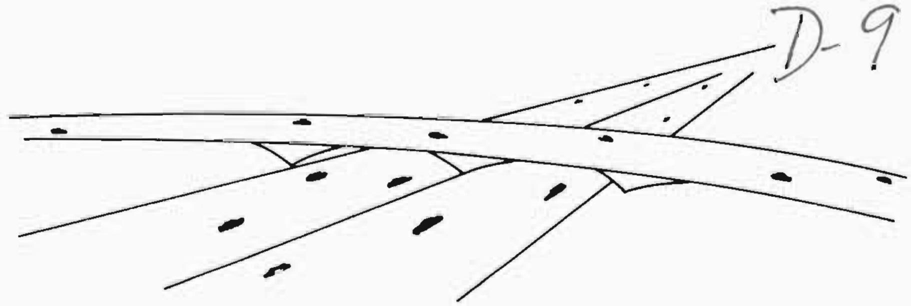

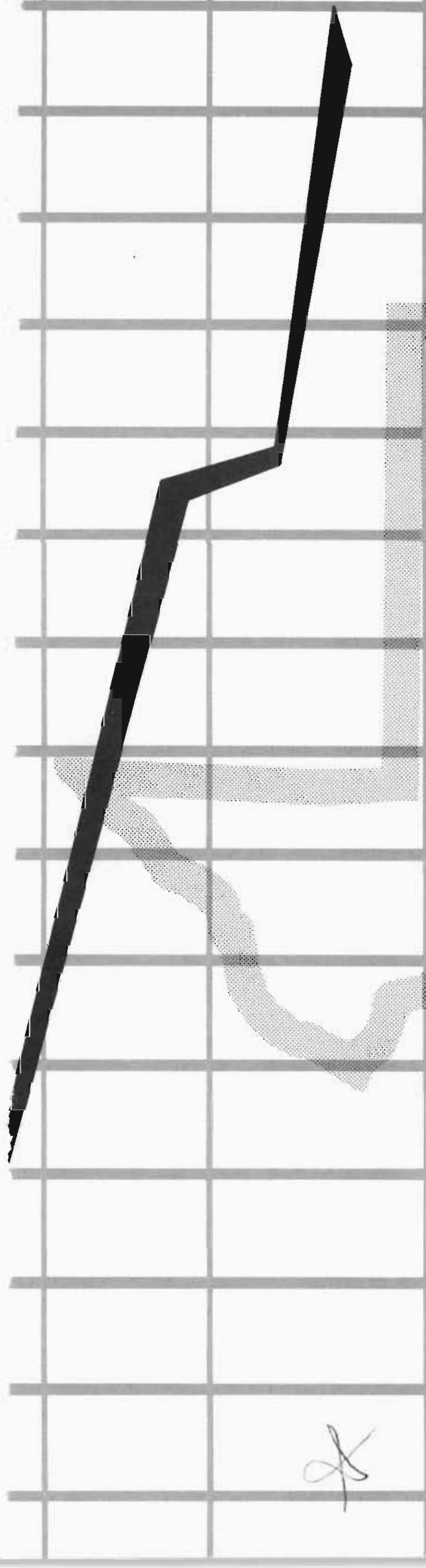

DEPARTMENTAL RESEARCH

Report Number SS 15.16

RECYCLING—A POSITIVE APPROACH

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

RECYCLING - A POSITIVE APPROACH

by

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Conducted by

District 8 - Abilene, Texas

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and Public Transportation

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ABSTRACT

This report describes the design, construction and performance of three rehabilitation projects which used recycled asphalt stabilized material as the base course. In each case the recycled material was a former surface course to which aggregate and asphalt was added. Generally, about 30 percent additional aggregate was used along with about 2.5 percent of AC-3 asphalt.

The performance has been very satisfactory with the oldest project having been in place over four years. Tests performed with road roughness measuring equipment during August, 1982 indicate the roadways are very smooth with SI values generally above 4.2. Deflection tests reveal rather stiff structures with the subgrade stiffness coefficient about 0.25 and the pavement stiffness coefficient about 0.55.

The report includes a discussion of the present state of the art in recycling and several do's and don't's in recycling with asphaltic material.

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THE ART OF RECYCLING

Webster's dictionary gives the definition of recycle as "to pass again through a series of changes or treatments as: to return to an original condition so that operation can begin again". This definition of recycling fits exactly what we should attempt to do by removing fatigued asphaltic concrete pavement and passing it through a series of changes to restore it to its original state. Before making this series of changes, a number of tests and considerations should be made to assure that recycling can be accomplished successfully.

One of the first considerations should be to determine exactly why the existing A.C.P. failed. A normal failure is one that occurs when the asphalt becomes oxidized, the asphalt hardens and the surface cracks, allowing moisture pentetration, or the surface breaks up under a fatigue type situation. The above listed failures <u>may be</u> possible recycling candidates. At least these pavements should be broken down and analyzed to determine if they can be "returned to an original condition". I would question the possiblity of recycling asphalt stripped aggregates or those that completely ravel and disintegrate.

If recycling seems possible, then the designers need to determine if recycling or resurfacing will solve the problem. Many times pavement failures are due to structure failures in the subgrade or base. The only cure for this situation is to remove the surface and make necessary repairs in the structure before designing the recycling material and surface.

Three projects have been completed on I-20 in District 8 and all three of them have had subgrade and base treatment before the recycled asphalt stabilized base was designed. No recycled material has been used on the surface in this district because we have not determined a method that we believe is suitable. We should not overlook the fact that we are recycling the subgrade, base, and asphalt concrete pavement. In all three projects the existing salvaged hot-mix is modified by the addition of coarse aggregate and asphalt to form a new product in the form of asphaltic stabilized base.

When the determination has been made that recycling is a possible alternative in your design process, your homework begins.

Large samples of the existing surface should be removed for representative testing. We recommend that a sample be removed the width of a front-end loader completely across the roadway, including shoulders. If the original design fluctuates more than one sample may be necessary. These samples are crushed to a maximum 1½" and split for testing. We send samples to D-9, the University of Texas, and T.T.I. for testing and recommendations. We have valued and used data from these agencies in all designs. The more input, the better the chances for a successful operation.

One of the largest factors influencing the outcome of a recycling project is the attitude and expertise of your construction staff and the contractor's staff. If a person does not believe in what he is doing, then its chance of success is very remote. Our contractors have worked very hard at making recycling work. Our engineering staff has been eager to experiment and learn to improve the art of recycling. Never before have these two organizations worked together as well as they did on the recycling endeavors. If you, as the designer, do not believe these two organizations will work well together trying to make your design a success then you should not attempt recycling.

Never recycle just for the purpose of seeing if it can be done. We have witnessed this procedure on several locations and invariably they wind up in a failure or less than adequate finished product. If the proper steps are taken you will not try to recycle material that is not recycable; you will not settle for inferior material; you will not recycle if it does not mean an improvement in the pavement structure; and you will stop operations if it does not meet your standards and expectations.

All of the recycling projects in this district have been recycled asphalt stabilized base. To be more specific, salvaged surface pavement has been converted to asphalt stablized base through a recycling process. The asphalt is extracted from a representative sample of the salvaged material and a screen anaylsis is run on the sample. The additional virgin material is added to bring the screen analysis up to asphalt stabilized base requirements and enough asphalt used to take care of the added rock and also soften the hardened salvaged asphalt. For all our projects this amounted to approximately 30% added rock and approximately 2.5% AC-3 asphalt. This only means that we have had enough salvaged material to add 30% coarse aggregate and bring our total depth up to the requirements of our design. If you, as a designer, have less salvaged material and need more depth you may need to add 50, 60, or 70 percent virgin material to achieve your required design depth. The point is that you dictate your design and use the salvaged material to your advantage in the mix. The salvaged pavement is simply an ingredient of your total design.

It is extremely important to monitor the temperature range closely when heating the recycled mix. We have not run any mix over 250 degrees F. Most of the mix runs from 200 degrees F to 235 degrees F behind the screed on the roadway. In the design phase it has been determined that the addition of a certain amount of new asphalt will soften the total asphalt mass to a predetermined penetration. It is extremely critical to pull samples and run tests to assure that your are not burning or hardening that asphalt beyond the predetermined range. In our opinion extreme heating is not necessary. By trial and error, we have found that the aforementioned temperature range will soften the asphalt material to a homogeneous mass and will allow optimum compaction. Again you are urged to do your homework and monitor your operation with proper testing.

The use of an asphalt softening agent to soften salvaged pavement is a controversial subject because of the unknowns about the agents. We have used very little of this product and would caution its use because we have seen one case where a complete failure occurred. In all of our recycling projects AC-3 was used and it provided the softening required to bring the old oxidized asphalt back to an acceptable range.

I think that this is the most critical element in the design of a recycled material. It is your challenge to design a mix that is homogeneous and strong enough to withstand the traffic but will not break down in hot climates. Many times the use of softening agents will give you a beautiful product but repetitive traffic and extreme temperature will cause the softening agent to come alive and rutting will occur overnight. Our theory is that if a soft asphalt will do the job, then use it. If AC-3 will not soften your combined mixture enough then you may need to add a small percentage of softening agent. Be very careful in the use of these products.

Pollution control has always been a problem in recycling projects but the contracting industry has produced machinery that has almost eliminated this problem. Most hot-mix plant manufacturers have modified their plants to accommodate recycling. If air pollution is a problem, numerous methods have been developed to successfully control pollution.

The performance of the three projects completed in this district can be summarized by saying "very good". All outward appearances reveal a normal new product with a smooth ride and very few cracks or problems. Please refer to the evaluation sheet for results of an on-site inspection.

The Mays meter was used to arrive at a serviceability index for each of these three projects. As you can see in the attached summary, the projects have a very pleasing ride and do not show any indication of swells or base failures. This is satisfying because the recycled asphaltic stabilized base only has approximately 2½" of riding surface, including a leveling coarse.

Another test used was the Dynaflect testing for performance of the pavement structure. Average results are shown on the attached tables. It appears that job number 2 has a lower stiffness coefficient than the other two projects. This could explain some minor rutting taking place on this project. It is our opinion that high stiffness coefficients are <u>not</u> necessarily good on a flexible pavement designed highway. In all our records we find the higher stiffness coefficients on concrete pavements or on deep pavement designs. Records of Dynaflect data were collected and studied from all over the State and it was our conclusion that the coefficients in the range of .6 was the better range for our type design. In our opinion, the last project completed has a .71 average and this could lead to a pavement cracking problem if our theory is correct.

It is impossible to look at the three completed projects and detect that they are recycled projects. All the tests conclude that the performance is normal for a new project and as far as public opinion is concerned we are doing what is expected in the recycling age. We believe these projects are excellent and we intend to keep on rehabilitating our highways by using the materials that have already been paid for.

APPENDIX A

RECYCLE CONSIDERATIONS

RECYCLE CONSIDERATIONS

DEFINITION: RECYCLE - TO PASS AGAIN THROUGH A SERIES OF CHANGES OR TREATMENTS AS: TO RETURN TO AN ORIGINAL CONDITION SO THAT OPERATION CAN BEGIN AGAIN.

CONSIDERATIONS:

1. WHY DID THIS HIGHWAY FAIL?
2. IS RECYCLING GOING TO CURE THE FAILURE?
3. HAVE I DONE MY HOMEWORK AND DETERMINED THAT THIS MATERIAL IS RECYCLABLE?
4. DO MY CONTRACTORS AND STATE EMPLOYEES HAVE THE ABILITY AND EQUIPMENT TO RECYCLE?
5. DO NOT RECYCLE JUST TO BE RECYCLING!
6. DO NOT RECYCLE MATERIAL UNLESS YOU ARE SURE THAT IT IS RECYCLABLE!
7. DO NOT SETTLE FOR LESS THAN THE BEST, EVEN THOUGH IT IS RECYCLED!
8. IF IT IS NOT AN IMPROVEMENT, DON'T DO IT!
9. IF YOU BEGIN RECYCLING AND THE PRODUCT DOES NOT MEET EXPECTATIONS, PLEASE STOP!

CONCLUSIONS:

THE SINGLE MOST IMPORTANT FUNCTION IN RECYCLING IS TO DO YOUR HOMEWORK. CONSULT D-9, T.T.I., UT, AND ANYONE ELSE THAT MIGHT HELP YOUR PROJECT. THOSE AGENCIES ARE THERE TO HELP.

APPENDIX B

EVALUATION INFORMATION
ON SITE INSPECTION
September, 1982

RECYCLED PAVEMENT EVALUATION

OBSERVATION FROM ON-SITE INSPECTION
SEPTEMBER, 1982

PROJECT #1 - ROSCOE BYPASS

THIS SECTION OF ROADWAY IS IN GENERALLY GOOD CONDITION. THERE ARE SOME MINOR (LESS THAN ½") WHEELPATH DEPRESSIONS IN THE TRAVEL LANE. THESE DEPRESSIONS APPEAR TO BE THE RESULT OF TRAFFIC WEAR AND NOT DEFORMATION.

THIS SECTION IS IN A VERY FLAT AREA WITH DRAINAGE RUNOFF PROBLEMS. AS A RESULT THERE IS SOME LONGITUDINAL CRACKING, MOSTLY IN THE OUTSIDE SHOULDER, INDICATING SOME LOSS OF LATERIAL SUPPORT.

PROJECT #2 - ROSCOE TO SWEETWATER

THIS SECTION OF ROADWAY IS IN GENERALLY GOOD CONDITION. THERE ARE SOME MINOR (LESS THAN ½") WHEELPATH DEPRESSIONS IN THE TRAVEL LANE, AND SOME VERY MINOR (LESS THAN ¼") WHEELPATH DEPRESSIONS IN THE PASSING LANE.

THESE DEPRESSIONS OCCURRED SOON AFTER THE PROJECT WAS COMPLETED AND IT IS MY BELIEF THAT THEY ARE THE RESULT OF CONSOLIDATION IN THE SURFACE COURSE. AN ATTEMPT HAS BEEN MADE TO FILL THE WHEELPATHS IN THE WEST-BOUND TRAVEL LANE WITH FINE GRADED HMACCL MATERIAL.

THERE IS A SLIGHT AMOUNT OF LONGITUDINAL CRACKING IN THE OUTSIDE SHOULDER.

PROJECT #3 - TAYLOR COUNTY LINE, TO 6 MILES WEST

THIS SECTION IS IN VERY GOOD CONDITION.

THE EAST END OF THE PROJECT HAS DEVELOPED SOME INTERMITTENT LONGITUDINAL CRACKS IN THE WESTBOUND LANE. THESE CRACKS OPENED DURING THE FIRST COLD WEATHER AFTER COMPLETION OF THE PROJECT. THEY WERE SEALED AT THAT TIME AND HAVE NOT SHOWN ANY FURTHER PROBLEM. THEY APPEAR TO BE OVER A LONG-ITUDINAL CONSTRUCTION JOINT IN THE UNDERLYING ASB.

A FEW SHORT AREAS ARE SHOWING VERY SLIGHT WHEELPATH DEPRESSIONS. THEY ARE PROBABLY THE RESULT OF SURFACE COURSE CONSOLIDATION.

APPENDIX C

JOB DESCRIPTIONS

#1 IH-20, ROSCOS BYPASS
#2 IH-20, ROSCOE TO SWEETWATER
#3 IH-20, TAYLOR C/L TO 6 MILES WEST

JOB NO. 1

PROJECT I 20-2(114)235
CONTROL 6-2-54
IH-20
NOLAN COUNTY

LIMITS: 1 MILE SOUTHWEST OF ROSCOE
TO: 1.5 MILES EAST OF ROSCOE
LENGTH: 2.935 MILES

WORK BEGAN: JULY 5, 1977
WORK COMPLETED: JUNE 16, 1978

RECYCLED ITEMS

ITEM	PROPOSED TONS	FINAL TONS
3052 ASPH (AC-3)	1,458	1,303
3052 ASPH ADDITIVE	132	11
3052 SALV MATL	43,455	41,167
3052 AGGR (COARSE)	7,949	7,348

RECYCLED DESIGN DEPTH

8" RECYCLED BITUMINOUS MATERIAL
10" EMULSION TREATED EXISTING BASE

TOTAL TRAFFIC

ESTIMATED 6,200,000 VEHICLE LOADS
APPROXIMATELY 30% TRUCKS OR 1,860,000 TRUCKS

JOB NO. 2

PROJECT I 20-2(107)238

CONTROL 6-2-57

IH-20

NOLAN COUNTY

LIMITS: 1.5 MILES EAST OF ROSCOE

TO: 4 MILES WEST OF SWEETWATER

LENGTH: 2.106 MILES

WORK BEGAN: MARCH 20, 1978

WORK COMPLETED: JUNE 11, 1979

RECYCLED ITEMS

ITEM	PROPOSED TONS	FINAL TONS
3084 ASPH (AC-3)	789	982
3084 ASPH ADDITIVE	394	189
3084 SALV MATL	32,352	34,466
3084 AGGR (COARSE)	5,918	6,072

RECYCLED DESIGN DEPTH

8" RECYCLED BITUMINOUS MATERIAL

10" EMULSION TREATED EXISTING BASE

TOTAL TRAFFIC

8,295,000 WHEEL LOADS 30% TRUCKS

2,488,500 TRUCK LOADS

JOB NO. 3

PROJECT FRI 20-2(122)254
CONTROL 6-3-76
IH-20
NOLAN COUNTY

LIMITS: FROM 6 MILES WEST OF TAYLOR COUNTY LINE
TO: TAYLOR COUNTY LINE
LENGTH: 6.002 MILES

WORK BEGAN: NOVEMBER 15, 1979
WORK COMPLETED: JULY 2, 1981

RECYCLED ITEMS

ITEM	PROPOSED TONS	FINAL TONS
3089 ASPH (AC-3)	2,531	2,626
3089 ASPH ADDITIVE	527	271
3089 SALV MATL	86,574	86,800
3089 AGGR (COARSE)	15,818	25,165

RECYCLED DESIGN DEPTH

APPROXIMATELY 6" LIME TREATED EXISTING BASE
7.5" RECYCLED BITUMINOUS MATERIAL

TOTAL TRAFFIC

3,187,500 WHEEL LOADS 30% TRUCKS
956,250 TRUCK LOADS

APPENDIX D

MIX DESIGN INFORMATION

RECYCLED PAVEMENT EVALUATION

RESULTS OF EXTRACTION TESTS

CORES TAKEN FROM ROADWAY

AUGUST, 1982

GRADATION

SIZE	PROJECT #1 ROSCOE BYPASS ACCUM. % BY WT. ON 100% AGGR.	PROJECT #2 ROSCOE TO SWEETWATER ACCUM. % BY WT. ON 100% AGGR.	PROJECT #3 TAYLOR C/L, TO 6 MILES WEST ACCUM. % BY WT. ON 100% AGGR.	AVERAGE 292 GR.4 ACCUM. % BY WT. ON 100% AGGR.
+1"	0	0	0	5.0
+7/8"	4.9	2.2	6.3	10.0
+5/8"	8.8	5.8	9.5	20.0
+1/2"	12.3	9.6	13.3	27.0
+3/8"	15.9	13.5	17.7	35.0
+4	34.2	36.9	39.4	53.0
+10	52.0	55.8	56.8	63.0
+40	69.7	72.4	72.2	80.0
-40	30.3	27.6	27.8	20.0
ASPHALT	6.8%	7.1%	7.6%	

RESULTS OF TESTS PERFORMED ON ASPHALT RECOVERED FROM CORES

	PROJECT #1	PROJECT #2	PROJECT #3
VISCOSITY @ 140°F	STOKES = 1158	STOKES = 4443	STOKES = 1319
PENETRATION @ 77°F	78	40	66
DUCTILITY @ 77°F	CM = 141	CM = 141	CM = 141

APPENDIX E

ROUGHNESS PERFORMANCE

PERFORMANCE EVALUATION - RECYCLED ASPHALTIC MIXES

SUMMARY - SERVICEABILITY INDEX

AS DETERMINED BY THE MAYS METER

TESTING PERFORMED AUGUST, 1982

	AVERAGE SERVICEABILITY INDEX			
	WEST LANE		EAST LANE	
	TRAVEL	PASS	TRAVEL	PASS
PROJECT #1 - ROSCOE BYPASS	4.25	4.30	4.20	3.75
PROJECT #2 - ROSCOE TO SWEETWATER	4.35	4.32	4.35	4.45
PROJECT #3 - TAYLOR C/L, 6 MILES WEST	4.50	4.50	4.20	4.50

APPENDIX F

DEFLECTION PERFORMANCE

RECYCLED PAVEMENT EVALUATION

RESULTS OF DYNAFLECT TESTING

TESTING PERFORMED AUGUST, 1982

SCI = SURFACE CURVATURE INDEX

AS2 = STIFFNESS COEFFICIENT OF SUBGRADE

AP2 = STIFFNESS COEFFICIENT OF PAVEMENT

	LANE	AVERAGE SCI	AVERAGE AS2	AVERAGE AP2
PROJ. #1 - ROSCOE BYPASS	E-B TRAVEL	0.180	0.24	0.55
	W-B TRAVEL	0.166	0.25	0.55
PROJ. #2 - ROSCOE TO SWEETWATER	E-B TRAVEL	0.200	0.25	0.50
	W-B TRAVEL	0.153	0.25	0.54
PROJ. #3 - TAYLOR C/L, 6 MILES WEST	E-B TRAVEL	0.091	0.26	0.71
	W-B TRAVEL	0.137	0.25	0.66