATION	WIDTH FEET	LENGTH FEET	SQ. YDS.	REMOVAL DEPTH INCHES	REMOVAL TONS	REPLACEMENT DEPTH INCHES	REPLACEMENT TONS
BENNETT	Kansas to Scenic	20	4,500	10,000	.5	300	1.5	900
CATALPA	Grant to New	26	1,720	4,969	1	298	1	298
CENTRAL	Boonville to National	40	4,750	21,111	1	1,267	1	1,267
CHEROKEE	Campbell to Jefferson	30	1,250	4,167	1	250	1	250
CHEROKEE	Jefferson to Holland	36	1,300	5,200	1	312	1	312
COLLEGE	Kansas to West Avenue	38	3,650	15,411	1	925	1	925
COURT	Boonville to Campbell	38	410	1,731	1	104	1	104
DALE	Glenstone to Barnes	39	2,250	9,750	1	585	1	585
DIVISION	Fremont to Glenstone	30	2,540	8,467	1	508	1	508
FLORIDA	Glenstone to a point East	27	380	1,140	1	69	1	69
FREMONT	Sunshine to Seminole	30	2,480	8,267	1	496	1	496
FREMONT	Republic Road to Briar	20	5,290	11,756	.5	353	1.5	1,058
FULBRIGHT	Nichols to Calhoun	28	1,180	3,671	1	220	1	220
GOLDEN	Seminole to South City Limits	22	6,680	16,329	.5	490	1.5	980
GRAND	Kansas to Scenic	20	4,650	10,333	.5	310	1	620
GRANT	Tampa to Commercial	36	5,550	22,200	1	1,332	1	1,332
HILLCREST	Chestnut Expressway to Nichols	20	2,550	5,667	.5	170	1.5	510

STREET	LOCATION	WIDTH FEET	LENGTH FEET	SQ. YDS.	REMOVAL DEPTH INCHES	REMOVAL TONS	REPLACEMENT DEPTH INCHES	REPLACEMENT TONS
HOLIDAY	Charleston to Harvard	37	1,850	7,606	1	456	1	456
JEFFERSON	Olive to Grand	36	4,700	18,800	1	1,128	1	1,128
JEFFERSON	Sunshine to Seminole	20	1,300	2,889	.5	87	1.5	260
MT. VERNON	13-ByPass to West City Limits	20	8,300	18,444	.5	553	1	1,107
NATIONAL	Kearney to North City Limits	22	6,380	15,596	1	936	1	936
NATIONAL	Cherokee to Seminole	12	1,100	1,467	2	176	2	176
NICHOLS	Johnson to Broadway	30	900	3,000	1	180	1	180
OAK GROVE	Seminole to a point North	20	1,020	2,267	1	136	1	136
ORCHARD	Chestnut Expressway to Mt. Vernon	20	2,570	5,711	.5	171	1	343
	Sub Total		79,250	235,949		11,812		15,156
BARNES	Bennett to a point South	30	200	667	0	-	1.5	60
BARTON	Lone Pine to Elmview	20	1,150	2,556	0	-	1.5	230
BERKELEY	Marlan to a point West	18	430	860	0	-	1.5	77
CLIFTON	Mill to Olive	22	650	1,589	0	-	1.5	143
DAYTON	Montclair to Walnut Lawn	26	1,820	5,258	0	-	1.5	521
DELAWARE	Battlefield to a point North	42	550	2,567	0	-	1.5	231
ELMVIEW	Burton to Gasconade	18	750	1,500	0	-	1.5	135
FERGUSON	Winkler to Swan	30	1,100	3,667	0	-	1.5	330
GASCONADE	Elmview to Bedford	20	3,430	7,622	0	-	1.5	686
GLENDALE	Seminole to a point South	22	550	1,344	0	-	1.5	121

STREET	LOCATION	WIDTH FEET	LENGTH FEET	SQ. YDS.	REMOVAL DEPTH INCHES	REMOVAL TONS	REPLACEMENT DEPTH INCHES	REPLACEMENT TONS
GLENN	Grand to State	20	1,800	4,000	0	-	1.5	360
GLENN	Grand to Catalpa	22	1,250	3,056	0	-	1.5	275
GRAND	Scenic to 13-ByPass	23	4,300	10,989	0	-	1.5	989
GREELEY	Parkview to Mentor	20	820	1,822	0	-	1.5	164
HAMPTON	Washita to Seminole	20	1,950	4,333	0	-	1.5	390
HILLCREST	Grand to Catalpa	22	1,270	3,104	0	-	1.5	279
HOMEWOOD	Lombard to Page	20	540	1,200	0	-	1.5	108
KANSAS	Sunshine to Cherokee	18	1,300	2,600	0	-	1.5	234
LOMBARD	Scenic to Glenn	22	1,285	3,141	0	-	1.5	283
LUSTER	Bennett to Cinderella	19	1,070	2,259	0	-	1.5	203
MADISON	Scenic to Glenn	20	1,300	2,889	0	-	1.5	260
MARLAN	Seminole to Berkeley	20	700	1,556	0	-	1.5	140
MARSHA	Luster to Wildan	20	1,090	2,422	0	-	1.5	218
MENTOR	Greeley to Republic Road	20	5,130	11,400	0	-	1.5	1,026
MILL	Warren to College	20	2,020	4,489	0	-	1.5	404
MISSOURI	Tracy to Whiteside	20	1,030	2,289	0	-	1.5	206
NETTLETON	Nichols to Calhoun	18	1,170	2,340	0	-	1.5	210
OAK PARK	Grand to Catalpa	20	1,260	2,800	0	-	1.5	252
OAK PARK	Grand to Madison	22	1,350	3,300	0	-	1.5	297
PAGE	Homewood to Oak Park	20	220	489	0	-	1.5	44
PARKVIEW	Battlefield to Greeley	24	2,620	6,987	0	-	1.5	629

STREET	LOCATION	WIDTH FEET	LENGTH FEET	SQ. YDS.	REMOVAL DEPTH INCHES	REMOVAL TONS	REPLACEMENT DEPTH INCHES	REPLACEMENT TONS
ROBBERSON	Central to a point North	45	500	2,500	0	-	1.5	225
ROBBERSON	North of Central to Lynn	30	1,760	5,867	0	-	1.5	528
STATE	Scenic to Glenn	20	1,300	2,889	0	-	1.5	260
TURNER	Broadway to Grant	20	1,200	2,667	0	-	1.5	240
WASHITA	Weaver to Fort	20	850	1,889	0	-	1.5	170
WATER	West Avenue to Clifton	20	610	1,356	0	-	1.5	122
WELLER	Seminole to Cherokee	20	1,260	2,800	0	-	1.5	252
WEST AVENUE	Nichols to Division	30	2,570	8,567	0	-	1.5	771
WHITESIDE	Grant to Missouri	20	1,200	2,667	0	-	1.5	240
	TOTALS		135,825	374,822		11,812		27,701

APPENDIX III

TECHNICAL PORTION OF A SPECIFICATION FOR HOT RECYCLING AND RESURFACING OF CITY STREETS

CITY OF SPRINGFIELD
DEPARTMENT OF PUBLIC WORKS

City Hall
830 Boonville
Springfield, Mo.

417-865-1611

SPECIFICATIONS
FOR

HOT RECYCLING AND RESURFACING OF CITY STREETS

REV.	DATE	REVISIONS	INIT.	BY: Robert L. Martin Jr.
				APPROVED
				Using Dept. Head
				Division Head
				Dir. Public Works
				Date 4/28/80 Page 1 of 59

SPRINGFIELD, MISSOURI
HOT RECYCLING AND RESURFACING
OF CITY STREETS

SCOPE OF WORK

No work may be performed under this contract until July 1, 1980 or thereafter.

Work under this contract includes all labor, equipment, and materials necessary for removing, loading, hauling, mixing, placing, compacting, recycling, and resurfacing of existing street surfaces in accordance with the specifications, the attached schedule and the Bid Proposal.

The streets listed on the schedule are those proposed for recycling and resurfacing, however, the City reserves the right to add, subtract or extend items in order to keep expenditures within available funds or because of unforeseen circumstances.

Necessary handwork to complete driveways and intersections and around manholes and other appurtenances is included in this contract.

If Alternate Bid "A" is bid in lieu of the BASE BID all planed material shall be loaded and hauled at the Contractor's expense to locations designated by the Engineer. Those locations are included herein in the "Technical Specifications".

TECHNICAL SPECIFICATIONS

1. DESCRIPTION: The Project shall consist of recycling and resurfacing existing street surface using hot recycled asphaltic material. All work shall be as specified in the paragraphs entitled: "Cold Planing of City Streets", and "Resurfacing of City Streets". The recycled asphaltic material shall be equal to that produced by regular methods.

   A tack coat of liquid reclamite asphalt emulsion shall be applied at the rate of .10 gal. per square yard or as directed by the Engineer. Liquid application rate must be controlled so that there is no liquid flushing to the surface. Recycled hot-mix asphalt as listed in the attached resurfacing specification shall be placed on the milled surface at the average rate of 100 lb. to the square yard with a heated vibratory screed that produces compaction densities above 85%. Compact surface with an 8 to 12 ton steel wheeled roller. The hot-mix asphalt shall be in place within 20 days after the surface has been planed or milled.

2. EQUIPMENT: The recycling work shall be performed with a machine or machines of a type that has operated successfully on a considerable mileage of work comparable to that proposed to be done under this contract. The City reserves the right to inspect and evaluate the equipment that will be used to perform this operation.

3. RECYCLING OPERATION: The contractor shall provide all necessary labor, materials, and equipment to perform the recycling work. The performance of this contract shall produce a new waterproof non-skid pavement surface with a life expectance equal to new hot-mix asphalt pavement surfaces produced by regular methods. This pavement surface shall meet the following inspection criteria:

A. Elevation

The completed pavement surface shall not raise the profile more than the depth specified on "Exhibit A" above the original existing average grade. In all cases finished grade shall provide a gradual drainage slope from the center of the street to the curb or ditch line.

B. Thickness

Minimum thickness of the newly recycled compacted pavement surface shall be one inch to a point six feet from the curb. Surface shall taper from this point to ½ inch--minimum thickness at the curb, gutter or edge of pavement on unimproved streets.

C. Surface

Maximum variation under a ten foot straight edge placed parallel with the curbline or edgeline shall be less than 1/4 inch in a straight section of pavement.

D. Longitudial Joints

Joints between successive paving passes must achieve less than 1/4 inch variation from profile after compaction.

4. SURFACE PREPARATION: Cleaning or sweeping of the roadway surface prior to recycling will be done by the City.

5. COLD PLANING OF CITY STREETS

A. Description

This item shall consist of planing the existing asphalt surface with equipment meeting the requirement hereinafter specified, which shall plane or mill the surface irregularities out of the existing bituminous pavement to produce a leveled surface. The planed and finished surface shall be free from gouges, ridges, sooting, oil film, and other imperfections.

B. Equipment

The planing work shall be performed with a pavement planing machine of a type that has operated successfully on a considerable mileage of work comparable to that proposed to be done under this contract.

The machine to be used shall be designed and constructed for cold planing work, self-propelled, and having in combination the means for planing, milling, or cutting the existing surface and picking up, elevating and discharging the cuttings into a truck, to insure minimum traffic congestion and provide material for reuse. The cutting width of the machine shall not be less than fifty-four inches (54"), and the total weight shall not be less than 26,000 pounds. The rear driving wheels shall be designed to protect the softened surface of the pavement, and be able to cut flush to all gutters, inlets, grates, manholes, or other similar obstructions within the paved area. A dust supression system must be part of the equipment and must meet the standards of city and state air pollution control laws.

C. Planing Operations

The temperatures at which the work is performed and the manner of performing the work shall be such that the asphalt pavement is not torn, gouged, shoved, broken, sooted, oil coated or otherwise damaged by the planing operation. Sufficient passes or cuts, shall be made such that all irregularities or high spots are eliminated, and that 100% of the surface area has been planed to the satisfaction of the inspector. The drum lacing patterns shall permit a grooved or smooth surface finish as selected by the City Engineer and the drum shall be enclosed to prevent discharge of any loose material on adjacent work area. The contractor shall provide all necessary labor, materials and equipment to load the asphalt and aggregate cuttings and transport them to the Hot-Mix Plant for recycling.

6. RESURFACING OF CITY STREETS

A. Asphaltic material and method of placement shall be in accordance with Section 401, Plant Mix Bituminous Pavement of the Standard Specifications for Highway Construction, 1973 Edition, published by the Missouri State Highway Commission. In particular, the following subsections must be complied with:

1) Section 401.2--Asphaltic cement shall be 85-100 penetration.

2) Section 401. 3.1-Gradation of aggregate shall be as listed under Grade D.

3) Section 401. 3.2-Aggregate materials shall be crushed limestone and flint sand in accordance with Subsection (b).

4) Section 401. 3.4-Representative samples and proposed job-mix formula shall be submitted to the City Engineer of the City of Springfield for approval.

5) Section 401.7--Cleaning or sweeping of surface for resurfacing shall be done by the City. Tack or prime may be omitted at the option of the Engineer.

B. Tack coat and sanding shall be in accordance with Section 407, Tack Coat of the Standard Specifications for Highway Construction, 1973 Edition published by the Missouri State Highway Commission. Liquid asphalt shall be Grade RC70 unless otherwise specified and shall conform to Section 407.2.

7. PAYMENT

Payment will be made based upon quantities of work in place and upon bid prices in contract. The bid prices shall include necessary traffic control in accordance with the special provisions as well as all labor, equipment, materials, supplies, mobilization, bond and insurance and any other costs associated with the recycling of asphalt pavement as stated in this contract.

8. ALTERNATE BID "A"

If Alternate Bid "A" is awarded in lieu of the BASE BID, all references to recycling in Paragraphs 1 thru 4 of these TECHNICAL SPECIFICATIONS shall be deleted. Those streets which were to have received recycled asphalt will be resurfaced with new asphaltic material in accordance with Paragraph 6, hereinbefore. Sites for unloading of recyclable material are as follows:

1) City Service Center - 1111 West Chestnut Expressway

2) Golden and Bennett

3) Pythian and East Trafficway

6. This project is also being accomplished to determine as well as can be expected the cost savings of recycling. One of the criteria for measurement is energy used. The Contractor will be asked in certain instances to write down beginning and ending hours or miles of vehicles used for this project and where possible automatic meters supplied by the City will be attached to equipment to reduce the manual record keeping.

7. Air Pollution is another measure of concern in recycling. In order to get some idea of air quality one (1) test at the batch site will be taken, if possible, by the City for qualitative purposes only. It will not be used for enforcement of air standards but should the test show significant pollution the Engineer and Contractor shall work together to modify the mix to conform to air quality standards.

8. Samples of asphalt from streets to be milled will be taken by the City and analysis of the asphalt will be provided to the contractor prior to submitting recommended mix.

9. Method of Payment. Payment shall be made on or about the tenth day of each month for 90% of the bid price for each item in place, as of the last day of the preceding month. Full payment shall be made on or about the tenth day after all work has been completed and approved.

10. Contractor will be required to have an occupational license with the City of Springfield, Missouri, before payment can be made for any work done.

11. If Alternate Bid "A" is awarded, Paragraph 5, 6, 7, and 8 of these Special Provisions will be deleted.

12. Contractor agrees in the performance of this contract not to discriminate on the ground or because of race, creed, color, national origin or ancestry, sex, religion, handicap, or political opinion or affiliation against any employee of said contractor or applicant for employment and shall include a similar provision in all subcontracts let or awarded hereunder.

13. Contractors attention is directed to the recently revised liability insurance requirements shown in the contracts. They are as follows:

    Contractor's Public Liability Insurance

    The amount of contractor's property damage insurance has been increased from, not less than $300,000 to not less than $800,000.

    Automobile Liability Insurance

    The amount of insurance for bodily injury or death for each accident has been increased to $800,000 from $300,000.

    Policy Limits for Bodily Injury under the Contractor's Public Liability Insurance and Owner's Protective Liability Insurance shall be written with no aggregates.

FORM OF PROPOSAL

DATE_____

TO: Purchasing Agent, City Hall, Springfield, Missouri

The undersigned, having carefully examined the Contract Documents, inclu this Form of Proposal, the Notice to Contractors, General Condition, Scope Work, Specifications, Special Provisions, Prevailing Wage Scale, Form Contract, Performance, Labor and Materials Bond, Affidavit regarding Prevail Wage, Fair Employment Practices and schedule for recycling of bituminous s faces and having examined all conditions affecting the work, propose to furn labor, materials, equipment, transportation, insurance and all things whatsoe necessary or required for the work in accordance with said Documents Specifications at the unit prices set out below:

BASE BID: This Bid includes all costs associated with Recycled Asphalt. planed areas are to be sanded and are to receive reclamite. These costs are be included as a portion of Bid Item 1. Those streets not being planed shall prepared with Tack Liquid Asphalt and Sanding Tack as required. These items included as Bid Items 3 and 4, respectively.

BASE BID

Item No.	Description	Unit	Unit Price	Tot
1.	Cold Planing, Loading, Hauling, Sanding, and Application of .10 gal. Reclamite per square yard	209,620 sq. yds.	$_____	$_____
2.	Recycled Plant mix bituminous pavement, in place	22,358 tons	$_____	$_____
3.	Tack Liquid Asphalt RC70, in place	1,100 gal.	$_____	$_____
4.	Sanding Tack, in place	25 tons	$_____	$_____
		TOTAL BASE BID	$_____	

ALTERNATE BID "A": This Bid includes all costs associated with the project and allows the use of new asphalt paving material in lieu of recycled asphalt. All planed materials are to be hauled to sites designated in the Technical Specifications.

ALTERNATE BID "A"

Item No.	Description	Unit	Unit Price	Total
1.	Cold Planing, Loading, Hauling, Sanding, and Application of,10 gal. Reclamite per square yard	209,620 sq. yds.	$_____	$_____
2.	Plant mix bituminous pavement, in place	22,358 tons	$_____	$_____
3.	Tack Liquid Asphalt RC70, in place	1,100 gal.	$_____	$_____
4.	Sanding Tack, in place	25 tons	$_____	$_____

TOTAL ALT. BID "A" $_____

NOTE: Contractor may bid on the BASE BID, ALTERNATE BID "A", or both. The City has grant funds available which can be used for recycled asphalt. These grant funds can be used for the "BASE BID" only and will be considered when determining the lowest and best bid.

SPRINGFIELD, MISSOURI
HOT RECYCLING AND RESURFACING
OF CITY STREETS

SPECIAL PROVISIONS

1. A minimum work week of forty hours is anticipated unless interrupted by unfavorable weather conditions.

   Whenever the term "City" is used in the following provisions it shall be construed to mean the City of Springfield, Missouri.

   Whenever the term Engineer is used in these specifications it shall be construed to mean the Director of Public Works or any of his authorized representatives.

2. Public Convenience and Safety - The contractor shall conduct operations so as to cause the least possible obstruction and inconvenience to public traffic. The contractor shall, at his own expense, furnish such flagmen and furnish, erect, construct and maintain such fences, barriers, lights, signs, detours, pedestrial walkways, driveway ramps and bridging as may be necessary to give adequate warning to the public that work is in progress and that dangerous conditions exist, to provide access to abutting properties and to permit the flow of pedestrial and vehicular traffic to safely and expeditiously pass the work. Where barricades are used, they shall be in accordance with the Traffic Control Manual approved by the City Council of the City of Springfield, Missouri by Special Ordinance No. 2696 on August 1, 1977.

   Except as authorized by the Engineer, vehicular and pedestrian traffic shall be allowed the use of the public street areas. Upon failure of the contractor to comply forthwith any order of the Engineer given pursuant to this section, the Engineer shall have the authority to cause said conditions stated above to be corrected and to deduct the cost thereof from any monies due to or become due to the contractor. Working hours may be limited by the City Traffic Engineer at some locations.

3. It shall be the responsibility of the contractor to protect all existing curbs, gutters, castings, road signs, shrubbery, trees and any other items from damage. Any items damaged by the contractor's operation shall be repaired or replaced to the satisfaction of the Engineer.

4. Time of completion - All work under this contract shall be completed not later than October 31, 1980. Liquidated damages in the amount of fifty ($50) dollars per day will be charged for each calendar day, except Saturday and Sunday, from October 31, 1980 until the work is completed.

5. Because this project is partially federally financed various tests and samples will be required by the City or the City's Consulting Engineer during the mixing of materials and during the resurfacing operation. Cooperation by the contractor is expected.

All taxes applicable to the work under this proposal are included herein.

Date_____

Respectfully submitted,

_____
(Firm Name)

Official Address:

_____ By:_____

_____ _____

APPENDIX IV

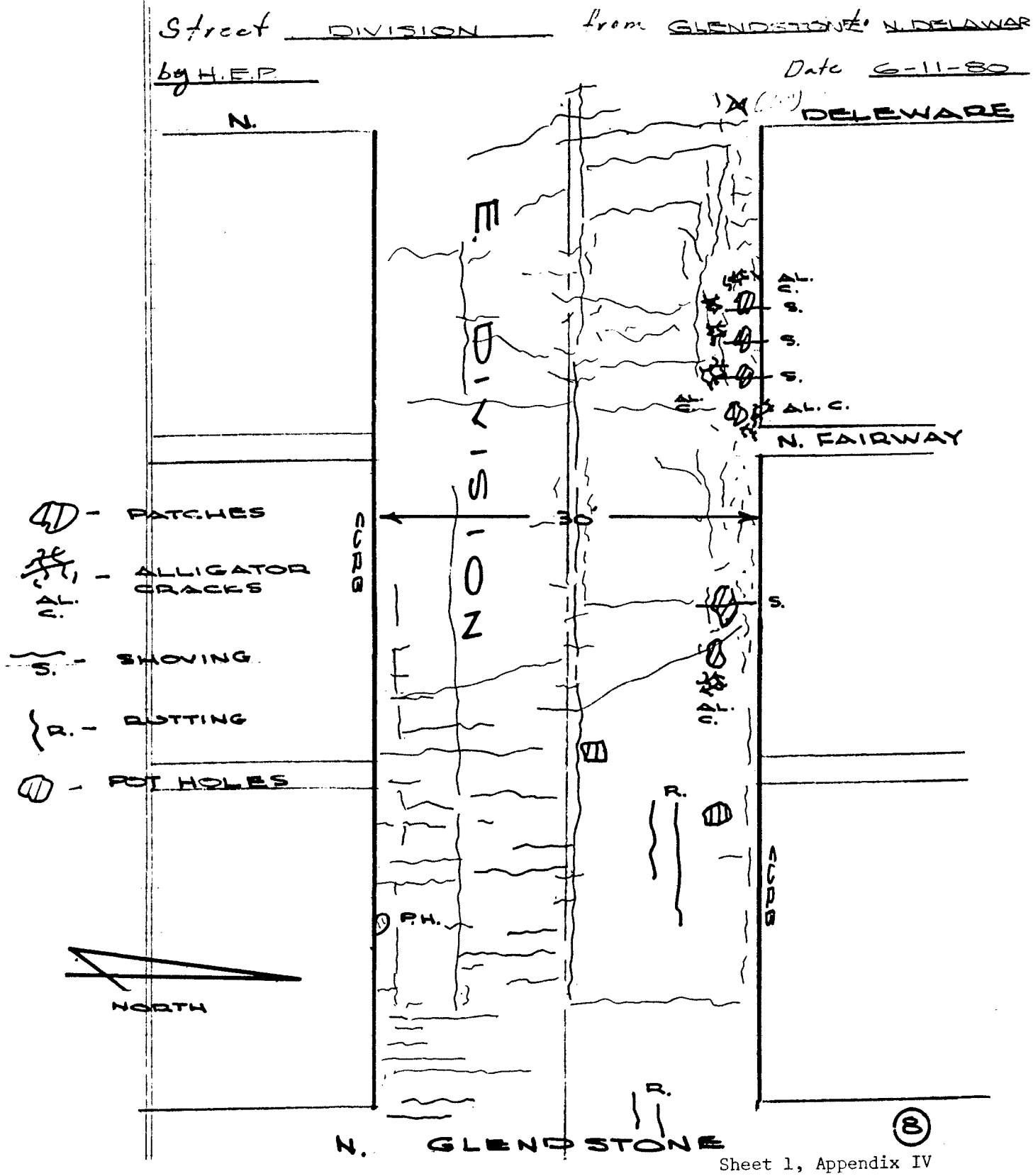
SCHEMATIC REPRESENTATION OF AREAS AND TYPES OF PAVEMENT DISTRESS

COMPLETE SET ON FILE
WITH CONSULTANT
ONE INCLUDED FOR EXAMPLE

City of Springfield, Mo.

1980 Asphalt Recycling Project

Demonstration Project No. 39



APPENDIX V

BENKLEMAN BEAM DEFLECTIONS
MADE ON EXISTING PAVEMENT SECTIONS
JUNE, 1980

Deflection readings made in June, 1980, using a single axle, dual tired truck having a rear axle load of 22,420 pounds. Photo key refers to the number shown on photograph in Appendix III.

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTION IN X 10^{-3}
1 W Catalpa @ S Thelma	10.8 feet South of manhole North side Catalpa, East side Thelma	1A	19
	7.33 feet South of curb 67.41 feet East of start of concrete at South New Avenue	1B	24
2 Central	11.25 feet North of curb 9.0 feet West of Northeast corner of house #510	2	28
	12.5 feet North of curb 41.1 feet West of West curb of North Summit	2A	11
	12.0 feet North of curb 47.5 feet West of West curb of North Sherman	2B	11
	11.2 feet South of curb 29.8 feet East of East curb of North Sherman	2C	13
	11.2 feet South of fire hydrant at North Hampton and Central	2D	13
3 Cherokee	10.1 feet South of curb 12.2 feet East of East curb of South Robberson	3	23
	9.3 feet North of curb 29.9 feet West of West curb of South Avenue	3A	12
4 Cherokee	11.1 feet South of curb 165.0 feet West of West edge of South Holland	4	14
	8.0 feet North of curb 44.6 feet West of West curb of South Roanoke	4A	13

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTIO IN X 10^{-3}
5 College	12.1 feet South of curb 76.1 feet West of edge road, North Lexington (South)	5	10
	10.2 feet North of curb 46.4 feet East of East edge of North Lexington	5A	7
	12.0 feet South of curb 14.3 feet West of West edge of North Park	5B	7
	12.1 feet North of curb 49.4 feet East of East edge of South Park	5C	5
6 W Court	12.43 feet North of curb 84.43 feet East of East curb along North Campbell	6	13
7 Dale	12.8 feet North of curb in line with centerline of North Crutcher	7	41
	14.3 feet North from fire hydrant at Northwest corner of Bristol Manufacturing Corporation	7A	76
	12.1 feet South of curb 56.8 feet East of South-east corner of Loren Cook Company (Office Building)	7B	35
8 Division	4.6 feet South of curb 39.6 feet West of West curb of North Fairway	8	45
	4.2 feet South of curb 33.1 feet West of West curb of North Evangel	8A	65
	8.1 feet North of curb 50.0 feet East of East curb of North Fremont	8B	18

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTION IN X 10^{-3}
9 E Florida	9.4 feet North of curb 21.2 feet West of edge of concrete street East side of job	9	28
10 Fremont	3.3 feet East of edge of road 22.2 feet South of South edge of East Whiteside	10	83
	7.4 feet West of curb 134.8 feet North of North edge of East Cherokee	10A	6
	4.7 feet West of curb 4.1 feet North of Southeast corner of building Volz/Kelly Real Estate	10B	9
11 Fremont	3.3 feet West of edge of road 13.0 feet South of start of East Carleton	11	23
	2.9 feet East of edge of road 14.7 feet South of South edge of East Sammy Lane	11A	43
	3.6 feet West of edge of road 35.9 feet South of South edge of East Holiday (East)	11B	36
	3.1 feet East of edge of road 52.7 feet North of North edge of East Holiday (West)	11C	31
	3.9 feet West of edge of road 38.8 feet South of South curb of East Camino Alto	11D	70
	3.2 feet East of edge of road 29.5 feet North of North curb of East Camino Alto	11E	47

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTION IN X 10^{-3}
12 Fulbright	6.1 feet West of edge of road 33.1 feet South of South edge of West Webster	12	29
	5.2 feet East of curb 39.3 feet South of South edge of West Calhoun	12A	51
13 National	6.6 feet West of edge of road 36.7 feet South of South edge of East Jean	13	32
	1.8 feet West of edge of road 177.3 feet North of North edge of East Talmage	13A	64
	3.2 feet West of edge of road 35.5 feet North of North edge of East Kerr	13B	51
	3.6 feet East of edge of road 37.5 feet South of South edge of East Kerr	13C	42
	4.1 feet East of edge of road 63.5 feet North of North edge of East Norton	13D	45
	4.7 feet West of edge of road 24.2 feet North of North edge of East McCanse	13E	22
	3.0 feet East of edge of road 31.2 feet North of North edge of East Smith	13F	53
14 Grant	7.6 feet West of curb 194.3 feet North of North side of West Nichols	14	12
	6.6 feet West of curb 86.6 feet North of North edge of West Webster	14A	7
	6.2 feet West of curb 55.8 feet South of South curb of West Hovey	14B	25.5

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTION IN X 10^{-3}
14 Grant (Cont.)	8.0 feet East of curb 92.8 feet South of South curb of Lynn Street	14C	29.5
	8.45 feet East of curb 96.1 feet North of North curb of West Scott	14D	12
	8.1 feet East of curb 137.2 feet South of South curb of West Central	14E	23
15 N Hillcrest	1.9 feet West of edge of road 9.9 feet South of South edge of West Chestnut Street	15	120
	4.1 feet East of edge of road 44.2 feet North of North edge of West Chestnut Street	15A	100
	5.9 feet East of edge of road 28.1 feet South of South edge of West Nichols	15B	80
16 Holiday	8.2 feet North of curb 42.0 feet West of West curb of South Roubindoux	16	24
	8.3 feet North of M. H. & Jung Street and Holiday	16A	28
17 Jefferson	11.95 feet West of West curb 39.72 feet South of curb along East Madison	Photo 1	24
	11.25 feet West of curb 49.05 feet South of curb along East Madison	Photo 2	12
	11.85 feet East of curb 9.70 feet South of reference nail in road South of South curb of East Elm	Photo 3	9

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTI IN X 10⁻
17 Jefferson (Cont.)	11.38 feet East of curb 40.78 feet South of curb (Reference nail)	17A	25
	11.26 feet East of curb 61.0 feet South of curb (Reference nail)	17C	25
18 Jefferson	18.2 feet West of first metal p.p. (no. 193) from Cherokee	18	40
	5.2 feet East of edge of road 33.0 feet South of South curb of East Lindberg	18A	19
19 W Mt. Vernon	4.30 feet South of edge of road in line with East curb along Suburban Avenue	19	20
	3.40 feet North of edge of road in line with West curb along Suburban Avenue	19A	65
	12.45 feet North of fire plug at Mt. Vernon and South Troy	19B	115
	20.25 feet South of p.p. West side of South Troy North side of Mt. Vernon	19C	30
	8.0 feet North of edge of road 9.4 feet East of East edge of South Miller Raod	19D	39.5
	3.9 feet South of edge of road 46.4 feet East of East edge of South Miller Road	19E	17
	3.6 feet North of edge of road in line with centerline of South Westgate	19F	50
	37.4 feet West of centerline of South Westgate 2.5 feet South of edge of road	19G	80

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTION IN X 10^{-3}
19 W Mt. Vernon (Cont.)	1.8 feet South of North edge of Mt. Vernon 15.5 feet East of centerline of Orchard Crest	19H	25
20 W Grand	3.47 feet West, 1.2 feet South of center M.H. 1 at South Park	20A	31
	8.2 feet North, 9.6 feet East of M.H. 1	20B	13
	18.97 feet South, 4.9 feet East of nail at centerline of South West on North side of Grand	20C	120
	18.97 feet South, 24.5 feet East of above nail	20D	92
	30.95 feet West, 3.2 feet South of above nail	20E	70
21 National	10.7 feet West of curb 17.0 feet South of South edge of East Whiteside	21	7
22 W Nichols	5.35 feet South of curb 51.5 feet West of West edge of North Franklin Avenue	22	26
23 Oak Grove	10.5 feet West of curb 57.2 feet North of North curb of East Seminole	23	78
	10.25 feet East of curb 0.4 feet North of start of cul-de-sac	23A	26
24 Orchard Crest	4.3 feet East of edge of road 49.65 feet North of North edge of Mt. Vernon	24	40
	5.15 feet East of edge of road in line with centerline of West Dover	24A	65

STREET NO. AND NAME	TEST LOCATION	PHOTO KEY	DEFLECTION IN X 10^{-3}
24 Orchard Crest (Cont.)	2.8 feet East of edge of road 112.85 feet South of South edge of Chestnut Expressway	24B	70

APPENDIX VI

RESULTS OF LABORATORY TESTS PERFORMED ON UPPER ONE INCH OF CORE SAMPLES TAKEN FROM EXISTING ASPHALTIC CONCRETE WEARING SURFACE AT SELECTED LOCATIONS

RESULTS OF LABORATORY TESTS PERFORMED ON
UPPER ONE INCH OF CORE SAMPLES TAKEN FROM
EXISTING ASPHALTIC CONCRETE WEARING SURFACE

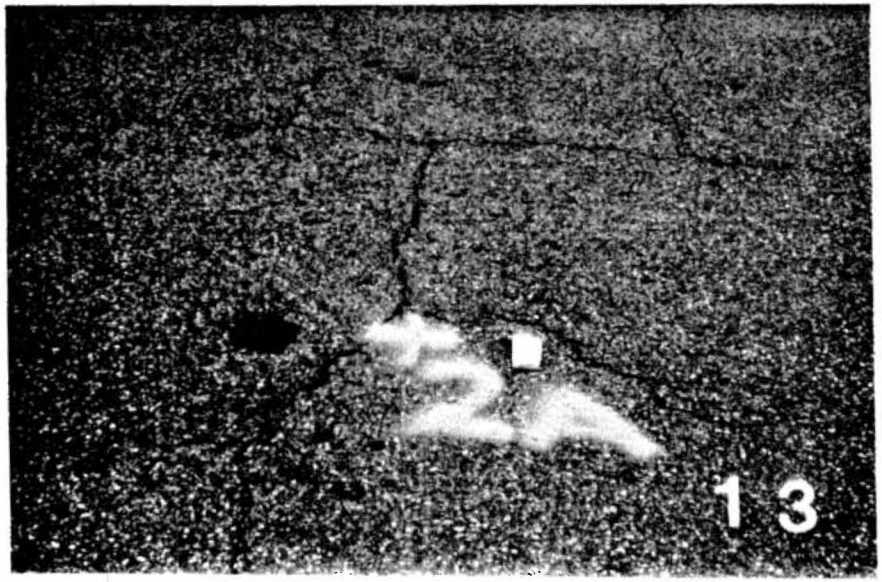
Sample Number	1	2	3	4
Location	Central Ave.	College St.	Jefferson Ave.	National Ave.
Extraction Gradation % Passing				
3/4" Sieve	100	100	100	100
1/2" Sieve	100	100	100	100
3/8" Sieve	86.7	89.2	86.2	95.0
# 4 Sieve	61.9	59.2	58.9	73.4
# 8 Sieve	43.2	42.5	46.6	57.2
# 16 Sieve	32.4	33.4	36.1	42.7
# 30 Sieve	21.5	23.8	25.8	27.1
# 50 Sieve	15.1	17.5	19.7	18.8
# 100 Sieve	6.8	9.1	8.2	10.4
# 200 Sieve	5.2	5.8	4.1	6.1
Asphalt Content	6.4	6.3	5.7	6.3
Asphalt Residue Tests				
Penetration @ 77°F	26mm	12mm	9mm	19mm
Ductility @ 77°F	13cm	11cm	12cm	13cm

APPENDIX VII

PHOTOGRAPHS OF TYPICAL AREAS OF DETERIORATION ON EXISTING ASPHALTIC CONCRETE WEARING SURFACES

LIST OF PHOTOGRAPHS

PHOTO KEY NO.	LOCATION	LOCATION NO.
13	Central Avenue, 12.5 feet North of South curb, 41.1 feet West of West curb of North Summit	2A
14	Dale Avenue, 12.8 feet North of South curb, in line with centerline of North Crutcher	7
15	Division Street, 4.2 feet South of North curb, 33.1 feet West of West curb of North Evangel	8A
16	Fremont Avenue, 2.9 feet East of West edge of road, 14.7 feet South of South edge of East Sammy Lane St.	11A
17	North Hillcrest, 1.9 feet West of East edge of road 9.9 feet South of South edge of West Chestnut St.	15
18	North Hillcrest, 4.1 feet East of West edge of road, 44.2 feet North of North edge of West Chestnut St.	15A
19	West Grand Street, 19 feet South of North edge of street, 4.9 feet East of centerline of South West Ave.	20C
20	Orchard Crest, 5.2 feet East of West edge of road, at centerline of West Dover	24A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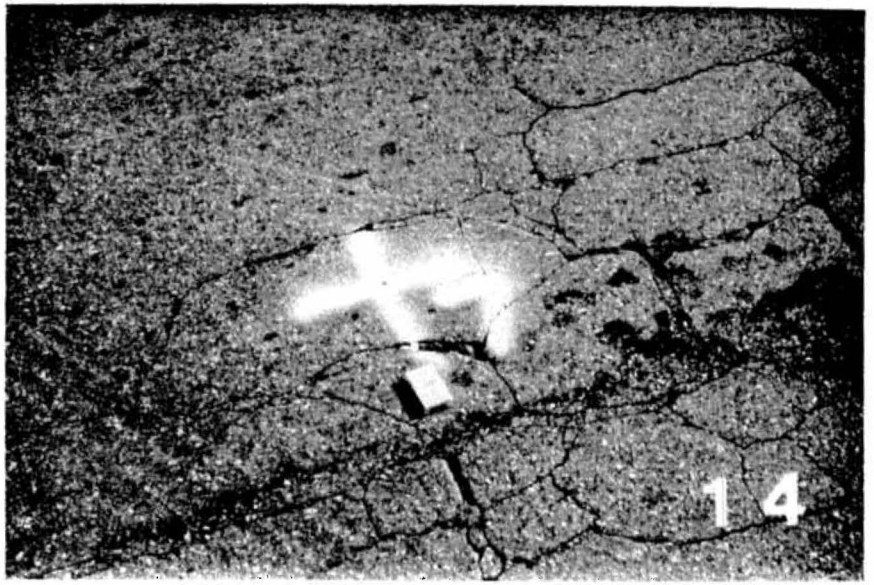
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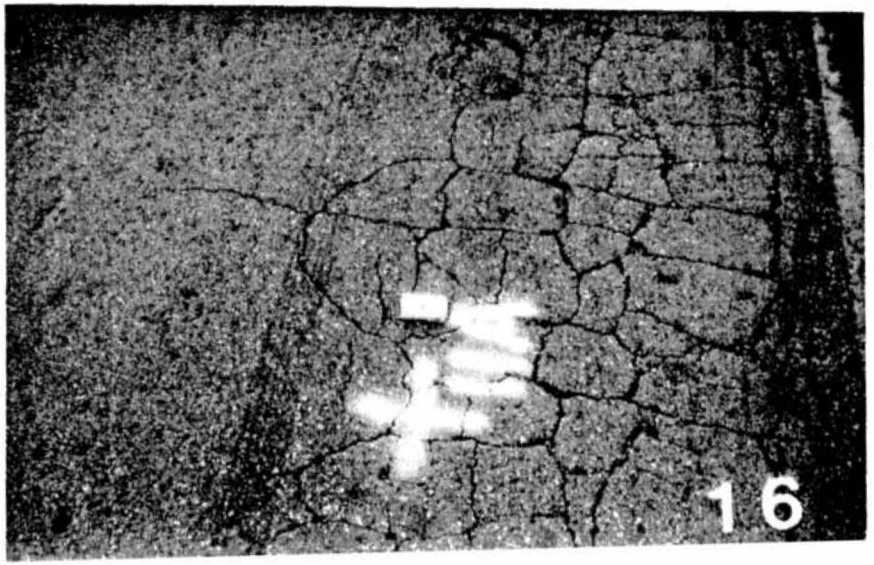
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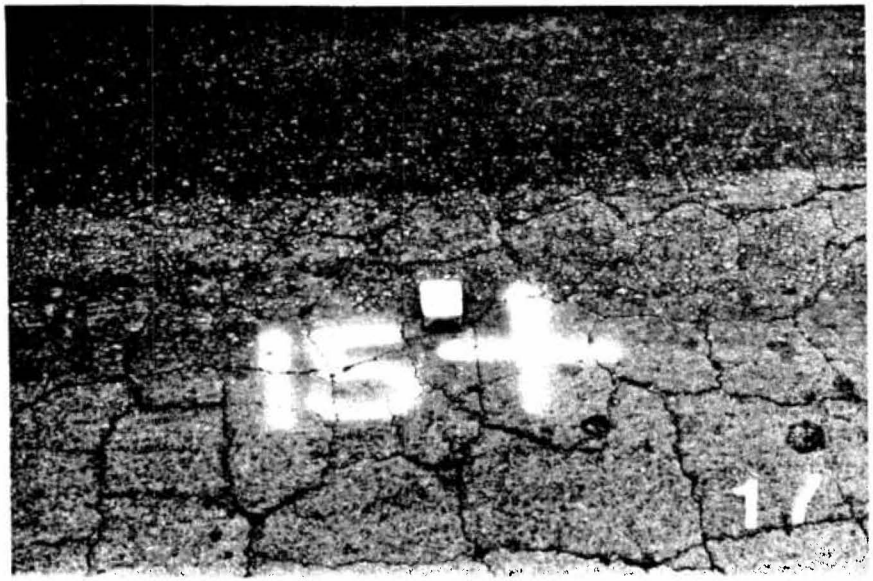
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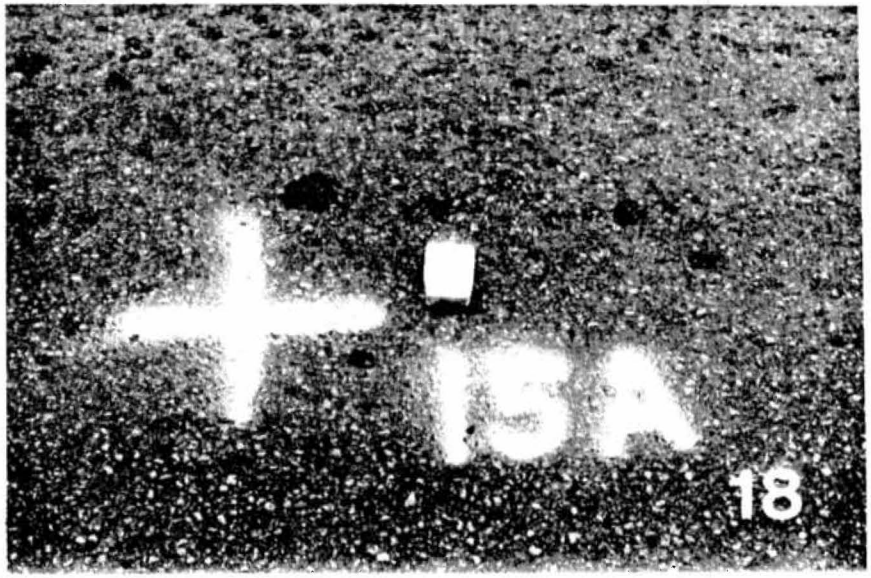
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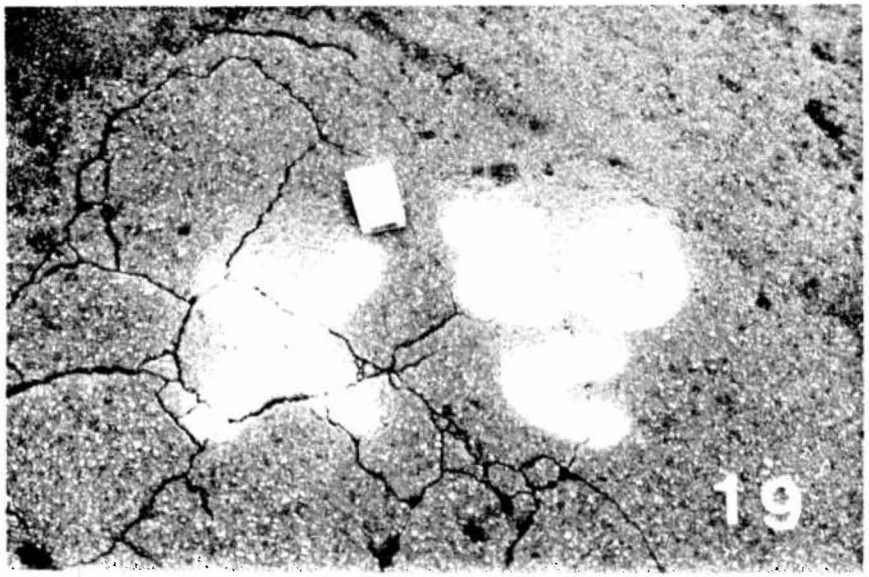
19


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APPENDIX VIII

CHARACTERISTICS OF THE PROPOSED ASPHALTIC CONCRETE MIX

Gradational Tests On Planed Recycled Material And Virgin Crushed Limestone Stockpiles

Sample No.	1	2	3	4	5	6
Material	Planed Material	Planed Material	1/2" Minus Crushed Limestone	Limestone Fine Aggregate	Limestone Fine Aggregate	9/16" Stockpile
% Passing						
3/4" Sieve	100	100	100	100	100	100
1/2" Sieve	99.7	99.6	99.0	99.7	100	99.8
# 4 Sieve	76.4	74.1	39.3	99.4	98.7	63.6
# 10 Sieve	53.2	55.7	11.1	80.5	80.1	34.3
# 40 Sieve	26.9	27.5	4.6	36.8	36.7	13.3
# 200 Sieve	9.1	9.5	4.1	15.0	13.2	5.9
Asphalt Content	3.92	5.0				

Sample No.	7	8	9	10	11
Material	3/8" Crushed Limestone	3/8" Crushed Limestone	Sand Stockpile	Joplin Chert Sand	Joplin Chert Sand
% Passing					
3/8" Sieve	100	100	100	100	
1/2" Sieve	100	100	100	100	100
# 4 Sieve	72.7	99.4	64.0	100	99.8
# 10 Sieve	33.5	94.3	27.5	95.1	95.8
# 40 Sieve	9.5	34.3	8.6	35.4	35.5
# 200 Sieve	4.6	7.3	4.7	9.5	9.8

Proposed Recycled Asphaltic Concrete Mix

Material	Planed Asphalt	1/2" Crushed Limestone	3/8" Crushed Limestone	Limestone Fine Aggregate	Joplin Chert Sand	Combined Gradation	Specification
% of Total	50%	14%	14%	15%	7%	100%	MSHD 401 Grade D
% Passing							
3/8" Sieve	50.0	14.0	14.0	15.0	7.0	100.0	100
1/2" Sieve	50.0	14.0	14.0	15.0	7.0	100.0	95 - 100
# 4 Sieve	35.1	8.0	10.2	14.8	7.0	75.1	60 - 90
# 10 Sieve	25.8	1.9	4.7	12.0	6.6	51.0	35 - 65
# 40 Sieve	15.1	0.6	1.3	5.5	2.4	24.9	10 - 30
# 200 Sieve	4.4	0.4	0.6	2.0	0.5	7.9	4 - 12
% Asphalt	2.5					2.5	
New Asphalt						3.0	
Total Asphalt						5.5	3.5 - 8.0

APPENDIX IX

PHOTOGRAPHS OF ASPHALTIC CONCRETE REMOVAL TECHNIQUES

LIST OF PHOTOGRAPHS

PHOTO KEY NO.	LOCATION
9	Mobil Power Sweeper on Grant Avenue
10	Scarifier making initial pass
11	Collection and loading operation on Grant Avenue
12	Collection and loading operation on Grant Avenue

M88A1

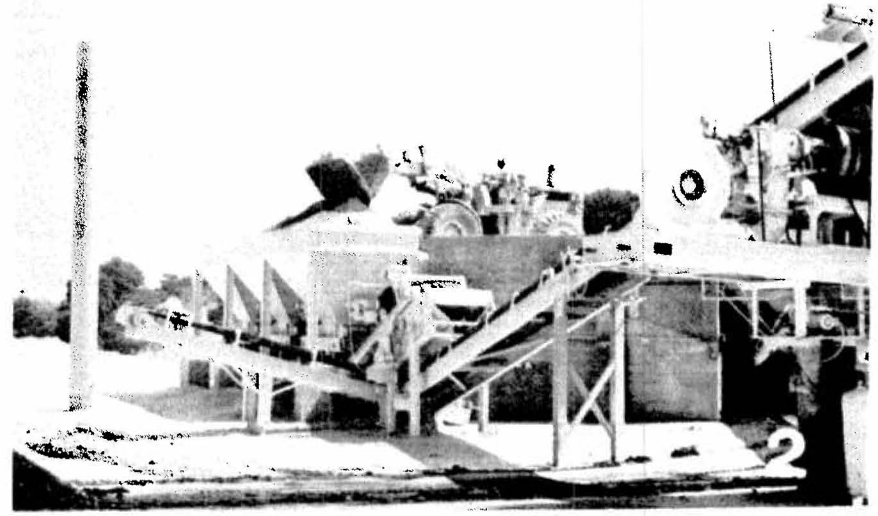
APPENDIX X

PHOTOGRAPHS OF CONTRACTOR'S BATCH PLANT

LIST OF PHOTOGRAPHS

PHOTO KEY NO.	LOCATION
1	Interior of Control trailer showing computerized batching consoles
2	Virgin aggregate bins and conveyor
3	Storage bins
4	View of new batch plant
5	Pulverized asphaltic concrete mix prior to recycling
6	Conveyor belts delivering both pulverized asphaltic concrete and virgin aggregates
7	View of new batch plant
8	Loading facilities


1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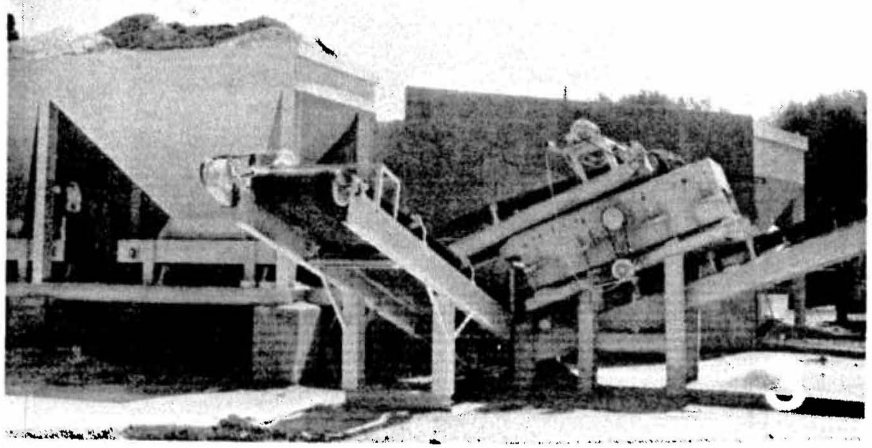
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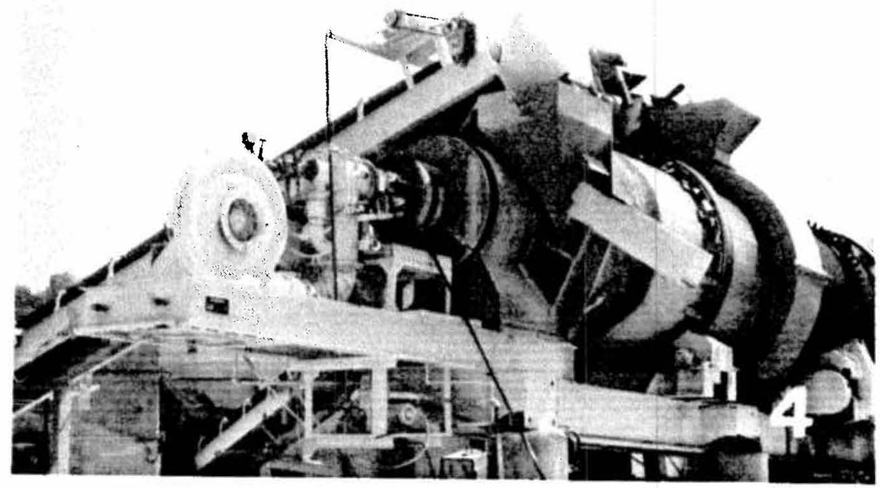
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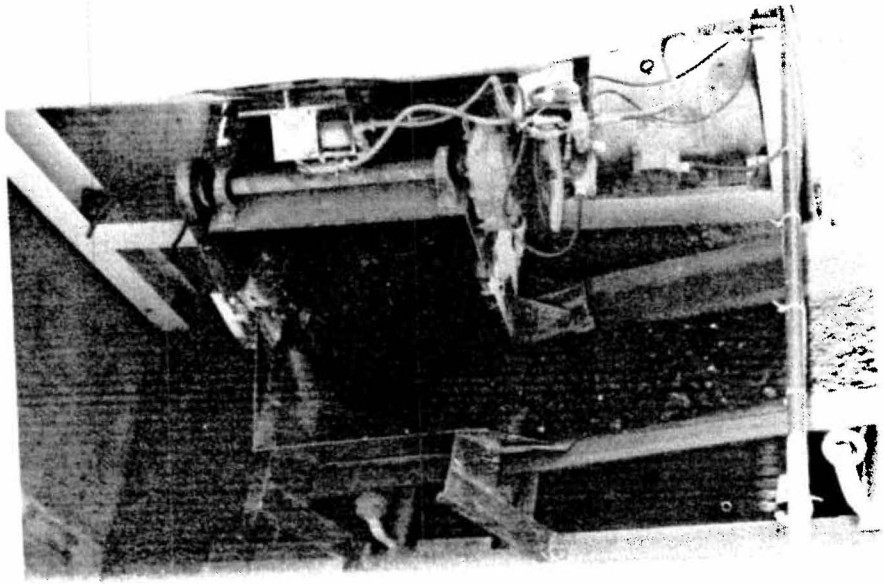

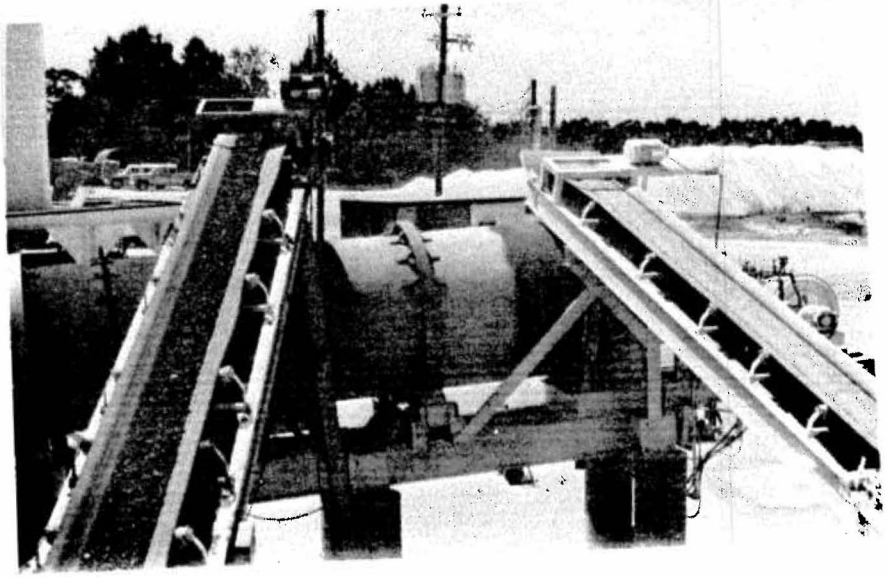

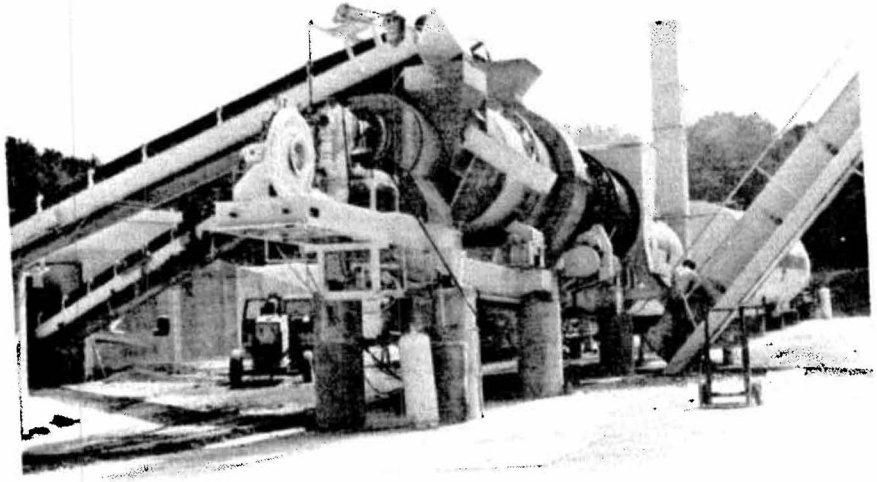

APPENDIX XI

SUMMARY OF FIELD TESTS TAKEN DURING RECYCLED MIX PLACEMENT

Test Number	1	2	3	4
Date of Test	7/24/80	7/24/80	7/28/80	7/29/80
Test Location	Central St. Southeast boundary line front of R-12 Pool	Central St. opposite Post Office	Intersection Central and National	Intersection Nichols and Johnston South lane
Mix Type	50/50	50/50	50/50	50/50
Temperature @ Placement	280°F	280°	280°	260°
% Passing				
3/4" Sieve	100	100	100	100
1/2" Sieve	100	100	100	100
# 4 Sieve	72.1	69.4	96.3	75.0
# 10 Sieve	48.2	44.4	48.0	50.1
# 40 Sieve	22.2	21.6	23.2	25.2
# 200 Sieve	8.8	9.0	9.5	8.9
% Asphalt	5.75	5.35	5.77	4.86
Marshall Specimen Data (Ave. of 3 specimens)				
Marshall Density (pcf)	147.2	147.3	146.8	148.5
% Total Voids	4.5	4.5	4.9	3.9
% Voids Filled	75.2	73.3	73.3	74.4
Marshall Stability	3215	2697	3319	3173
Flow	17	15	14	12
Core Specimen Data				
Ave. Thickness		1 7/16"	15/16"	
Ave. % Compaction		95.3	93.7	

Test Number	5	6	7	8
Date of Test	7/29/80	7/30/80	7/30/80	7/31/80
Test Location	Intersection of Grant and Calhoun	Intersection of Delaware and Division to South curb	1926 Dale Street, North side	Intersection of National and Talmage East side
Mix Type	50/50	50/50	50/50	50/50
Temperature @ Placement	275°	280°	250°	265°
% Passing				
3/4" Sieve	100	100	100	100
1/2" Sieve	100	99.6	99.7	100
# 4 Sieve	64.5	66.5	74.6	66.8
# 10 Sieve	42.2	43.8	50.6	40.8
# 40 Sieve	22.5	22.2	25.9	18.6
# 200 Sieve	9.2	9.0	10.9	8.1
% Asphalt	4.23	4.80	4.69	4.30
Marshall Specimen Data (Ave. of 3 specimens)				
Marshall Density (pcf)	148.2	149.0	147.9	146.1
% Total Voids	4.1	3.5	4.2	5.4
% Voids Filled	70.9	76.2	72.4	64.9
Marshall Stability	3305	3105	3171	3356
Flow	12	15	18	13
Core Specimen Data				
Ave. Thickness	1 1/4"		1 7/16"	
Ave. % Compaction	93.2		92.3	

Test Number	9	10	11	12
Date of Test	7/31/80	8/1/80	8/4/80	8/4/80
Test Location	Intersection of National and Jean West side	Intersection of College and Forest South side	Opposite 1922 South Jefferson East lane	Opposite 602 Cherokee centerline
Mix Type	50/50	50/50	50/50	50/50
Temperature @ Placement	270°	275°	295°	275°
% Passing				
3/4" Sieve	100	100	100	100
1/2" Sieve	99.1	99.7	100	100
# 4 Sieve	73.2	67.1	67.3	68.2
# 10 Sieve	49.9	44.4	44.7	44.4
# 40 Sieve	25.1	23.1	22.7	23.8
# 200 Sieve	11.5	10.7	9.8	11.0
% Asphalt	5.42	4.90	5.50	4.90
Marshall Specimen Data (Ave. of 3 specimens)				
Marshall Density (pcf)	146.7	148.1	147.9	147.7
% Total Voids	4.9	3.9	4.2	4.3
% Voids Filled	71.8	74.9	75.5	72.6
Marshall Stability	3617	2996	3706	3994
Flow	14	16	19	16
Core Specimen Data				
Ave. Thickness	1"	1 1/6"		1 1/4"
Ave. % Compaction	94.1	92.2		92.2

Test Number	13	14	15	16
Date of Test	8/5/80	8/5/80	8/6/80	8/6/80
Test Location	Intersection Cherokee and Fremont, West side	100 feet South of Price and Fremont, West side	Intersection Jefferson and McDaniel West side	Intersection Jefferson and Walnut East side
Mix Type	50/50	50/50	50/50	50/50
Temperature @ Placement	270°	265°	280°	265°
% Passing				
3/4" Sieve	100	100	100	100
1/2" Sieve	100	100	100	100
# 4 Sieve	74.8	72.7	67.1	71.8
# 10 Sieve	50.8	50.1	43.7	47.8
# 40 Sieve	26.1	27.1	22.4	25.5
# 200 Sieve	11.0	11.4	9.7	11.8
% Asphalt	5.60	5.50	5.60	5.24
Marshall Specimen Data (Ave. of 3 specimens)				
Marshall Density (pcf)	147.3	147.7	148.2	149.5
% Total Voids	4.6	4.3	4.0	3.2
% Voids Filled	73.7	74.7	76.6	79.5
Marshall Stability	2651	3030	2863	3151
Flow	17	15	21	18
Core Specimen Data				
Ave. Thickness		1 7/16"		1 5/16"
Ave. % Compaction		96.9		94.2

Test Number	17	18	19	20
Date of Test	8/7/80	8/7/80	8/8/80	8/13/80
Test Location	100 feet East of Mt. Vernon and Suburban North side	Intersection Mt. Vernon and Orchard Crest, South side	100 feet East of Southwest St. and Grand, North lane	Opposite 1025 North West St. West lane
Mix Type	50/50	50/50	50/50	50/50
Temperature @ Placement	280°	280°	----	----
% Passing				
3/4" Sieve	100	100	100	100
1/2" Sieve	99.9	100	99.7	100
# 4 Sieve	65.9	71.3	83.7	69.3
# 10 Sieve	42.3	49.7	60.3	47.3
# 40 Sieve	20.5	27.0	27.9	26.5
# 200 Sieve	7.5	10.9	11.0	10.8
% Asphalt	5.4	5.1	5.9	4.9
Marshall Specimen Data (Ave. of 3 specimens)				
Marshall Density (pcf)	147.5	148.9	147.4	147.3
% Total Voids	4.5	3.6	4.5	4.6
% Voids Filled	73.9	77.1	75.3	71.4
Marshall Stability	3440	3317	3152	2788
Flow	13	16	17	16
Core Specimen Data				
Ave. Thickness		1 5/16"	1 3/16"	
Ave. % Compaction		92.2	96.5	

Test Number	21	22
Date of Test	8/13/80	8/15/80
Test Location	Opposite 327 Clifton East lane	75 feet East of Glen on State, North lane
Mix Type	50/50	50/50
Temperature @ Placement	----	265°
% Passing		
3/4" Sieve	100	100
1/2" Sieve	100	100
# 4 Sieve	75.9	75.7
# 10 Sieve	53.2	54.3
# 40 Sieve	30.0	30.2
# 200 Sieve	12.6	12.7
% Asphalt	4.72	4.82
Marshall Specimen Data (Ave. of 3 specimens)		
Marshall Density (pcf)	147.4	147.0
% Total Voids	4.50	4.77
% Voids Filled	71.0	70.1
Marshall Stability	2886	2734
Flow	18	15
Core Specimen Data		
Ave. Thickness	1 15/16"	1 3/8"
Ave. % Compaction	93.2	96.9

APPENDIX XII

CALCULATIONS OF ENERGY CONSUMPTION

COMPARISON OF ENERGY CONSUMPTION
FOR CONVENTIONAL AND RECYCLED MIX

The source of refined asphalt cement is assumed to be Kansas City, Missouri. The haul distance is 180 miles each way. Each ton of conventional asphalt mix would have 0.055 ton of asphalt cement and 0.945 ton of crushed limestone aggregates. The recycled mix contained 0.030 tons of new asphalt cement, 0.025 tons of recycled asphalt cement, 0.473 tons of new aggregate and 0.472 tons of virgin crushed limestone per ton of mix. The energy consumptions are as follows:

CONVENTIONAL ASPHALT MIX

Materials	BTU/TON MIX
Manufacture Asphalt Cement 587,500 BTU/ton x 0.055 T/ton	32,313 BTU
Haul Asphalt Cement 180 miles x 2 x 1960 BTU/ton mi x 0.055 T/ton	38,808
Crushed Stone 70,000 BTU/ton x 0.945 T/ton	66,150
Haul to Plant 0.025 gal/ton x 139,000 BTU/gal x 0.945 T/ton	3,284
Total Materials	140,555 BTU/ton
Plant Operation	
Electricity 0.062 Kwh/ton x 3415 BTU/kw	212 BTU/ton
Propane 2.5 gal/ton x 91,000 BTU/gal	227,500
Total Plant Operation	227,712 BTU/ton

Haul and Place	BTU/TON MIX
Gas Powered Trucks 0.34 gal/ton x 125,000 BTU/gal x 42%	17,850
Diesel Powered Trucks 0.16 gal/ton x 139,000 BTU/gal x 58%	12,900
Laydown and Compaction 0.074 gal/ton x 139,000 BTU/gal	10,286
Total Delivery and Placement	41,036 BTU/ton
Total Estimated Energy of Conventional Mix	409,303 BTU/ton

Removal of Existing Surface	
Sweep, scarife and load 0.183 gal/ton x 139,000 BTU/gal	25,474
Haul to Close Dump Sites (See note 1) 0.16 gal/ton x 1/3 x 139,000 BTU/gal	7,413 BTU/ton
Total Removal of Surface	32,887 BTU/ton

Total Estimated Energy Consumption of Conventional Mix

409,303 BTU/ton x 24,189 tons	9,900,630,267
32,887 BTU/ton x 11,022 tons	362,480,514
Total BTU	10,263,110,781

Equivalent BTU Per Ton of Mix Placed

10,263,110,781 ÷ 24,189	424,288 BTU/ton

Note 1: The factor "1/3" represents the approximate ratio of the distance to various unspecified close dump sites for temporary disposal of the scarified material to the average distance from project(s) to Contractor's plant.

RECYCLED MIX

Materials	BTU/TON MIX
Manufacture Asphalt 0.03 T x 587,500 BTU/ton	17,625
Haul Asphalt Cement 180 miles x 2 x 1960 BTU/+ mi x 0.030 T/ton	21,168
New Crushed Limestone 70,000 BTU/ton x 0.473 ton/tons	33,100
Haul Aggregate and Recycled Mix from Stockpiles 0.025 gal/ton x 0.945 T/T x 139,000	3,371
Total Materials	75,264
Plant Operation	
Electricity 0.062 Kwh/ton x 3,415 BTU/kw	212
Propane 2.16 gal/ton x 91,000 BTU/gal	196,560
Total Plant Operation	196,772
Hauling and Placement	
Same as Conventional Mix	41,036
Haul Recycled Asphalt to Plant 0.16 gal/ton x 139,000 BTU/gal x 0.473 T/T	10,519
Sweep, Scarify and Load Recycled Asphalt 0.183 gal/ton x 139,000 BTU/gal x 0.473 T/T	12,032
Total Energy Consumption For Recycled Mix	335,623 BTU/ton
Savings In Energy Consumption	97,665 BTU/ton
Total Project Savings (equivalent gallons of gasoline) 97,665 BTU/ton x 24,189 tons ÷ 125,000 BTU/gal	18,899 gallons

*U.S. GOVERNMENT PRINTING OFFICE: 1981-0-726-359/1341