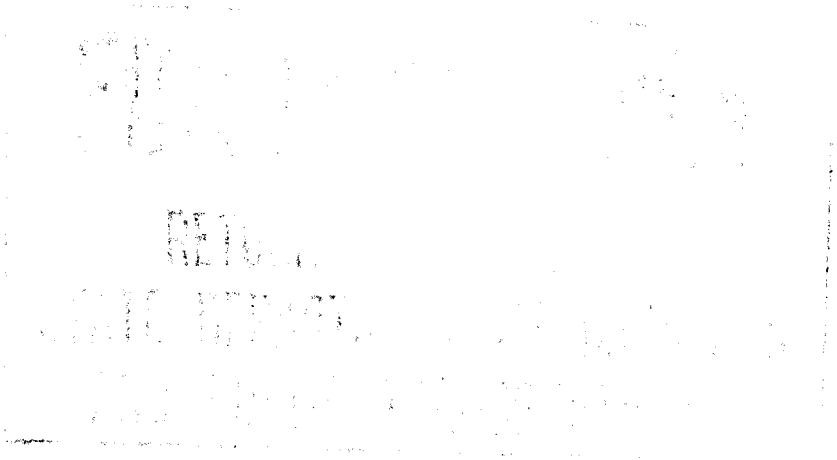
Demonstration Projects Program
Technology Transfer
FHWA-DP-39-11
March 1979

DEMONSTRATION PROJECT NO. 39

RECYCLING ASPHALT PAVEMENTS

Roscoe, Texas



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REGION 15
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NOTICE

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

AND

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
DEMONSTRATION PROJECTS DIVISION
REGION 15

DEMONSTRATION PROJECT 1-8D-77-527
RECYCLING ASPHALTIC CONCRETE PAVEMENT

by

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State Department of Highways & Public Transportation

DISCLAIMER STATEMENT

The contents of this report reflect the views of the authors who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration. This report does not constitute a standard, specification, or regulation

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CHAPTER I
INTRODUCTION

As the nation faces a growing energy shortage and a concomitant shortage of road materials, transportation departments at all levels are re-evaluating present construction methods. The Texas Department of Highways and Public Transportation is no exception. Project 214, also called "Engineering, Economy and Energy Considerations in Design, Construction and Materials," is a study made by the department on the efficient allocation of energy, material, and financial resources.[1] As a result of the study, a small experimental recycling project was initiated by the department in 1974 near McAllen, Texas.

PAST METHODS

Concurrent with the McAllen experiment, a contract was under way north of Snyder, Texas on U.S. 84 in the Abilene District. The design criteria of the project was typical of past methods used in correcting deterioration problems on the highway system in the district. The design called for an overlay of 3 inches of asphalt stabilized base and 1-1/2 inches of asphaltic concrete pavement; a type of rehabilitation that has been used for the past four or five years in the Abilene area with moderate success. The cracked pavement eventually reappears however, providing a limited solution to the problem. Before the recycling concept, the best alternative to the overlay procedure was to remove all the old pavement, reshape and

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[1] "Engineering, Economy and Energy Considerations in Design, Construction and Materials," Texas Department of Highways & Public Transportation and Texas Transportation Institute, Texas A & M University, Cooperative Research Project 2-9-74-214.

restore the base, and replace the entire surface with approximately 5 inches of asphalt materials. This has proven to be not only expensive and wasteful, but also harmful to the environment as the old pavement had to be buried or deposited in open areas.

FIRST ATTEMPT AT RECYCLING IN DISTRICT 8

Because of the possibilities observed at the McAllen recycling project, a request was approved to explore recycling on the ongoing U.S. 84 overlay project. Under a revised contract agreement, the contractor was to remove approximately 1/2 mile of the existing asphaltic concrete pavement, crush, heat, and relay the material as an asphalt stabilized base. To reach the required asphalt content, additional asphalt was added ranging from 1 percent AC-10 to 4 percent EA-11M emulsion.[2] Roadway results were satisfactory--mix appearance as well as workability were both good.

The hot-mix plant used on this project was a standard plant with a bag filter system. The pollution problems were intense. The asphalt particles clogged and eventually destroyed the entire set of filtration bags causing 100 percent stack emissions. The standard plant was then replaced with a drum-dryer plant. Stack emission problems still persisted. After varying the percent mixtures of different types of asphalt, moisture content, and percents of new aggregate with the salvaged material, it was determined that modifications of the plant would have to be made to meet Texas Air Control Board standards.

In succeeding years, equipment manufacturers began development of pollution-free recycling systems. After observing experiments throughout the United States and witnessing the successful

[2]Texas Highway Department, 1972 Standard Specifications for Construction of Highways, Streets and Bridges. Adopted by the State Highway Department of Texas, January 3, 1972.

efforts of two separate systems, a request was approved for a complete rehabilitation project on Interstate 20 at Roscoe, Texas.

Because of the experimental nature of the project, a Pre-Bidders Conference was held in the District Office in Abilene on March 10, 1977 to give interested contractors an opportunity to discuss possible problems and to offer comments for project improvements. The following contractors were present and expressed interest in the project:

Abilene Paving Company, Inc.	Abilene, Texas
Ashland Oil, Inc.	Cambridge, Mass.
Bailey Bridge Company, Inc.	Abilene, Texas
Cooper & Woodruff, Inc.	Amarillo, Texas
Dahlstrom Corporation	D/FW Airport, Texas
Jagoe-Public Company	Denton, Texas
J. H. Strain & Sons, Inc.	Tye, Texas
Jones Bros. Rental Equip. Co., Inc.	Odessa, Texas
Strain Brothers, Inc.	San Angelo, Texas
Texas Bitulithic Company	Dallas, Texas
H. B. Zachry Company	San Antonio, Texas

On March 24, 1977, the contract was let to J. H. Strain & Sons, Inc. for $1,724,262.61. Other bidders on the project were Cooper & Woodruff, Inc., and Ashland Oil, Inc. Work began on this project July 5, 1977.

CHAPTER II

DESIGN CRITERIA

COMPUTERIZED ANALYSIS

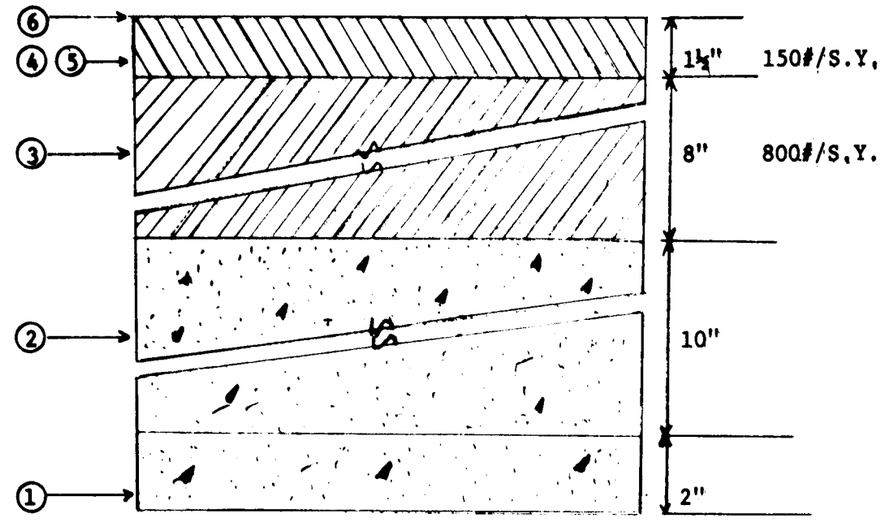
The highway department computer program, "Flexible Pavement Design System," was used in determining pavement design for the recycling project.[1] Major variables considered in the pavement design program are freeze-thaw cycles, annual rainfall, soil types, vertical rise of soil, traffic volume and related axle weights, and expected pavement life. Other less significant values must also be considered in the design program. (See Technical Appendix I)

Design criteria for the section was determined to be 8 inches of asphalt stabilized base, 10 inches of flexible base, and 1-1/2 inches of asphaltic concrete pavement overlay for a riding surface. (See Figures 1, 2, and 3)

HISTORY OF EXISTING PAVEMENT STRUCTURE

A complete soil and roadway materials analysis was made on the 2.9 mile section of I.H. 20 which was selected as the site for the recycling project. Samples of existing roadway materials were sent to the Materials and Test Division of the Texas Department of Highways and Public Transportation in Austin, Texas, the Texas Transportation Institute in College Station, Texas, and the Center for Highway Research at the University of Texas in Austin, Texas. Evaluations of the various test results are included in this report. (See Technical Appendix II)

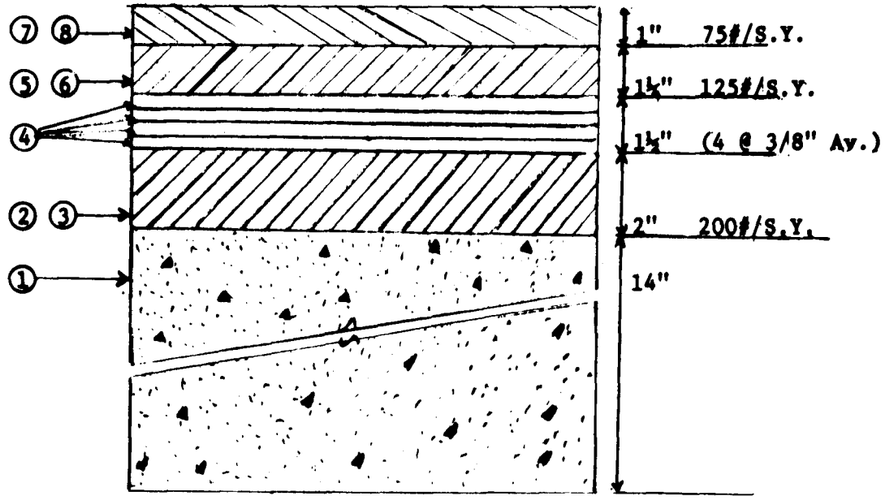
[1]Texas Highway Department, Part I - Flexible Pavement Design Manual, Highway Design Division, 1972.



1. Item 215 & spl. Exist Flex Base left in place.
2. Item 2037 Asph Treat of Exist Base (Road Mix)
3. Item 3052 Salv & Re-cycling Bituminous Materials (Hot)
4. Item 340 Asph (AC)
5. Item 340 Aggr (Ty D)
6. Item 3051 Sprinkle Treatment (For Asph-Conc Pave)

Fig. 1 Proposed Pavement Structure

*SOURCE: Texas Highway Department - 1972 Standard Specifications for Construction of Highways, Streets and Bridges, Adopted by the State Highway Department of Texas on January 3, 1972.



① Flex. Base
② Asph (?)
③ Aggr (Ty D) } Original Construction (10/58)

④ Seal Coat (8/61) Asph (OA-135), Aggr (PA)(Ty B Gr 5 Mod)
④ Seal Coat (9/62) Asph (OA-135), Aggr (Ty A Gr 4)
④ Seal Coat (9/64) Asph (AC-10), Aggr (Ty PB Gr 4 Mod)
④ Seal Coat (9/68) Asph (?), Aggr (Ty PB Gr 4 Mod or Lt. Wt. Gr 4 Mod)

⑤ Asph (AC)
⑥ Aggr (Ty D) } Asph Concrete Level Up (1/73)

⑦ Asph (AC)
⑧ Aggr (Ty A) } Lt. Wt. Overlay (1/73)

Fig. 2 Existing Pavement Structure

BATCH DESIGNS
FOR
ASPHALT STABILIZED BASE MATERIAL
ITEM #3057

Mixture made up of the following materials:

1. Salvaged Pavement
2. Salvaged Flexible Base
3. New Coarse Aggregate
4. Asphalt

Design No.	% 1. Mtl.	% 2. Mtl.	% 3. Mtl.	% 4. Mtl.	Type New Asph.	% New Asph. added to 100% Aggr.
1	67.65	15.69	14.70	1.96	AC-3	2.0
2	67.48	15.65	14.67	2.20	AC-3	2.25
2A	67.48	15.65	14.63	2.44	AC-5	2.25
3	67.12	15.61	14.60	2.72	AC-3	2.8
4	67.00	15.53	14.56	2.91	AC-3	3.0

Figure 3

In general, the existing asphaltic concrete pavement material contained approximately 5.8 percent asphalt. Existing pavement aggregate had retained its original quality. Maximum particle size of the aggregate was 3/8 inch.

PAVEMENT DESIGN DETERMINATIONS

To produce an asphalt stabilized base from the salvaged material, Item 292, "Asphalt Stabilized Base," as described in the Texas Highway Department's standards and specifications, was used as a control.[2] Since the existing pavement was only 5-3/4 inches deep, additional existing flexible base (approximately 2 inches) was included to make up the 8 inches called for in the design. A mixture of 70 percent salvaged pavement, 20 percent coarse aggregate additive, and 10 percent salvaged base was used to produce the asphalt stabilized base. Laboratory tests indicated the remaining untreated limestone base, exposed by removal of the top 7-1/2 inches, contained an excessive amount of fine particles. The tests also indicated that the existing base could meet design specifications by compaction. A 4 percent solution of emulsified asphalt would waterproof the existing base and give it the desired stability.

Laboratory tests indicated that 2.5 percent high penetration, (AC-3), asphalt would be sufficient to coat the additional aggregate and soften the existing asphalt. Such an addition would raise the penetration of the residual asphalt from approximately 20± to mid 50, adequate for asphalt stabilized base.

[2]Texas Highway Department, 1972 Standard Specifications for Construction of Highways, Streets and Bridges. Adopted by the State Highway Department of Texas January 3, 1972.

CHAPTER III
CONSTRUCTION PROCEDURE

I.H. 20 traffic was removed from the lane under construction to allow complete freedom of operations. The entire section was speed-zoned to 40 MPH.

PAVEMENT REMOVAL & SUBGRADE PREPARATION

The existing asphaltic concrete pavement and approximately 2 inches of the flexible base was scarified with ripper teeth mounted on the rear of a D-14 motor grader.* The scarified material was bladed into a windrow and picked up with a front-end loader and transported three miles to the crushing location.*

After removal of the required surface and base material, the contractor disk-plowed the remaining base material to loosen it for penetration of an asphalt emulsion. The emulsion application varied depending on air temperature and moisture content of the base material. The emulsion was plowed into the base material and mixed with a high speed mixer to a depth of 10 inches.* Three mixing cycles were required for uniform mixing. The base material was then compacted with a vibrating roller. Test holes were periodically cored to observe the condition of the base for uniform mixing and mixing depth. Rolling patterns and density tests throughout the project were obtained with a nuclear density machine. The base was shaped to grade and a light solution of emulsion was applied for a prime coat. The tests and their results were recorded by the field inspector for depth documention.

* See pictures at end of chapter.

The base material and asphaltic concrete pavement removed from the roadway were stockpiled together at the beginning of the project. This procedure, however, proved unsatisfactory. Removing the base and existing surface together was discontinued because the base tended to segregate in the stockpile producing a nonuniform material after crushing. After isolating the segregation problem, the 2 inches of existing flexible base was stockpiled separately.

A jaw-type crushing unit was used successfully--no gumming of the crusher jaws occurred.* A cone crusher had been tried at another location in the district with unsuccessful results as the cone tends to "pancake" the material instead of breaking it down. A recrushing of all asphalt particles exceeding the 1-1/2 inch maximum was required.

MIX-PLANT OPERATIONS

The mix plant for this project was a Boeing Drum-Dryer Plant* which had been modified to avoid the pollution problems encountered on the district's first recycling attempt on U.S. 84 north of Snyder.

A thermal shield made from high alloy steel was placed in front of the burner in the dryer to disperse the flame evenly, creating a uniform distribution of heat.* In addition, the shield prevented the materials from being exposed directly to the flame.

Modification was required on the feed-belt system into the drum since the standard system dropped the crushed material and mix ingredients directly into the open flame.* The feeder belt was moved from the top of the drum to the bottom where materials could be induced into the drum beneath the flame. The feeder belt change greatly reduced pollution problems.

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* See pictures at end of chapter.

The lower end of the Boeing Plant was covered with 3 inches of high-quality insulation to prevent heat loss and to create a more uniform temperature range throughout the drum.* The insulation was covered with metal to hold it in place. A variable choke venturi was installed in the duct work between the drum and the wet scrubber dust collector.* Each side of the venturi was equipped with sixteen high pressure spray nozzles to knock out dust particulate as it passed through the ducting. The only other modification to the plant was water nozzles on the belt in front of the entrance to the plant that saturated the fine asphalt particles before they entered the plant. This process prevented the particles from drying too rapidly in the intense heat.

AIR QUALITY CONTROL

After all plant modifications, the stack output was running 40 percent opacity which would not pass Air Control Board standards. In an effort to reduce opacity, the moisture content of the crushed pavement was increased by watering the stockpile with a watertruck. Tests indicated that 6 percent moisture in the recycled mix solved the opacity problem; the stack readings were well within the standards of the Air Control Board and the problem of excessive moisture retention in the mix was not encountered.

Two separate stack samples were taken by the Air Control Board during this project--one September 21 and 22, 1977, and another on November 2, 1977. The results of the September test showed a concentration of .0977 grains per dry standard cubic foot, falling short of the Air Control Board specifications of .04 grains. The November test results showed .0645 grains, again not conforming to Air Control Board specifications. The failure in both tests was due to

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* See pictures at end of chapter.

vaporized asphalt, rather than dust particles, collecting on the test filters in the plant. Portions of these stack sample results are included in this report. (See Technical Appendix IX)

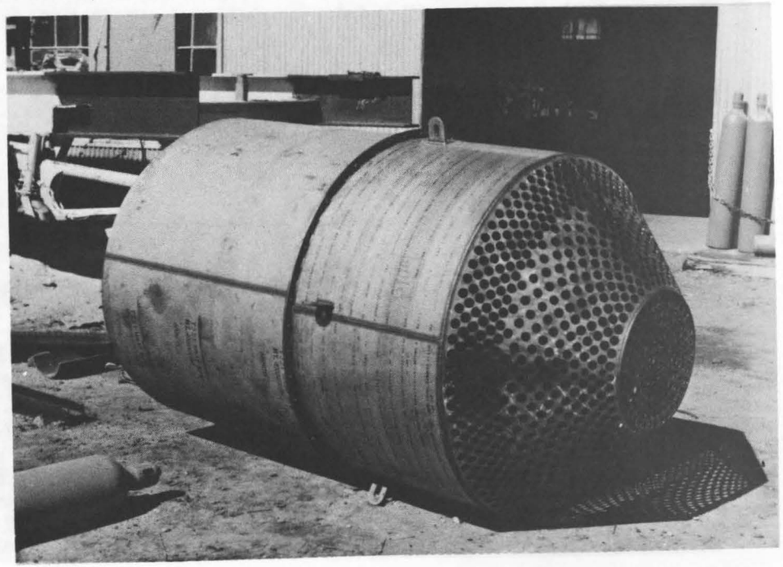
As a result of the data gathered in the two stack sample tests, equipment alterations and new methods of material manipulation will be implemented in future recycling projects in a concerted effort to reduce the particulate to conform to Air Control Board standards.

Picture #1 - Ripper teeth mounted on the rear of a D-14 motor grader.

Picture #2 - Scarified material bladed into a windrow.

Picture #3 - High speed mixer used to mix emulsion into existing base material.

Picture #4 - Modified Boeing Drum-Dryer Plant

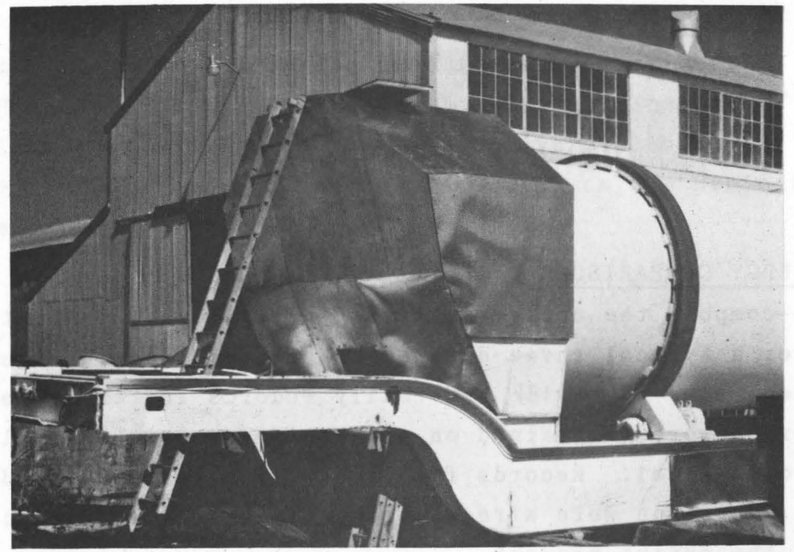


Picture #5 - Thermal shield made from high alloy steel

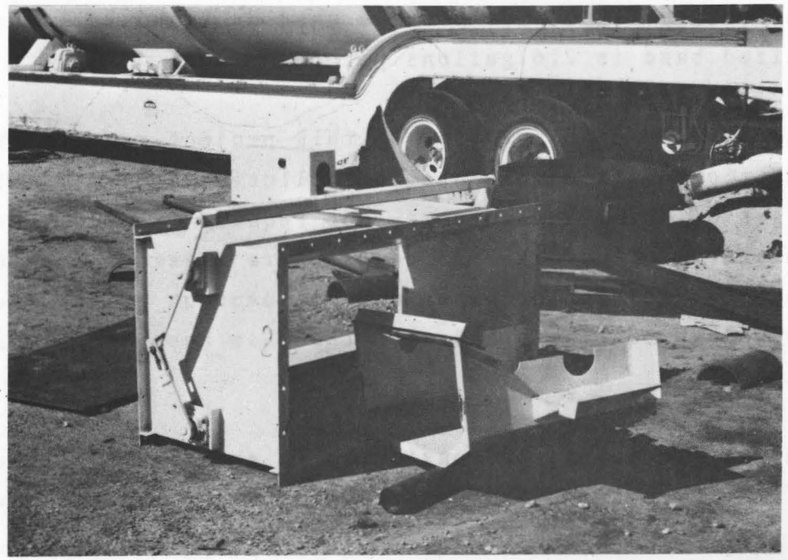
Picture #6 - Feed-belt inducing materials into bottom of drum beneath flame.

Picture #7 - Crushing Unit

Picture #8 - Belt Feed to Boeing Plant



Picture #9 - Insulation on lower end of Boeing Plant to prevent heat loss



Picture #10 - Variable choke venturi

CHAPTER IV
ENERGY ANALYSIS

ENERGY COMPARISONS

To compute the energy analysis, actual fuel consumption over a typical three day period of operations was recorded. (See Pages 17 and 18) Daily records for the three day period were maintained on all equipment using diesel and propane fuel. Records for propane fuel use on the dryer in the plant were already being maintained for the length of the entire project.

While the overall energy consumption for recycled base is less than that of standard asphaltic stabilized base, the propane fuel used in the plant dryer with recycled material exceeded the amount of fuel needed for standard asphaltic stabilized base. The plant used on this project consistently used 3 gallons of propane per ton of recycled material. An average figure for propane used on standard asphaltic stabilized base is 2.6 gallons per ton of mix.

The drum-dryer plant used on this project requires the addition of free moisture for pollution control. Other types of hot-mix plants may not require the addition of moisture in the mix. In cases where moisture does not have to be added, the propane fuel consumption of the recycle method versus the standard method has been found to be very close.

Another factor to be considered in establishing amounts of energy consumption on a project is availability of a

base source. There was a base source in close proximity to the I.H. 20 project making the haul distances for both the recycle method and the standard method very close. The greater the distance of the base source from the project, the greater the savings from recycling.

BASIS FOR ENERGY CALCULATIONS*

CRUSHING UNIT:

Major Equipment - D-353 Cat Power Unit
D-343 Cat Generator Set (200 kw)
966 Loader
621 Cat Scraper
D- 6 Cat Dozer (1/2 time)
F-600 Ford Water Truck
F-600 Ford Service Truck

Diesel Consumed- 425 gal/day
Production of Recycled Material- 1500 ton/day
Fuel Consumption- 0.28 gal/ton

DRYER SUPPORT EQUIPMENT:

Major Equipment - D-398 Cat Electrical Unit
980-B Cat Loader
F-600 Ford Water Truck

Diesel Consumed- 500 gal/day
Production of Recycled Material- 800 ton/day
Fuel Consumption- 0.62 gal/ton

NOTE: The consumption rate is high for this operation because this is the total energy source for the plant operation. This power plant runs continuously whether in production or not.

BOEING DRYER DRUM:

Major Equipment - Boeing 600 Heater

Propane Consumed- 3500 gal/day
Production of Recycled Material- 1156 ton/day
Fuel Consumption- 3.00 gal/ton

* Production and consumption quantities are averages based on three days of production.

LOAD AND TRANSPORT BASE:

Major Equipment - 14-G Cat Blade
12-F Cat Blade
Ford F-150 Mechanic Truck
GMC Service Truck
11-Various Capacity Dump Trucks
2-966 Cat Loaders
1-980 Cat Loader

Diesel Consumed- 2002 gal/day
Material Transported- 9975 tons
Fuel Consumption- 0.2 gal/ton

HAUL AND PLACE RECYCLE MIX:

Major Equipment - Barber Green Laydown Machine
Cedar Rapids Laydown Machine
Tampo Pneumatic Roller
Tampo Vibrating Roller
GMC Service Truck
F-100 Sign Truck
F-100 Foreman Truck
7-12 CY Tandem Dump Trucks

Fuel Consumed- 884 gal/day
Production of Recycled Material- 2679 tons
Fuel Consumption- .33 gal/ton

ENERGY REQUIREMENTS
FOR RECYCLED ASPHALT STABILIZED BASE

MATERIALS:

Asphalt Cement (2.8%)		
Manufacture 1 Ton Asphalt Cement (100%)	=	587,500 Btu/t
Haul 70 Mi. X 2 @ 3,270 Btu/t	=	457,800 Btu/t
Total		1,045,300 Btu/t
1,045,300 Btu/t X 2.8% Asph. in Mix	=	29.269 Btu/t
Salvage Base (20%)		
Load & Haul Base 0.2 Gal/t		
0.2 Gal/t X 139,000 Btu/gal X .20	=	5,560 Btu/t
97.2% X 5,560 Btu/t	=	5,404 Btu/t
Crushed Rock Additive (15%)		
4 Mi. Haul X 2 X 3,800 Btu/t	=	30,400 Btu/t
.28 Gal Fuel/t X 139,000 Btu/gal	=	38,920 Btu/t
Total		69,320 Btu/t
69,320 Btu/t X .15	=	10,398 Btu/t
97.2% X 10,398 Btu/t	=	10,107 Btu/t
Crushed Bituminous Materials (65%)		
Scarify & Transport (avg. 3 mi)		
0.2 Gal. Fuel/t X 139,000 Btu/gal	=	27,800 Btu/t
Crush Bit. Conc. & Stockpile		
.28 Gal Fuel/t X 139,000 Btu/gal	=	38,920 Btu/t
Total		66,720 Btu/t
66,720 Btu/t X .65	=	43,368 Btu/t
.972 X 43,368 Btu/t	=	42,153 Btu/t

PLANT OPERATION:

Propane Fuel for Dryer		
3 Gal/t X 91,000 Btu/gal	=	273,000 Btu/t
Plant Support Equipment		
0.62 Gal/t X 139,000 Btu/gal		86,180 Btu/t
Total		359,180 Btu/t

HAUL AND PLACE MIX (avg. 3 mi)

0.33 Gal Fuel/t Mix X 139,000 Btu/gal	=	45,870 Btu/t
TOTAL ENERGY CONSUMED		491,983 Btu/t

SOURCE: Basic energy calculations taken from "Energy Requirements For Roadway Pavements,: The Asphalt Institute, Asphalt Institute Building, College Park, Maryland 20740, MISC-75-3, April 1975.

ENERGY REQUIREMENTS
FOR STANDARD ASPHALT STABILIZED BASE

MATERIALS

Asphalt Cement (6.5%)		
Manufacture 1 Ton Asphalt Cement (100%)	=	587,500 Btu/t
Haul 70 Mi. X 2 @ 3,270 Btu/t	=	457,800 Btu/t
Total		1,045,300 Btu/t
1,045,300 Btu/t X .065 Asph. in Mix	=	67,945 Btu/t
Crushed Limestone		
0.28 Gal Fuel/t X 139,000 Btu/gal	=	38,920 Btu/t
38,920 Btu/t X 93.5%	=	36,390 Btu/t

WASTED OLD PAVEMENT

Scarify & Haul Waste Pavement		
0.2 Gal Fuel/t X 139,000 Btu/gal	=	27,800 Btu/t

PLANT OPERATIONS

Propane 2.6 Gal Fuel/t X 91,000 Btu/gal	=	236,600 Btu/t
Plant Support Equipment		
* 500 Gal/day Fuel / 1500 Ton/day = .33 Gal/t		
.33 Gal/t X 139,000 Btu/gal	=	45,870 Btu/t
Total		282,470 Btu/t

HAUL AND PLACE

** 7 mile / 3 mile X .33 Gal/t X 139,000 Btu/gal	=	107,030 Btu/t
TOTAL ENERGY CONSUMED		521,635 Btu/t
TOTAL ENERGY SAVED PER TON OF RECYCLED MIX	=	29,652 BTU
29,652 BTU / 521,635 Btu/t	=	5.7 SAVED

SOURCE: Basic energy calculations taken from "Energy Requirements For Roadway Pavements," The Asphalt Institute, Asphalt Institute Building, College Park, Maryland 20740, MISC-75-3, April 1975.

* 1500 Ton/day is the average production for this area.

** Virgin materials processed 7 miles from the job site rather than 3 miles. This conversion is used to extend energy consumed because of the additional miles.

CHAPTER V
SUMMARY AND CONCLUSION

The I.H. 20 project in Nolan County confirmed other evidence that the pavement recycling concept is a reality and will in fact save energy and raw materials. Although a 6 percent energy savings on a project of this magnitude is not an overwhelming figure, it is meaningful. Inherent factors of the project itself such as base source location, type of plant used, etc., reduced energy savings. New construction materials saved due to recycling was approximately 50 percent - a significant savings.

Traffic was carried directly on the recycled base for several months. The riding surface was not smooth, but structural strength was evident since there were no failures in the base.

Visual emissions were never a problem during this project, however, particulate count on two tests did not meet the required .04 grains per standard cubic feet. Meeting particulate standards is a problem on any project regardless of the type materials used. After modifications in plant operation and equipment adjustments, tests performed indicated a large improvement in emissions control. However, required specifications have still not been met. Further modifications are showing indications of solving this problem.

The standard Texas methods of rating flexible pavements

were applied to the finished product, resulting in an overall high rating in each case.[1] Skid resistance values on the pavement were well above average.[2] Rolling sequence patterns required to produce optimal compaction were normal.

During the project, one load of softening agent (Paxole) was mixed with asphalt at a rate of one part agent to two parts AC-3. Dramatic changes were observed in the mix with the softening agent.[3] Density was easily obtained, workability increased, and the mix had the appearance of standard asphalt stabilized base. The use of a softening agent produces a smoother riding surface for construction traffic. Due to these findings, softening agents will be required on future recycle projects in District 8.

The results of this project and the data gathered shows that recycling of old asphaltic concrete pavement is a viable construction procedure. Evidence indicates that the future in recycling will yield tremendous savings in energy and natural resources, without sacrificing quality in pavement strength or design.

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[1] Technical Appendix VII
[2] Technical Appendix III
[3] Technical Appendix V

APPENDIX I

PAVEMENT DESIGN

TEXAS HIGHWAY DEPARTMENT
PPS - 11
FLEXIBLE PAVEMENT DESIGN

PROB	DIST.	COUNTY	CONT.	SECT.	HIGHWAY	DATE	IPE	PAGE
22	8	NOLAN	0	2	IH-20	12/28/76	183	1

COMMENTS ABOUT THIS PROBLEM

PROB NO 22 IS A RECYCLE THREE LAYER PAVE STR DES, WITH ASPH CONC PAVE, RECYCLE ASPH CONC PAVE, AND EMUL TREAT EXIST BASE (3.3 GAL EMUL/SY), WITH 1.0 IN PVR AND 0.50 SC ON EXIST BASE, MCCOY

BASIC DESIGN CRITERIA

LENGTH OF THE ANALYSIS PERIOD (YEARS)	20.0
MINIMUM TIME TO FIRST OVERLAY (YEARS)	6.0
MINIMUM TIME BETWEEN OVERLAYS (YEARS)	6.0
MINIMUM SERVICEABILITY INDEX PT	3.0
DESIGN CONFIDENCE LEVEL	9
INTEREST RATE OR TIME VALUE OF MONEY (PERCENT)	7.0

PROGRAM CONTROLS AND CONSTRAINTS

NUMBER OF SUMMARY OUTPUT PAGES DESIRED (8 DESIGNS/PAGE)	3
MAX FUNDS AVAILABLE PER 80.YD. FOR INITIAL DESIGN (DOLLARS)	20.00
MAXIMUM ALLOWED THICKNESS OF INITIAL CONSTRUCTION (INCHES)	19.5
ACCUMULATED MAX DEPTH OF ALL OVERLAYS (INCHES) (EXCLUDING LEVEL-UP)	4.0

TRAFFIC DATA

ADT AT BEGINNING OF ANALYSIS PERIOD (VEHICLES/DAY)	6860.
ADT AT END OF TWENTY YEARS (VEHICLES/DAY)	17205.
ONE-DIRECTION 20.-YEAR ACCUMULATED NO. OF EQUIVALENT 18-KSA	10343000.
AVERAGE APPROACH SPEED TO THE OVERLAY ZONE(MPH)	50.0
AVERAGE SPEED THROUGH OVERLAY ZONE (OVERLAY DIRECTION) (MPH)	20.0
AVERAGE SPEED THROUGH OVERLAY ZONE (NON-OVERLAY DIRECTION) (MPH)	50.0
PROPORTION OF ADT ARRIVING EACH HOUR OF CONSTRUCTION (PERCENT)	6.0
PERCENT TRUCKS IN ADT	30.0

ENVIRONMENT AND SUBGRADE

DISTRICT TEMPERATURE CONSTANT	26.0
SWELLING PROBABILITY	1.00
POTENTIAL VERTICAL RISE (INCHES)	1.00
SWELLING RATE CONSTANT	0.10
SUBGRADE STIFFNESS COEFFICIENT	0.83

TEXAS HIGHWAY DEPARTMENT
FPS = 11
FLEXIBLE PAVEMENT DESIGN

PROB	DIST.	COUNTY	CONT.	SECT.	HIGHWAY	DATE	IPE	PAGE
22	8	NOLAN	6	2	IH=20	12/28/76	183	2

INPUT DATA CONTINUED

CONSTRUCTION AND MAINTENANCE DATA
****

SERVICEABILITY INDEX OF THE INITIAL STRUCTURE	4.4
SERVICEABILITY INDEX PI AFTER AN OVERLAY	4.2
MINIMUM OVERLAY THICKNESS (INCHES)	1.0
OVERLAY CONSTRUCTION TIME (HOURS/DAY)	10.0
ASPHALTIC CONCRETE COMPACTED DENSITY (TONS/C.Y.)	1.80
ASPHALTIC CONCRETE PRODUCTION RATE (TONS/HOUR)	150.0
WIDTH OF EACH LANE (FEET)	12.0
FIRST YEAR COST OF ROUTINE MAINTENANCE (DOLLARS/LANE-MILE)	50.00
ANNUAL INCREMENTAL INCREASE IN MAINTENANCE COST (DOLLARS/LANE-MILE)	30.00

DETOUR DESIGN FOR OVERLAYS
****

TRAFFIC MODEL USED DURING OVERLAYING	3
TOTAL NUMBER OF LANES OF THE FACILITY	4
NUMBER OF OPEN LANES IN RESTRICTED ZONE (OVERLAY DIRECTION)	1
NUMBER OF OPEN LANES IN RESTRICTED ZONE (NON-OVERLAY DIRECTION)	2
DISTANCE TRAFFIC IS SLOWED (OVERLAY DIRECTION) (MILES)	2.00
DISTANCE TRAFFIC IS SLOWED (NON-OVERLAY DIRECTION) (MILES)	0.0
DETOUR DISTANCE AROUND THE OVERLAY ZONE (MILES)	0.0

PAVING MATERIALS INFORMATION
****

LAYER	MATERIALS CODE	NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A	ACP (TY D)	36.94	0.96	1.50	1.50	30.00
2	B	ASB (RECYCLE)	28.31	0.85	5.00	8.00	40.00
3	C	EMUL TRT EXIST BSE	10.63	0.80	10.00	10.00	90.00

TEXAS HIGHWAY DEPARTMENT
FPS = 11
FLEXIBLE PAVEMENT DESIGN

PROB	DIST.	COUNTY	CONT.	SECT.	HIGHWAY	DATE	IPE	PAGE
22	8	NOLAN	6	2	IH=20	12/28/76	183	3

FOR THE 1 LAYER DESIGN WITH THE FOLLOWING MATERIALS--

LAYER	MATERIALS CODE	NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A	ACP (TY D)	36.94	0.96	1.50	1.50	30.00
		SUBGRADE		0.83			

THE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO OBTAIN A STRUCTURE
THAT WILL MEET THE MINIMUM TIME TO THE FIRST OVERLAY RESTRICTION.

TEXAS HIGHWAY DEPARTMENT
FPS = 11
FLEXIBLE PAVEMENT DESIGN

PROB	DIST.	COUNTY	CONT.	SECT.	HIGHWAY	DATE	IPE	PAGE
22	8	NOLAN	6	2	IH=20	12/28/76	183	4

FOR THE 2 LAYER DESIGN WITH THE FOLLOWING MATERIALS--

LAYER	MATERIALS CODE	NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A	ACP (TY D)	36.94	0.96	1.50	1.50	30.00
2	B	ASB (RECYCLE)	28.31	0.85	5.00	8.00	40.00
		SUBGRADE		0.83			

THE CONSTRUCTION RESTRICTIONS ARE TOO BINDING TO OBTAIN A STRUCTURE
THAT WILL MEET THE MINIMUM TIME TO THE FIRST OVERLAY RESTRICTION.

TEXAS HIGHWAY DEPARTMENT
FPS = 11
FLEXIBLE PAVEMENT DESIGN

PROB	DIST.	COUNTY	CONT.	SECT.	HIGHWAY	DATE	IPE	PAGE
22	8	NOLAN	6	2	IH=20	12/28/76	183	5

FOR THE 3 LAYER DESIGN WITH THE FOLLOWING MATERIALS--

LAYER	MATERIALS CODE	NAME	COST PER CY	STR. COEFF.	MIN. DEPTH	MAX. DEPTH	SALVAGE PCT.
1	A	ACP (TY D)	36.94	0.96	1.50	1.50	30.00
2	B	ASB (RECYCLE)	28.31	0.85	5.00	8.00	40.00
3	C	EMUL TRT EXIST BSE	10.63	0.50	10.00	10.00	50.00
		SUBGRADE		0.23			

3 THE OPTIMAL DESIGN FOR THE MATERIALS UNDER CONSIDERATION--
FOR INITIAL CONSTRUCTION THE DEPTHS SHOULD BE
ACP (TY D) 1.50 INCHES
ASB (RECYCLE) 8.00 INCHES
EMUL TRT EXIST BSE 10.00 INCHES
THE LIFE OF THE INITAL STRUCTURE = 8. YEARS
THE OVERLAY SCHEDULE IS
2.50 (INCH(ES) (INCLUDING 0.5 INCH LEVEL-UP) AFTER 8. YEARS.
1.50 (INCH(ES) (INCLUDING 0.5 INCH LEVEL-UP) AFTER 15. YEARS.

TOTAL LIFE = 21. YEARS
SERVICEABILITY LOSS DUE TO SWELLING CLAY IN EACH PERFORMANCE PERIOD IS
(1) 0.184
(2) 0.073
(3) 0.036

THE TOTAL COSTS PER SQ. YD. FOR THESE CONSIDERATIONS ARE

INITIAL CONSTRUCTION COST	10.783
TOTAL ROUTINE MAINTENANCE COST	0.218
TOTAL OVERLAY CONSTRUCTION COST	2.051
TOTAL USER COST DURING OVERLAY CONSTRUCTION	0.076
SALVAGE VALUE	-1.390
TOTAL OVERALL COST	11.738

NUMBER OF FEASIBLE DESIGNS EXAMINED FOR THIS SET -- 2

AT THE OPTIMAL SOLUTION, THE FOLLOWING
BOUNDARY RESTRICTIONS ARE ACTIVE--
1. THE MINIMUM DEPTH OF LAYER 1
2. THE MAXIMUM DEPTH OF LAYER 1
3. THE MINIMUM DEPTH OF LAYER 3
4. THE MAXIMUM DEPTH OF LAYER 3
5. THE MAXIMUM THICKNESS OF INITIAL CONSTRUCTION

TEXAS HIGHWAY DEPARTMENT
FPS - 11
FLEXIBLE PAVEMENT DESIGN

PROB	DIST.	COUNTY	CONT.	SECT.	HIGHWAY	DATE	IPE	PAGE
22	8	NOLAN	6	2	IH-20	12/28/76	103	6

SUMMARY OF THE BEST DESIGN STRATEGIES
IN ORDER OF INCREASING TOTAL COST

	1	2
MATERIAL ARRANGEMENT	ABC	ABC
INIT. CONST. COST	10.78	10.39
OVERLAY CONST. COST	2.05	2.76
USER COST	0.08	0.10
ROUTINE MAINT. COST	0.22	0.22
SALVAGE VALUE	-1.39	-1.43
TOTAL COST	11.74	12.04
NUMBER OF LAYERS	3	3
LAYER DEPTH (INCHES)		
D(1)	1.50	1.50
D(2)	8.00	7.50
D(3)	10.00	10.00
NO. OF PERF. PERIODS	3	3
PERF. TIME (YEARS)		
T(1)	8.	7.
T(2)	15.	16.
T(3)	21.	24.
OVERLAY POLICY(INCH) (INCLUDING LEVEL-UP)		
O(1)	2.5	3.5
O(2)	1.5	1.5
SWELLING CLAY LOSS (SERVICEABILITY)		
SC(1)	0.18	0.17
SC(2)	0.07	0.10
SC(3)	0.04	0.04

+0.11/S.Y. For Sprinkle Treatment

THE TOTAL NUMBER OF FEASIBLE DESIGNS CONSIDERED WAS 2

APPENDIX II

EXISTING PAVEMENT TEST RESULTS

Table 1. Moisture Effects on Marshall Stability Before and After Recycling

Sample	Marshall Stability Before Lottman: Stability Value	Marshall Stability Before Lottman: Flow (In)	Sample	Marshall Stability After Lottman: % Water	Marshall Stability After Lottman: Stability Value	Marshall Stability After Lottman: Flow (In)
A7A	3182	13	A3A	5.0	1733	23
			A8A	4.7	982	16
			A9A	10.6	1400	15
Avg	3182	13	Avg	6.8	1372	18
			A4B	2.0	1499	21
			A6B	1.0	627	22
			A9B	0.0	866	25
Avg			Avg	3.0	998	23
			A2C		1043	21
			A5C	0.0	1019	28
			A8C		1122	21
Avg			Avg	0.0	1061	23
D2A	1264	23	D23A	3.1	327	34
D20A	1307	16	D42A	1.1	325	34
D33A	698	20	D60A	2.2	348	35
Avg	887	20	Avg	2.1	333	34
D11B	2630	21	D33B	0.0	432	46
D20B	1469	26	D36B	0.3	513	36
D29B	1176	25	D60B	0.0	396	44
Avg	1758	24	Avg	0.1	449	42
D11C	1595	21	D5C	1.6	495	32
D26C	1553	20	D42C	0.4	680	35
			D57C	0.3	528	46
Avg	1574	21	Avg	0.8	568	38

Table 2. Moisture Effects on Hveem Stability Before and After Recycling

		Hveem Stability: Before Lottman		Hveem Stability: After Lottman	
Sample	% Water	Stability Value	R Value	Stability Value	R Value
A5A		45	96	23	90
A8A	4.7	28	93	17	87
A9A	10.6	40	97	37	93
Avg	7.6	38	98	26	90
A4B	2.0	36	91	3	34
A6B	1.0	18	83	8	41
A9B	0.0	27	78	11	56
Avg	1.0	27	87	7	44
A2C		32	92	3	37
A5C	0.0	25	78	15	61
A8C		20	80	5	49
Avg	0.0	26	83	8	49
D23A	3.1	25	85	4	36
D42A	1.1	22	76	6	23
D60A	2.2	30	90	4	53
Avg	2.1	26	84	5	37
D33B	0.0	22	72	11	40
D36B	0.3	26	85	10	62
D60B	0.0	13	76		24
Avg	0.1	20	78	11	42
D5C	1.6	25	86	15	59
D42C	0.4	12	67	2	37
D57C	0.3	17	72	16	55
Avg	0.8	18	75	11	50

Table 3 . Temperature Effects on Resilient Moduli and Indirect Tension Data Before Recycling.

Sample	Resilient Modulus (10^6psi) -13°F	32°F	77°F	100°F	Indirect Tension Modulus (psi)	Stress (psi)	Strain (in./in.)
A1A	3.424	1.700	.7905	.4231			
A2A	2.085	1.513	.4195	.1541			
A3A	2.656	1.826	.8847	.5472			
A4A	2.843	1.436	.4842	.3322			
A5A	2.328	1.054	.3313	--			
A6A	2.105	1.621	.5885	.2586			
A7A	1.804	1.485	.6557	.3453			
A8A	2.741	1.474	.4253	.1584			
A9A	3.091	1.293	.5693	.3329			
A10A	2.776	1.301	.3100	.1893			
Avg	2.585	1.470	.5460	.3046			
A1B	--	--	--	--			
A2B	3.520	2.554	.8985	.3501			
A3B	2.825	1.796	.7877	.2465			
A4B	3.952	2.518	.8663	.3341			
A5B	2.470	2.716	.4883	.2968			
A6B	3.214	1.758	.5611	.1613			
A7B	2.842	1.987	.4410	.1426			
A8B	3.746	2.514	1.0912	.3299			
A9B	3.085	1.518	.3874	.1131			
A10B	3.831	2.551	.7436	.1589			
Avg	3.276	2.212	.6961	.2370			
A1C	3.318	2.396	1.122	.4231			
A2C	1.701	.9674	.3797	.2013			
A3C	--	--	--	--			
A4C	2.691	1.611	.5399	.1844			
A5C	2.804	1.988	.5438	.1764			
A6C	2.338	1.735	.4120	.1824			
A7C	--	--	--	--			
A8C	3.676	2.277	.8958	.1338			
A9C	3.488	2.191	1.022	.5109			
A10C	2.464	2.551	.5793	.2030			
Avg	2.810	1.946	.6868	.2519			

Table 4 : Moisture Effects on Resilient Elastic Properties Before and After Recycling

Sample	Lottman Procedure Vol(Dry) (cc)	Vol(SSD) (cc)	% H_2O (%)	Before Lottman Resilient Modulus (10^6 psi) 77°F	After Lottman Resilient Modulus (10^6 psi) 77°F
A2A	218.0	223.6	2.5	.4195	.3099
A6A	280.0	279.4		.5885	.1947
A10A	365.2	366.0	0.2	.3100	.2195
Avg	287.7	289.7	1.4	.4393	.2414
A5B	493.2	498.3	1.0	.4883	.1319
A7B	405.8	409.2	0.8	.4410	.0598
A10B	483.4	485.3	0.4	.7436	.0572
Avg	460.8	464.3	0.8	.5576	.0829
A4C	432.7	437.0	1.0	.5379	.0598
A6C	377.0	381.1	1.1	.4120	.0688
A10C	392.4	396.0	0.9	.5793	.0844
Avg	400.7	404.7	1.0	.5097	.0710
D8A	529.0	544.6	2.9	.4323	.0317
D36A	498.0	507.2	1.8	.5829	.0368
D54A	482.0	495.0	2.7	.1277	.0122
Avg	503.0	515.6	2.5	.3799	.0269
D26B	419.0	431.4	3.0	.6194	.0355
D51B	420.0	432.5	3.0	.3248	.0392
D54B	516.0	523.0	1.4	.3440	.0345
Avg	451.6	462.2	2.6	.4294	.0364
D8C	498.0	510.1	2.4	.6388	.0420
D51C	480.0	485.3	1.1	.4976	.0345
D54C	511.5	520.5	1.8	.2711	.0293
Avg	496.5	505.3	1.8	.4692	.0353

Table 5: Physical Properties and Stabilities Before Recycling

Samples	Bulk Sp.Gr.	Rice Sp.Gr.	% Air Voids	Stability			
				Hveem		Marshall	
				Stability Value	R Value	Stability Value	Flow (In)
A12	1.445		18.4				
A2A	1.555		12.1				
A3A	1.520		14.1				
A4A	1.681		5.1				
A5A	1.500		15.3	45	96		
A6A	1.575		11.1				
A7A	1.502		15.2			3182	13
A8A	1.580		10.8	28	100		
A9A	1.643		7.2	40	97		
A10A							
Avg	1.556	1.771	12.1	38	98	3182	13
A1B	2.206		7.4				
A2B	2.302		3.4				
A3B	2.242		5.9				
A4B	2.324		2.4	36	100		
A5B	2.301		3.4				
A6B	2.224		6.6	18	83		
A7B	2.185		8.3				
A8B	2.278		4.3				
A9B	2.222		6.7	27	78		
A10B	2.325		2.3				
Avg	2.261	2.382	5.1	27	87		
A1C	2.283		3.9				
A2C	2.195		7.6	32	92		
A3C	2.289		3.7				
A4C	2.327		2.1				
A5C	2.250		5.3	25	78		
A6C	2.249		5.3				
A7C	2.251		5.3				
A8C	2.271		4.4	20	80		
A9C	2.296		3.4				
A10C	2.288		3.7				
Avg	2.270	2.376	4.5	26	83		

Table 6: Asphalt Properties Before and After Recycling

	Asphalt Properties		
	Penetration @ 77°F (MM)	Viscosity @ 140°F (Poise)	Ring & Ball Temp (°F)
Phase 'A'			
Layer A	14	19,190	146
Layer B	24	6,648	134
Layer C	14	19,702	144
Phase 'D'			
Layer A	36	4,156	130
Layer B	36	4,060	129
Layer C	52	2.309	121

Table 7. Temperature Effects on Resilient Moduli and Indirect Tension Data After Recycling.

Sample	Resilient Modulus (10^6psi)				Indirect Tension		
	-13°F	32°F	77°F	100°F	Modulus (psi)	Stress (psi)	Strain (in./in.)
D2A	2.664	1.429	.6174	.1832			
D5A	1.807	1.099	.3170	.1013	26920	66.3	.002462
D8A	1.902	1.282	.4323	.1430			
D11A	2.126	1.193	.3586	.1096	33741	61.5	.001823
D14A	--	--	--	--			
D17A	--	--	--	--			
D20A	3.721	1.871	.6761	.1800			
D23A	3.345	2.339	.8046	.2409			
D26A	--	--	--	--			
D29A	--	--	--	--			
D33A	2.632	1.396	.3413	.0708			
D36A	3.113	1.649	.5829	.1612			
D39A	--	--	--	--			
D42A	2.495	1.274	.3208	.0818			
D45A	1.905	1.241	.3482	.0870	13908	43.1	.003100
D48A	--	--	--	--			
D51A	--	--	--	--			
D54A	1.049	.6265	.1277	.0861			
D57A	--	--	--	--			
D60A	2.5424	1.035	.3316	.0979			
Avg	2.440	1.367	.4382	.1286	24856	57.0	.002461
D2B	2.339	1.221	.4165	.1331			
D5B	--	--	--	--			
D8B	--	--	--	--			
D11B	3.400	1.732	1.147	.4494			
D14B	--	--	--	--			
D17B	--	--	--	--			
D20B	2.418	1.552	.5883	.1469			
D23B	2.350	1.061	.2705	.0741			
D26B	2.688	1.776	.6194	.1899			
D29B	2.774	1.873	.4615	.0483			
D33B	2.085	1.135	.2572	.0651			
D36B	1.306	.6116	.1668	.0907			
D39B	--	--	--	--			
D42B	--	--	--	--			
D45B	2.051	1.130	.2714	.0658			
D48B	--	--	--	--			
D51B	2.442	1.821	.3248	.0877			
D54B	2.068	1.334	.3440	.1098			

Table 7. Continued

Sample	Resilient Modulus (10^6psi)				Indirect Tension		
	-13°F	32°F	77°F	100°F	Modulus (psi)	Stress (psi)	Strain (in./in.)
D57B	--	--	--	--			
D60B	2.147	1.381	.4168	.1051			
Avg	2.337	1.386	.4404	.1307			
D2C	--	--	--	--			
D5C	2.470	1.288	.4848	.1587			
D8C	2.931	1.479	.6388	.2269			
D11C	2.669	1.704	.7334	.2643			
D14C	--	--	--	--			
D17C	--	--	--	--			
D20C	3.709	1.948	.7533	.2485			
D23C	--	--	--	--			
D26C	2.004	1.183	.3595	.0585			
D29C	2.848	1.658	.5091	.1274			
D33C	--	--	--	--			
D36C	--	--	--	--			
D39C	3.089	1.889	.2324	.0392			
D42C	3.017	1.650	.4110	.0832			
D45C	--	--	--	--			
D48C	3.096	1.720	.4146	.0887			
D51C	2.936	1.669	.4976	.0743			
D54C	2.085	1.154	.2711	.0744			
D57C	2.711	1.291	.3995	.1079			
D60C	--	--	--	--			
Avg	2.800	1.553	.4756	.1293			

Table 8: Physical Properties and Stabilities After Recycling

Samples	Bulk Sp.Gr.	Rice Sp.Gr.	% Air Voids	Stability			
				Hveem		Marshall	
				Stability Value	R Value	Stability Value	Flow (In)
D2A	2.129		8.6			1264	23
D5A	2.035		12.7				
D8A	2.086		10.5				
D11A	2.073		11.0				
D14A	2.095		10.1				
D17A	2.165		7.1				
D20A	2.229		4.3			1307	16
D23A	2.260		3.0	25	85		
D26A	2.123		8.9				
D29A	2.246		3.6				
D33A	2.066		11.3			698	20
D36A	2.179		6.5				
D39A	2.011		13.7				
D42A	2.125		8.8	22	76		
D45A	2.010		13.7				
D48A	1.973		15.3				
D51A	1.932		17.1				
D54A	1.934		17.0				
D57A	19.54		16.1				
D60A	2.110		9.4	30	90		
Avg	2.086	2.330	10.5	19	84	1090	20
D2B	2.113		10.4				
D5B	2.202		6.7				
D8B	2.138		9.6				
D11B	2.216		6.1			2630	21
D14B	2.009		14.8				
D17B	2.121		10.1				
D20B	2.139		9.3			1469	26
D23B	2.150		8.9				
D26B	2.119		10.2				
D29B	2.254		4.5			1176	25
D33B	2.106		10.7	22	72		
D36B	2.058		12.7	26	85		
D39B	2.052		13.0				
D42B	2.068		12.3				
D45B	2.025		14.1				
D48B	2.055		12.9				

Table 8: Continued

Samples	Bulk Sp.Gr.	Rice Sp.Gr.	% Air Voids	Stability			
				Hveem		Marshall	
				Stability Value	R Value	Stability Value	Flow (In)
D51B	2.057		12.8				
D54B	2.087		11.5				
D57B	2.182		7.5				
D60B	2.123		10.0	12	76		
Avg	2.020	2.359	14.4	20	78	1758	24
D2C	2.102		9.2				
D5C	2.126		8.1	25	86		
D8C	2.153		6.9				
D11C	2.176		6.0			1595	21
D14C	2.089		9.7				
D17C	2.178		5.9				
D20C	2.208		4.6				
D23C	2.052		11.3				
D26C	2.100		9.2			1553	20
D29C	2.178		5.9				
D33C	2.172		6.1				
D36C	2.232		3.5				
D39C	2.244		3.0				
D42C	2.169		6.3	12	67		
D25C	2.121		8.3				
D48C	2.142		7.4				
D51C	2.145		7.3				
D54C	2.072		10.4				
D57C	2.157		6.8	17	72		
D60C	2.071		10.5				
Avg	2.144	2.314	7.3	18	75	3148	20

DISTRICT,,08, CSN,,1770004 - DETAIL TEST LISTING SKID RESISTANCE REPORT 1 DATE 09/13/76 PAGE 5

CONSTRUCTION SECTION INFORMATION	SOURCE INFORMATION	CONTROL-SECTION INFO.	SKID HISTORY
HIGHWAY... IM 20 ADT.....8,300	PAVEMENT, HMAC	CO, C-S RMP EMP: 177 6-02 6,270 11,311	MO/YR -LN LO/AV/HI TVL SN TRAFFIC (000): 9/75 W-A 46/51/55 7,103; 9/75 O-A 47/51/54 7,103
CSN LENGTH 5,041 TRAFFIC...10,019,400	PLACED... 06/75 BINDER... 7.70		
FRO-.. 1 MILE S- OF ROSCOE	PRI AGG.. TYPE A LIGHTWEIGHT		
TO.... 4 MILES WEST OF SWEETWATER	2ND AGG.. LIGHTWEIGHT		
CODE COL=....5...10...15...20...25...30	-- SOURCE NUMBERS & NAMES FOLLOW --		
COMMENT1	P- 297-FEATHERLITE-RANGER,TX		
COMMENT2	S- 297-FEATHERLITE-RANGER,TX		

CONSTANTS THIS TEST - (1) TESTED ON 9/09/76 (3) AIR TEMPERATURE AT TEST WAS 62 DEGREES F.
(2) USING TRUCK NO, 41 (4) TRAVELING *OPPOSITE* THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM, MILES	SN *** A	SN BREAKDOWN BY LANE: B	C	D	E & OVER	*** FLUSH	PATCH	SN BREAKDOWN BY COMMENT: INTER-SECT,	STRUC-TURE	R,R, XING	CURVE	CITY LIMIT	DIST, SELECT
1-A	38	0,3	53 *** 53				***								
2-A	38	0,6	52 *** 52				***								
3-A	39	0,9	51 *** 51				***								
4-A	39	1,2	52 *** 52				***								
5-A	39	1,5	50 *** 50				***								
6-A	40	1,8	48 *** 48				***								
7-A	39	2,1	47 *** 47				***								
8-A	39	2,4	49 *** 49				***								
9-A	40	2,7	50 *** 50				***								
10-A	39	3,0	49 *** 49				***								
11-A	39	3,3	48 *** 48				***								
12-A	37	3,6	48 *** 48				***								
13-A	39	3,9	48 *** 48				***								
14-A	39	4,2	46 *** 46				***								
15-A	39	4,5	46 *** 46				***								
NUMBER OF TESTS...			15 *** 15				***								
SKID NUMBER - LO...			46 *** 46				***								
SKID NUMBER - AVG..			49 *** 49				***								
SKID NUMBER - HI...			53 *** 53				***								

CONSTRUCTION SECTION INFORMATION	PAVEMENT, MATERIAL, & SOURCE INFORMATION	CONTROL-SECTION INFO.	SKID HISTORY
HIGHWAY... IH 20 ADT.....8,300	PAVEMENT, HMAC	CO. C-S BMP EMP: 177 6-02 6,270 11,311	MO/YR TVL LN SN LO/AV/HI TRAFFIC (000): 9/75 A-A 46/51/55 7,103
CSN LENGTH 5.041 TRAFFIC...10,019,400	PLACED... 06/75 BINDER... 7.70		9/75 O-A 47/51/56 7,103
FROM.. 1 MILE SW OF ROSCOE	PRI AGG.. TYPE A LIGHTWEIGHT		
TO.... 4 MILES WEST OF SWEETWATER	2ND AGG.. LIGHTWEIGHT		
CODE COL-....5...10...15...20...25...30	-- SOURCE NUMBERS & NAMES FOLLOW --		
COMMENT1	P- 297-FEATHERLITE-RANGER,TX		
COMMENT2	S- 297-FEATHERLITE-RANGER,TX		

CONSTANTS THIS TEST - (1) TESTED ON 9/09/76 (3) AIR TEMPERATURE AT TEST WAS 62 DEGREES F.
(2) USING TRUCK NO. 41 (4) TRAVELING ***WITH*** THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM. MILES	SN *** A	B	C	D	E & OVER	*** FLUSH	PATCH	INTER-SECT.	STRUC-TURE	R.R. XING	CURVE	CITY LIMIT	DIST. SELECT
1-A	39	0.3	51 *** 51					***							
2-A	39	0.6	50 *** 50					***							
3-A	39	0.9	48 *** 48					***							
4-A	37	1.2	48 *** 48					***							
5-A	41	1.5	50 *** 50					***							
6-A	39	1.8	49 *** 49					***							
7-A	38	2.1	48 *** 48					***							
8-A	39	2.4	47 *** 47					***							
9-A	39	2.7	46 *** 46					***							
10-A	38	3.0	50 *** 50					***	50						
11-A	37	3.3	50 *** 50					***	50						
12-A	39	3.6	48 *** 48					***							
13-A	38	3.9	47 *** 47					***							
14-A	39	4.2	48 *** 48					***	48						
15-A	39	4.5	45 *** 45					***	45						
16-A	41	4.8	46 *** 46					***							
NUMBER OF TESTS			16 *** 16					***	4						
SKID NUMBER - LO			45 *** 45					***	48						
SKID NUMBER - AVG			48 *** 48					***	49						
SKID NUMBER - HI			51 *** 51					***	50						

CONSTRUCTION SECTION INFORMATION	PAVEMENT, MATERIAL, & SOURCE INFORMATION	CONTROL-SECTION INFO.	SKID HISTORY
HIGHWAY... IH 20 ADT.....8,300	PAVEMENT, SURF. TRT./SEAL	CO. C-S BMP EMP: 177 6-02 6,270 11,311	MO/YR TVL LN SN LO/AV/HI TRAFFIC (000): 9/75 A-B 14/31/47 7,103
CSN LENGTH 5.041 TRAFFIC...10,015,700	PLACED... 08/75 BINDER...**.**		9/75 O-B 20/44/53 7,103
FROM.. 1 MILE SW OF ROSCOE	PRI AGG.. GRADE 4 LIGHTWEIGHT		
TO.... 4 MILES WEST OF SWEETWATER	2ND AGG..		
CODE COL-....5...10...15...20...25...30	-- SOURCE NUMBERS & NAMES FOLLOW --		
COMMENT1 TRAVEL LANES	P- 297-FEATHERLITE-RANGER,TX		
COMMENT2	S-		

CONSTANTS THIS TEST - (1) TESTED ON 9/14/76 (3) AIR TEMPERATURE AT TEST WAS 81 DEGREES F.
(2) USING TRUCK NO. 41 (4) TRAVELING *OPPOSITE* THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM. MILES	SN *** A	B	C	D	E & OVER	*** FLUSH	PATCH	INTER-SECT.	STRUC-TURE	R.R. XING	CURVE	CITY LIMIT	DIST. SELECT
1-B	40	0.3	49 ***	49				***							
2-B	41	0.6	50 ***	50				***							
3-B	42	0.9	49 ***	49				***							
4-B	42	1.2	46 ***	46				***							
5-B	42	1.5	51 ***	51				***							
6-B	43	1.8	42 ***	42				***							
7-B	42	2.1	44 ***	44				***							
8-B	41	2.4	40 ***	40				***							
9-B	43	2.7	40 ***	40				***							
10-B	42	3.0	39 ***	39				***							
11-B	42	3.3	41 ***	41				***							
12-B	41	3.6	21 ***	21				***	21						
13-B	42	3.9	46 ***	46				***							
14-B	42	4.2	48 ***	48				***							
15-B	41	4.5	52 ***	52				***							
NUMBER OF TESTS			15 ***	15				***	1						
SKID NUMBER - LO			21 ***	21				***	21						
SKID NUMBER - AVG			44 ***	44				***	21						
SKID NUMBER - HI			52 ***	52				***	21						

HIGHWAY... IH 20 ADT.....8,300
CSN LENGTH 5.041 TRAFFIC...10,015,700
FROM.. 1 MILE SE OF ROSCOE
TO.... 4 MILES WEST OF SWEETWATER
CODE COL-....5...10...15...20...25...30
COMMENT1 TRAVEL LANES
COMMENT2

PAVEMENT, SURF. TRT./SEAL
PLACED... 08/75 BINDER...**.**
PRI AGG.. GRADE 4 LIGHTWEIGHT
2ND AGG..
SOURCE NUMBERS & NAMES FOLLOW
P- 297-FEATHERLITE-RANGER,TX
S-

CO.	C-S	BMP	EMP
177	6-02	6.270	11.311

SKID HISTORY

MO/YR	TVL LN	SN LO/AV/HI	TRAFFIC (000)
9/75	N-B	14/31/47	7,103
9/75	O-B	20/44/53	7,103

CONSTANTS THIS TEST - (1) TESTED ON 9/14/76 (3) AIR TEMPERATURE AT TEST WAS 81 DEGREES F.
(2) USING TRUCK NO. 41 (4) TRAVELING ***WITH*** THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM. MILES	SN ***	SN BREAKDOWN BY LANE A	B	C	D	E & OVER	*** FLUSH	PATCH	SN BREAKDOWN BY COMMENT INTER-SECT.	STRUC-TURE	R.R. XING	CURVE	CITY LIMIT	DIST. SELECT
1-N	41	0.4	45 ***	43				***								
2-N	42	0.6	61 ***	61				***								
3-N	42	0.9	42 ***	42				***								
4-N	40	1.2	45 ***	45				***								
5-N	42	1.5	43 ***	43				***								
6-N	43	1.8	25 ***	25				***		45						
7-N	41	2.1	30 ***	30				***								
8-N	43	2.4	47 ***	47				***		30						
9-N	42	2.7	34 ***	34				***								
10-N	42	3.0	34 ***	34				***								
11-N	42	3.3	32 ***	32				***								
12-N	42	3.6	31 ***	31				***								
13-N	42	3.9	30 ***	30				***		30						
14-N	42	4.2	36 ***	36				***								
15-N	42	4.5	44 ***	44				***								
16-N	43	4.8	46 ***	46				***								
NUMBER OF TESTS....			16 ***	16				***		3						
SKID NUMBER - LO...			25 ***	25				***		30						
SKID NUMBER - AVG..			39 ***	39				***		34						
SKID NUMBER - HI...			61 ***	61				***		43						

"STORAGE DESTRUCTION" ERROR.

CSN HEADER INFORMATION CANCELLED.

REASON - NONMATCH OF DISTRICT NO. AND SECURITY IDENTIFIER.

Roscoe Bypass — IH 20
West Bound Travel Lane

CONSTANTS THIS TEST - (1) TESTED ON 5/31/78 (3) AIR TEMPERATURE AT TEST WAS 86 DEGREES F.
(2) USING TRUCK NO. 41 (4) TRAVELING *OPPOSITE* THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM. MILES	SN ***	SN BREAKDOWN BY LANE A	B	C	D	E & OVER	*** FLUSH	PATCH	SN BREAKDOWN BY COMMENT INTER-SECT.	STRUC-TURE	R.R. XING	CURVE	CITY LIMIT	DIST. SELECT
1-S	41	0.1	51 ***	51				***								
2-S	39	0.2	52 ***	52				***								
3-S	39	0.4	44 ***	44				***								
4-S	39	0.6	53 ***	53				***								
5-S	41	0.8	48 ***	48				***								
6-N	40	1.0	49 ***	49				***								
7-S	40	1.2	50 ***	50				***								
8-N	37	1.4	42 ***	42				***								
9-S	39	1.6	47 ***	47				***				47				
10-S	42	1.8	41 ***	41				***								
11-S	40	2.0	48 ***	48				***								
12-S	40	2.2	47 ***	47				***								
13-S	39	2.4	49 ***	49				***								
14-S	39	2.6	47 ***	47				***								
15-S	38	2.8	49 ***	49				***				49				
NUMBER OF TESTS....			15 ***	15				***				2				
SKID NUMBER - LO...			41 ***	41				***				47				
→ SKID NUMBER - AVG..			48 ***	48				***				48				
SKID NUMBER - HI...			53 ***	53				***				49				

''STORAGE DESTRUCTION'' ERROR,

CSN HEADER INFORMATION CANCELLED,

REASON - NONMATCH OF DISTRICT NO, AND SECURITY IDENTIFIER,

Roscoe Bypass — IH 20
East Bound Travel Lane

CONSTANTS THIS TEST - (1) TESTED ON 5/31/78 (3) AIR TEMPERATURE AT TEST WAS 88 DEGREES F,
(2) USING TRUCK NO, 41 (4) TRAVELING ***WITH*** THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM, MILES	SN ***	SN BREAKDOWN BY LANE A	B	C	D	E & OVER	*** FLUSH	PATCH	SN BREAKDOWN BY COMMENT INTER-SECT,	STRUC-TURE	R,R, XING	CURVE	CITY LIMIT	DIST, SELECT
1-B	38	0,0	51 ***	51				***								
2-B	38	0,0	51 ***	51				***								
3-B	41	1,0	49 ***	49				***								
4-B	41	1,2	52 ***	52				***								
5-B	41	1,4	50 ***	50				***								
6-B	41	1,6	51 ***	51				***								
7-B	41	1,8	54 ***	54				***								
8-B	39	2,0	54 ***	54				***								
9-B	42	2,2	52 ***	52				***								
10-B	41	2,4	48 ***	48				***								
11-B	41	2,6	47 ***	47				***								
12-B	39	2,8	47 ***	47				***								
13-B	38	3,0	49 ***	49				***								
14-B	42	3,2	44 ***	44				***								
15-B	42	3,4	51 ***	51				***								
NUMBER OF TESTS			15 ***	15				***								
SKID NUMBER - LO			44 ***	44				***								
→ SKID NUMBER - AVG			50 ***	50				***								
SKID NUMBER - HI			54 ***	54				***								

''STORAGE DESTRUCTION'' ERROR,

CSN HEADER INFORMATION CANCELLED,

REASON - NONMATCH OF DISTRICT NO, AND SECURITY IDENTIFIER,

Roscoe Bypass — IH 20
West Bound Passing Lane

CONSTANTS THIS TEST - (1) TESTED ON 5/31/78 (3) AIR TEMPERATURE AT TEST WAS 88 DEGREES F,
(2) USING TRUCK NO, 41 (4) TRAVELING *OPPOSITE* THE FROM/TO DESCRIPTION

WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM, MILES	SN ***	SN BREAKDOWN BY LANE A	B	C	D	E & OVER	*** FLUSH	PATCH	SN BREAKDOWN BY COMMENT INTER-SECT,	STRUC-TURE	R,R, XING	CURVE	CITY LIMIT	DIST, SELECT
1-A	39	0,2	58 ***	58				***								
2-A	38	0,4	60 ***	60				***				60				
3-A	41	0,6	59 ***	59				***								
4-A	39	0,8	64 ***	64				***								
5-A	39	1,0	57 ***	57				***								
6-A	38	1,2	57 ***	57				***								
7-A	37	1,4	59 ***	59				***								
8-A	41	1,6	59 ***	59				***								
9-A	40	1,7	57 ***	57				***								
10-A	39	1,8	55 ***	55				***								
11-A	39	1,9	54 ***	54				***								
12-A	39	2,0	52 ***	52				***								
13-A	38	2,1	58 ***	58				***								
14-A	38	2,2	58 ***	58				***								
NUMBER OF TESTS			14 ***	14				***				1				
SKID NUMBER - LO			52 ***	52				***				60				
→ SKID NUMBER - AVG			57 ***	57				***				60				
SKID NUMBER - HI			64 ***	64				***				60				

Roscoe Bypass — IH 20
East Bound Passing Lane

"STORAGE DESTRUCTION" ERROR,

CSN HEADER INFORMATION CANCELLED,

REASON = NONMATCH OF DISTRICT NO, AND SECURITY IDENTIFIER,

CONSTANTS THIS TEST - (1) TESTED ON 5/31/78 (3) AIR TEMPERATURE AT TEST WAS 88 DEGREES F,
(2) USING TRUCK NO, 41 (4) TRAVELING ***WITH*** THE FROM/TO DESCRIPTION

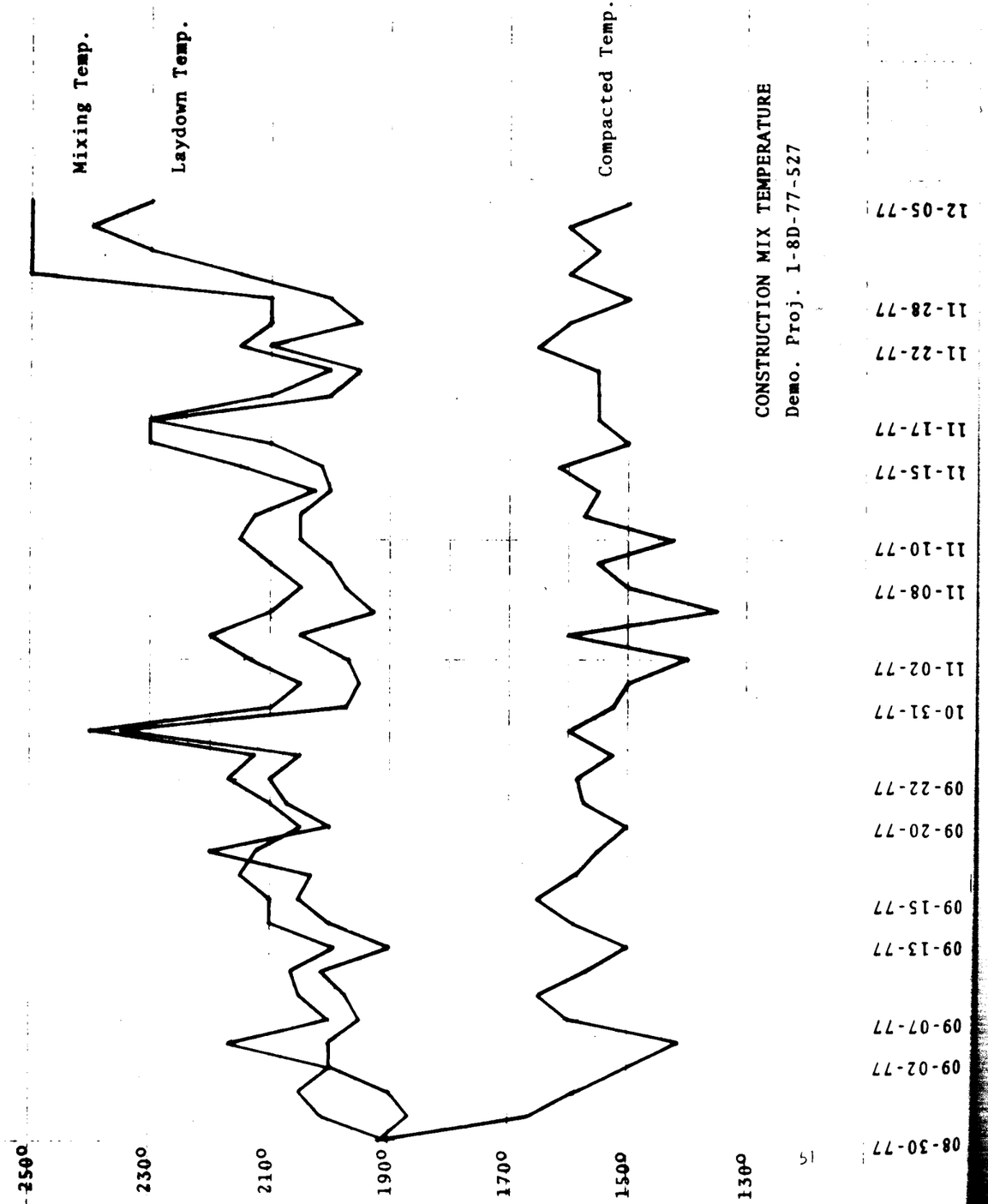
WARNING - THIS TEST ALONE IS INSUFFICIENT TO ESTABLISH THE SAFE FRICTION VALUE FOR A HIGHWAY

TEST & LANE	SPEED	CUMM, MILES	SN BREAKDOWN BY LANE: SN ***	A	B	C	D	E & OVER	SN BREAKDOWN BY COMMENT: *** FLUSH	PATCH	INTER-SECT,	STRUC-TURE	R,R, XING	CURVE	CITY LIMIT	DIST, SELECT
1-A	41	0,1	51 ***	51					***							
2-A	42	0,2	49 ***	49					***							
3-A	42	0,4	54 ***	54					***							
4-A	43	0,6	49 ***	49					***							
5-A	39	0,8	57 ***	57					***							
6-A	40	1,0	65 ***	65					***							
7-A	41	1,2	58 ***	58					***							
8-A	39	1,4	59 ***	59					***							
9-A	40	1,6	64 ***	64					***							
10-A	36	1,8	61 ***	61					***							
11-A	40	2,0	65 ***	65					***							

***** PROCEDURE NOTATION - SKID TEST 12 DELETED ON RECEIPT OF OBSERVER INITIATED !COMMENT 9! COMMAND,

***** PROCEDURE NOTATION - CONSTRUCTION SECTION DELETED ON RECEIPT OF SECOND SUCCESSIVE !COMMENT 9! COMMAND,

NUMBER OF TEST = 11
SKID NUMBER - Low = 49
SKID NUMBER - Avg. = 57
SKID NUMBER - High = 65



APPENDIX V

EFFECTS OF SOFTENING AGENT ADDITIVE

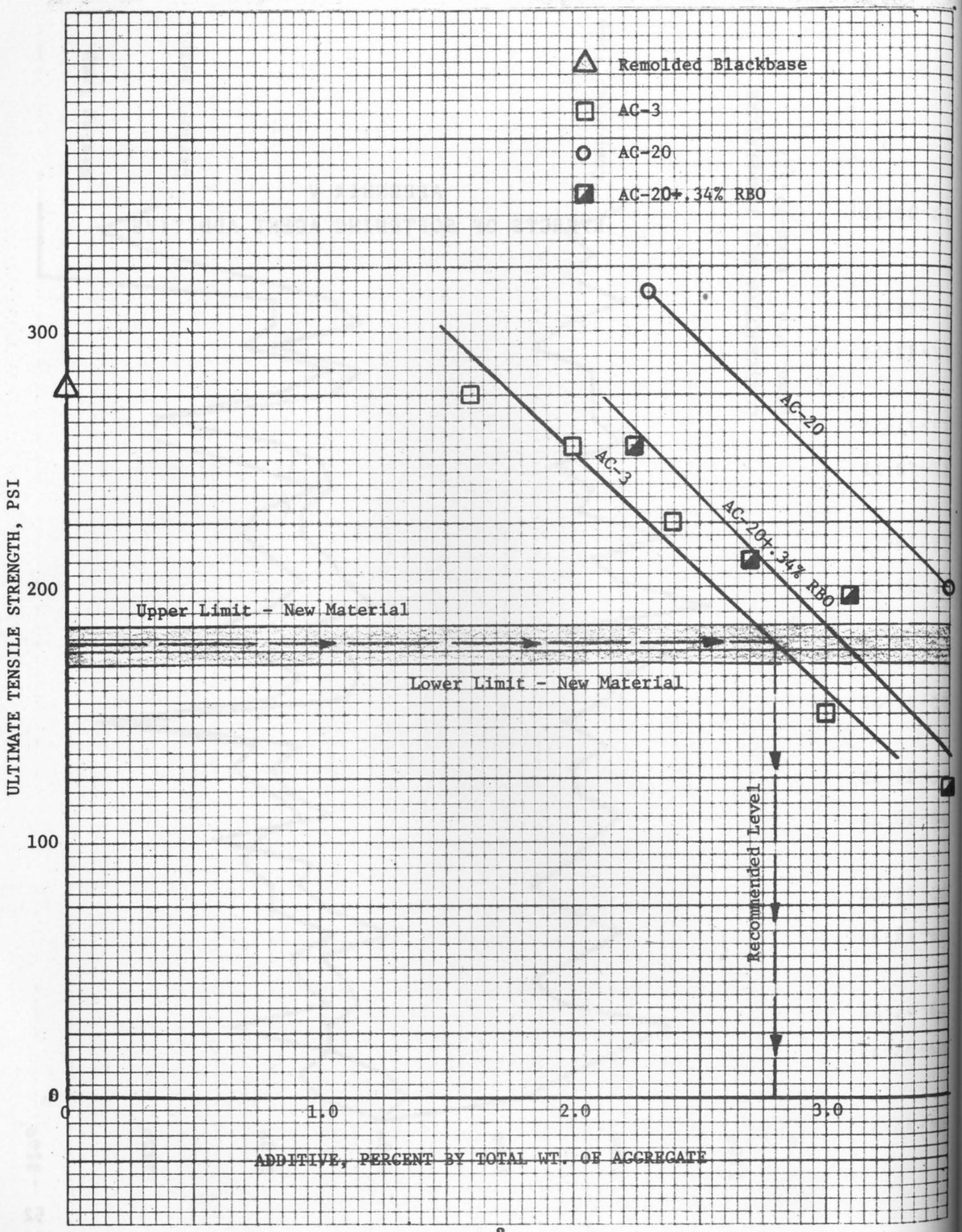


FIGURE 1. EFFECT OF ADDITIVE ON TENSILE STRENGTH

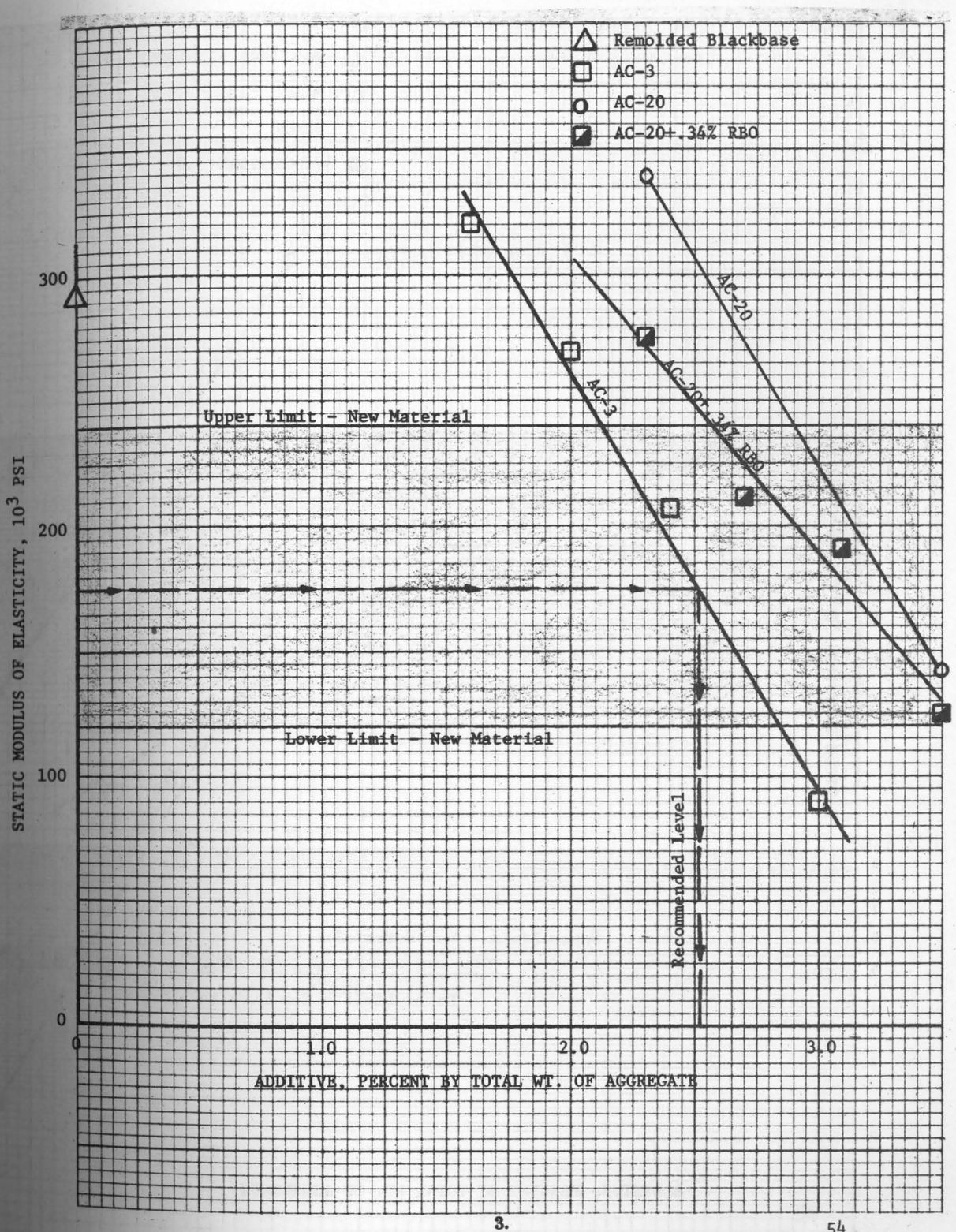


FIGURE 2. EFFECT OF ADDITIVE ON STATIC MODULUS OF ELASTICITY

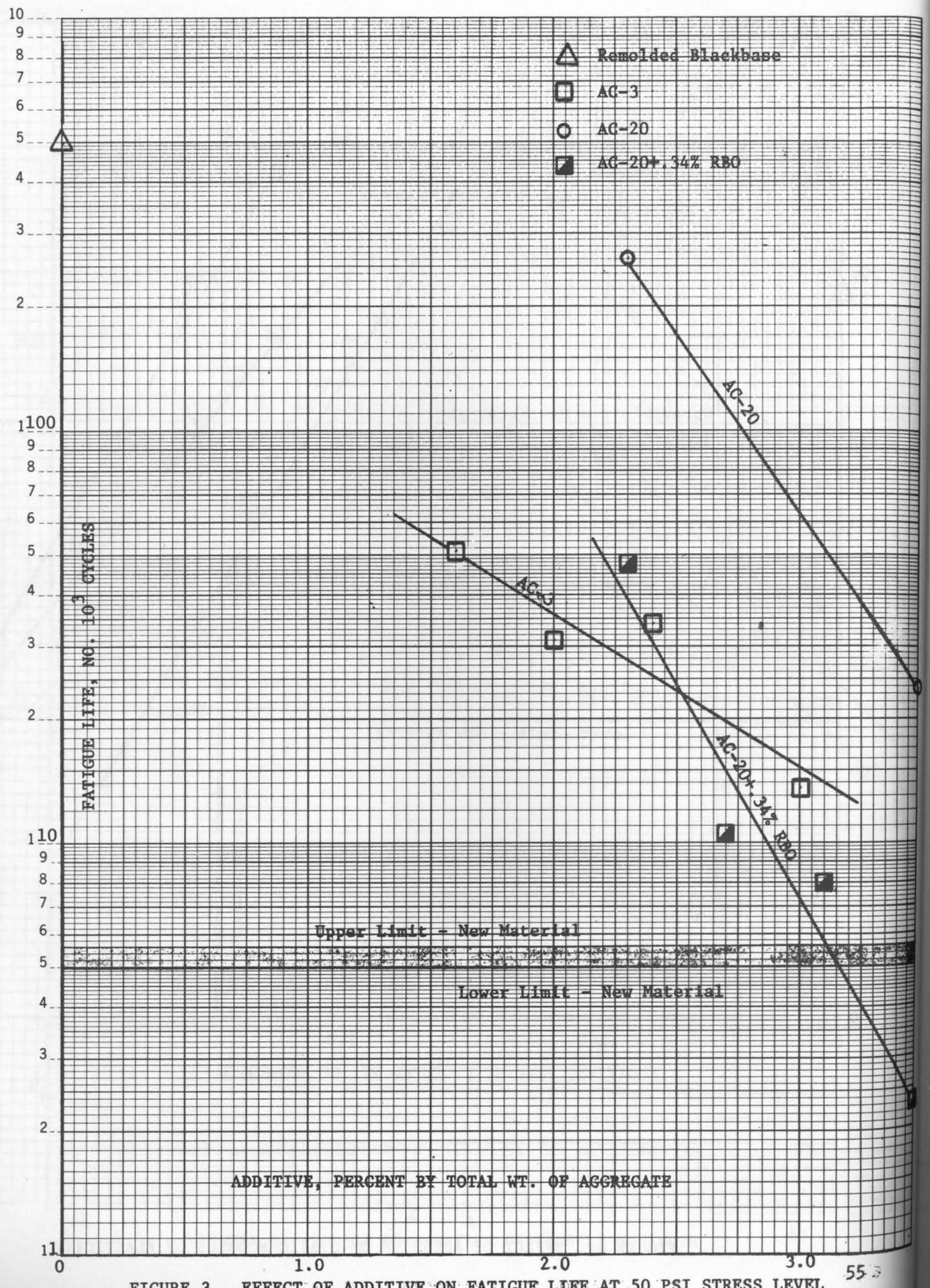


FIGURE 3. EFFECT OF ADDITIVE ON FATIGUE LIFE AT 50 PSI STRESS LEVEL

55

APPENDIX VI
EXTRACTION RESULTS

No Charge

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
AUSTIN, TEXAS 78701

GENERAL TEST REPORT

CONTRACT NO. _____ CONTROL INFORMATIONAL PD. _____

ENGINEER W. L. Plumlee PROJECT NO. _____

ADDRESS Abilene COUNTY _____ HWY. _____

CONTRACTOR J. H. Strain & Sons, Inc. DISTRICT 8 REQ. NO. _____

LABORATORY NO. F77510109 MATERIAL _____

DATE RECEIVED 9-2-77 PRODUCER _____
9-12-77

SAMPLED FROM _____ IDENTIFICATION MARKS J 770349 H

QUANTITY _____ SPECIFICATION ITEM _____

EXTRACTION TEST RESULTS

Size	F77510109 Crushed HMAC (% by wt)
Ret. 1/2"	0
1/2" - 3/8"	3.6
3/8" - No. 4	24.2
No. 4 - No. 10	22.2
Ret. No. 10	50.0
No. 10 - No. 40	18.4
No. 40 - No. 80	13.6
No. 80 - No. 200	5.6
Pass No. 200	6.4
Residual Bitumen	6.0

TEST RESULTS ON RESIDUAL BITUMEN

Viscosity @ 140° F., Stokes ---------- 15,396
Ductility @ 77°F., Cm. ---------- 39
Penetration @ 77°F. ---------- 21

Division of Materials and Tests
FOR INFORMATION ONLY

lcc Chuck Hughes

NO CHARGE

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
AUSTIN, TEXAS 78701

GENERAL TEST REPORT

CONTRACT NO. _____ CONTROL INFORMATIONAL PD. _____

ENGINEER W. L. Plumlee PROJECT NO. _____

ADDRESS Abilene, Texas COUNTY _____ HWY. _____

CONTRACTOR J. H. Strain & Sons, Inc. DISTRICT 8 REQ. NO. _____

LABORATORY NO. F77510110 MATERIAL _____

DATE RECEIVED 9-2-77 PRODUCER _____
9-12-77

SAMPLED FROM _____ IDENTIFICATION MARKS J 770350 H

QUANTITY _____ SPECIFICATION ITEM _____

EXTRACTION TEST RESULTS

Size	F77510110 Recycled HMAC W/AC-3 Added (% by wt) 2.0%
Ret. 1 1/4"	0
1 1/4" - 1"	1.9
1" - 7/8"	5.2
7/8" - 5/8"	4.0
5/8" - 1/2"	3.7
1/2" - 3/8"	3.4
3/8" - No. 4	19.2
No. 4 - No. 10	17.5
Ret. No. 10	54.9
No. 10 - No. 40	15.7
No. 40 - No. 80	10.6
No. 80 - No. 200	5.1
Pass No. 200	8.1
Residual Bitumen	5.6

TEST RESULTS ON RESIDUAL BITUMEN

Viscosity @ 140°F., Stokes ---------- 3709
Ductility @ 77°F., Cm. ---------- 141
Penetration @ 77°F. ---------- 45

lee Chuck Hughes

Division of Materials and Tests
FOR INFORMATION ONLY

Form 231-Rev. 3-76

NO CHARGE

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
AUSTIN, TEXAS 78701

GENERAL TEST REPORT

CONTRACT NO. _____ CONTROL Informational PD _____

ENGINEER _____ PROJECT NO. _____

ADDRESS _____ COUNTY Nolan HWY. I-20

CONTRACTOR _____ DISTRICT 8 REQ. NO. _____

LABORATORY NO. F77510148 MATERIAL Crushed Pavt. Salvage from stock

DATE RECEIVED 11-17-77 PRODUCER _____

SAMPLED FROM 11-30-77 IDENTIFICATION MARKS 770467N

QUANTITY _____ SPECIFICATION ITEM _____

EXTRACTION TEST RESULTS

Size	F77510148 (% by wt.)
Ret. 7/8"	0
Ret. 5/8"	1.7
5/8" - 1/2"	0.4
1/2"- 3/8"	2.9
3/8" - No. 4	22.6
No. 4 - No. 10	21.6
Ret. No. 10	49.2
No. 10 - No. 40	19.7
No. 40 - No. 80	12.0
No. 80 - No. 200	6.4
Pass No. 200	7.1
Residual Bitumen	5.5

TEST RESULTS ON RESIDUAL BITUMEN

Viscosity @ 140°F., Stokes ---------- 19,857
Ductility @ 77°F., cm. ---------- 9
Penetration @ 77°F. ---------- 17

lcc C. Hughes

Division of Materials and Tests
FOR INFORMATION Only

Form 231-Rev. 3-76

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
AUSTIN, TEXAS 78701

NO CHARGE

GENERAL TEST REPORT

CONTRACT NO. _____ CONTROL INFORMATIONAL PD _____

ENGINEER _____ PROJECT NO. _____

ADDRESS _____ COUNTY Nolan HWY. I-20

CONTRACTOR _____ DISTRICT 8 REQ. NO. _____

LABORATORY NO. F77510147 MATERIAL Recycle mix w/Emulsified AC-3 & Recycle

DATE RECEIVED 11-21-77 PRODUCER _____

SAMPLED FROM 11-30-77 IDENTIFICATION MARKS 770469N

QUANTITY _____ SPECIFICATION ITEM _____

EXTRACTION TEST RESULTS

Size	F77510147 (% by Wt.)
Ret. 1 1/2"	0
Ret. 1"	3.1
1" - 7/8"	2.2
7/8"-5/8"	4.8
5/8"-3/8"	2.9
3/8"-No.4	21.8
No.4-No.10	17.7
Ret. No.10	52.5
No.10-No.40	15.8
No.40-No.80	9.3
No.80-No.200	5.5
Pass No.200	10.1
Residual Bitumen	6.8

TEST RESULTS ON RESIDUAL BITUMEN

Viscosity @ 140°F.,stokes ---------- 1333
Ductility @ 77°F., cm. ---------- 141
Penetration @ 77°F. ---------- 71

C. Hughes

Division of Materials and Tests
FOR INFORMATION Only

Form 231-Rev. 3-76

NO CHARGE

STATE DEPARTMENT OF
HIGHWAYS AND PUBLIC TRANSPORTATION
DIVISION OF MATERIALS AND TESTS
AUSTIN, TEXAS 78701

GENERAL TEST REPORT

CONTRACT NO. ________ CONTROL ________ PD ________

ENGINEER B.R. Lindley PROJECT NO. Research No. 08-3-214-052708-807

ADDRESS ________ COUNTY Nolan HWY. I-20

CONTRACTOR J.H. Strain & Sons, Inc. DISTRICT 8 REQ. NO. ________

LABORATORY NO. E77640240-0241 MATERIAL Recycle Mix

DATE RECEIVED 11-25-77 11-22-77 12-2-77 PRODUCER J.H. Strain & Sons, Inc.

SAMPLED FROM Plant IDENTIFICATION MARKS See below

QUANTITY ________ SPECIFICATION ITEM 3052

EXTRACTION TEST RESULTS

Size	E77640240 J-770472N 65%- Salv. Pavement 20%- Salv. Base 15%- Addative Aggr. 2.8%- AC-3 (% by wt.)	E77640241 J-770470N 65%- Salv. Pavement 20%- Salv. Base 15%- Addative Aggr. 2.8%= AC- 3 w/Paxole (1/3 Paxole & 2/3 AC-3) (% by wt.)
Ret. 1 1/2"	0	0
Ret. 1"	3.5	3.0
1" - 7/8"	0	0
7/8" - 5/8"	4.8	3.5
5/8" - 1/2"	3.7	1.7
1/2" - 3/8"	4.1	3.4
3/8" - No. 4	13.5	17.1
No. 4 - No. 10	17.7	19.8
Ret. No. 10	52.2	48.5
No. 10 - No. 40	16.4	17.1
No. 40 - No. 80	9.0	9.7
No. 80 - No. 200	5.8	6.0
Pass No. 200	9.8	10.5
Residual Bitumen	6.7	8.2

TESTS RESULTS ON RESIDUAL BITUMEN

Viscosity @ 140°F., stokes ---------10,795 --------------------------433
Ductility @ 77°F., Cm. --------------- 85 ---------------------------141
Penetration @ 77°F. ------------------ 31 ---------------------------152

EXTRACTION TEST RESULTS

Item 3052 Recycled Asphalt Stabilized Base

PERCENT

Sieve																	
+ 1"									7.3	4.6	5.8	2.9	2.0	2.7	3.1	4.9	3.8
+3/4"	16.1	8.6	6.0	27.5	15.0	13.4	4.7	11.9	9.5	7.9	18.0	6.6	8.4	9.1	6.2	9.8	10.6
+3/8"	23.4	22.0	21.8	43.1	29.9	26.1	26.3	24.0	23.4	23.9	29.7	17.6	21.2	23.3	29.5	22.5	32.2
+ 4"	42.7	43.6	45.7	59.5	47.9	44.6	47.5	43.6	43.1	44.3	51.3	36.7	41.9	60.0	51.9	39.9	55.5
+ 10"						60.6	62.8	61.7	59.4	60.2	65.7	55.3	58.1	62.8	66.6	55.7	69.1
+ 40"	70.1	72.1	74.3	79.8	76.1	75.8	75.3	76.1	74.2	74.9	77.5	72.7	73.3	75.6	78.7	75.3	78.8
- 40"	23.7	22.4	25.7	20.2													
+200"					90.6	89.8	89.4	89.7	89.5	88.8	90.5	88.3	90.1	89.4	91.5	90.2	91.1
Pass200"				9.4	10.2	10.6	10.3	10.5	11.2	9.5	11.7	9.9	10.6	8.5	9.8	8.8	9.0
Residual Asph.	6.2	5.5	6.3	5.0		6.4	6.6	5.9	7.1	6.0	5.9	6.1	5.6	6.2	5.6	5.6	5.5

SAMPLES FOR EXTRACTION TESTS TAKEN
AUGUST 17 THROUGH DECEMBER 5, 1977

EXTRACTION TEST RESULTS

Item 3052 Recycled Asphalt Stabilized Base

PERCENT

Sieve																
+ 1"	7.3	2.8	3.1	7.9	8.4	6.5	4.5	2.4	2.9	2.8	2.2		8.0		2.9	6.7	2.1
+3/4"	17.4	8.0	11.4	11.0	13.3	17.4	14.4	7.2	5.6	3.4	7.0	3.0	12.1	5.6	6.6	13.4	5.7
+3/8"	37.6	10.7	20.6	17.9	23.3	27.2	25.6	15.6	36.8	6.7	18.0	11.5	21.6	14.8	15.2	21.7	18.1
+ 4"	56.2	37.8	42.1	37.4	43.6	44.7	45.5	37.1	61.3	36.8	37.5	30.9	41.6	33.3	36.1	40.8	40.2
+ 10"	74.7	56.9	60.3	56.7	61.2	61.9	62.9	57.9	70.5	59.0	57.3	56.8	61.0	54.0	57.6	58.3	59.6
+ 40"	84.7	74.5	74.0	72.3	75.9	76.6	75.5	72.8	79.4	76.5	75.5	75.3	75.6	74.4	72.7	74.8	77.1
- 40"																	
+200"	91.0	90.3	89.1	87.9	89.8	90.6	90.4	89.5	92.1	91.3	91.4	90.3	91.2	90.9	89.3	89.8	92.5
Pass 200"	9.7	10.5	10.9	12.1	10.2	9.4	9.6	10.5	7.9	8.7	8.6	9.7	8.8	9.1	10.7	10.2	7.5
Residual Asph.	6.1	6.5	6.7	7.4	6.3	6.2	7.6	7.7	6.2	6.3	6.9	7.0	6.9	7.4	7.5	5.7	6.4

SAMPLES FOR EXTRACTION TESTS TAKEN
AUGUST 17 THROUGH DECEMBER 5, 1977

EXTRACTION TEST RESULTS

Item 3052 Recycled Asphalt Stabilized Base

PERCENT

Sieve								
+ 1"	3.8		3.7	4.2	2.6	7.7	2.0	9.0
+3/4"	5.4	9.3	6.0	7.0	4.8	15.6	6.1	12.4
+3/8"	12.3	23.6	17.7	19.4	12.5	26.2	15.4	21.3
+ 4"	33.6	44.5	38.7	42.5	31.1	46.4	36.5	40.3
+ 10"	57.5	62.8	59.3	63.4	53.3	61.7	56.6	58.7
+ 40"	74.6	78.7	76.1	76.4	74.0	76.5	74.8	75.8
- 40"								
+200"	90.5	92.8	91.0	90.7	89.8	90.0	91.3	90.0
Pass 200"	9.5	7.2	9.0	9.3	10.2	10.0	8.7	10.0
Residual Asph.	6.4	6.0	6.2	6.3	6.3	5.9	6.7	6.5

SAMPLES FOR EXTRACTION TESTS TAKEN
AUGUST 17 THROUGH DECEMBER 5, 1977

BIDDER 3 | DATE 3 77 | DIV 8 | JOB 22 | TEXAS HIGHWAY DEPARTMENT FORM 234-A 5-64 SM

ITEM	SUB CODE	S.P. NO.	ITEM DESCRIPTION	UNIT	APPROXIMATE QUANTITIES	UNIT BID PRICE	EXTENSION
150	501		BLAD	HR	150.000	30.00000	4,500.00
150	502		BLAD (EROSN CONT)	HR	50.000	30.00000	1,500.00
204	501		SPRINK	MG	302.000	4.00000	1,208.00
204	505		SPRINK (EROSN CONT)	MG	30.000	4.00000	120.00
213	502		ROLL (MEDM PNEUM TIRE)(TY A)	HR	610.000	20.00000	12,200.00
322	528		AGGR (CL B TY A GR 3)	CY	35.000	20.00000	700.00
322	529		AGGR (CL B TY A GR 4)	CY	30.000	20.00000	600.00
322	614		ASPH	GAL	2,000.000	1.00000	2,000.00
340	501	056	ASPH (AC)	TON	571.000	88.00000	50,248.00
340	504	056	AGGR (TY D)	TON	8,946.000	13.40000	119,876.40
560	523	003	TERM - ANCH SECT	EA	18.000	275.00000	4,950.00
562	501		REMOV AND REPL METAL BEAM GD FENCE	LF	10,425.000	7.25000	75,581.25
562	505		REMOV AND REPL TERM-ANCH SECT	EA	6.000	330.00000	1,980.00
592	501	002	CONSTRUCTING DETOURS (CL 1)	STA	16.200	2,400.00000	38,880.00
740	501		DELIN TY I (IND HOUSED)	EA	124.000	3.00000	372.00
740	502		DELIN TY II (IND HOUSED)	EA	100.000	5.00000	500.00
2037	501		ASPH TREAT BASE	SY	131,854.000	1.35000	178,016.40
2037	502		ASPH MATL (EA-11M)	GAL	581,100.000	.50000	290,550.00
3051	501		SPRINKLE TREAT	CY	480.000	40.00000	19,200.00

PROJECT I 20-2(114)235
COUNTY DILAN

BIDDER 3 | DATE 3 77 | DIV 8 | JOB 22

TEXAS HIGHWAY DEPARTMENT
FORM 234-A 5-64 5M

ITEM · CODE			ITEM DESCRIPTION	UNIT	APPROXIMATE QUANTITIES	UNIT BID PRICE	EXTENSION
ITEM NO.	DESC CODE	S. P. NO.					
3052	501		ASPH (AC-3)	TON	1,458.000	88.00000	128,304.00
3052	502		ASPH ADDITIVE	TON	132.000	190.00000	25,080.00
3052	503		SALV MATL	TON	43,455.000	14.64000	636,181.20
3052	504		AGGR (COARSE)	TON	7,949.000	14.64000	116,373.36
5010	501		METAL BM GD FENCE POSTS (TIM)	EA	866.000	11.00000	9,526.00
7017	501		REMOV DELIN ASSEM	EA	224.000	3.00000	672.00
7146	501		BEACONS	LS	1.000	3,000.00000	3,000.00
7222	504		DELIN POST (6.5 FT)	EA	224.000	6.00000	1,344.00
7263	501		TEMP PAV MARK	LF	800.000	1.00000	800.00
					TOTAL		1,724,262.61

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APPENDIX IX
AIR QUALITY TESTS

SOURCE EVALUATION

J. H. Strain & Sons, Inc.

Roscoe, Texas

on

September 21 & 22, 1977

Account No. 903-028-0

October 18, 1977

PREPARED BY THE STAFF OF THE

TEXAS AIR CONTROL BOARD

TABLE OF CONTENTS

*Appendices are available upon request.

QUALITY ASSURANCE
EVALUATION

The attached report has been evaluated in terms of adherence to standard procedures, practices defensible by sound engineering logic and compliance with established Quality Assurance policies.

As a result of this evaluation, this report is classified as a SOURCE EVALUATION and the following discrepancies are noted as a matter of record:

*Sample was taken using 42 sampling points instead of 44 points that were the minimum number of points dictated by stack dimension criteria established by the Environmental Protection Agency and adhered to by the Texas Air Control Board.

J. H. Strain & Sons, Inc.
Plant

Roscoe, Texas
Location

September 21 & 22, 1977
Date of Sampling

Manny H. Pointer
Team Leader

October 31, 1977
Date of Signature

James B. Draper, P.E.
Quality Assurance, Source Evaluat

Date of Signature

Introduction

On September 21 and 22, 1977, a team from the Source Evaluation Section of the Texas Air Control Board sampled the scrubber stack on the portable hot mix plant of J. H. Strain and Sons, Inc. At this time the plant was located near Roscoe, Texas and was processing recycled asphalt. This source was sampled to evaluate particulate and sulfur dioxide emissions from this process. The team leader was Manny Pointer, Engineering Assistant III; he was assisted by Nick Starche and Jim Knipstein, P.E.

New Source Performance Standards, Particulate

New Source Performance Standards (NSPS) for this source allow 0.04 grains per dry standard cubic foot, in-stack particulate concentration. Data obtained on this test has been converted to units of "grains per dry standard cubic foot" on page A-12. The average concentration was 0.0977 grains per dry standard cubic foot.*

Texas Air Control Board equipment and procedures were used in obtaining this data; however, the impinger catch has been deleted in calculating the above in-stack concentration to agree with Environmental Protection Agency (EPA) Method 5. Other Texas Air Control Board differences from EPA Method 5 were the use of deionized water wash in place of an acetone wash for cleanup of the probe liner and glass ware, and the use of an unheated probe liner in place of a heated liner.

Voided Samples

Sample one was terminated because the plant stopped operations for the day; this data has been voided. On sample two, a post sample check of the isokinetic percentage showed that this sampling did not meet Texas Air Control Board standards for particulate sampling; however this sample can be used for the gaseous sulfur dioxide analysis. After completion of sample four, the glass filter holder broke. Since this presented possible filter contamination, this sample is voided for particulate sampling, but is valid for sulfur dioxide sampling. Particulate data from sample four has been included for comparison purposes but has not been used to obtain data averages.

* Not corrected for excess air.

Sulfur Dioxide

Sulfur dioxide pollutant mass rate was hand calculated from samples two, three and four. Hand calculations are shown on page A-13. Average sulfur dioxide pollutant mass rate was 0.42 lb/hr.

Texas Air Control Board Rule 105.1, Particulate

Average allowable particulate emission rated under Texas Air Control Board Rule 105.1 was 36.2 lb/hr while average particulate pollutant mass rate was 19.3 lb/hr. Impinger catch was included in the calculation of this pollutant mass rate.

Sample Time Correction

Plant power provided by a portable generator did not produce 60 Hz current. Necessary corrections have been made to the sample time shown on the raw data before it was input into the computer program.

Additional Information on Plant Operation

Since the recycling of asphalt pavement is a relatively new process, the following information was obtained, for reference only, from plant personnel. At the time of sampling, the burner fuel was propane. The percent of excess air is calculated on page A-14 and was 153% based on an average of eight orsat readings. The "average" temperature of the mix at the exit of the drum was 225 degrees fahrenheit. Nominal production rate was 200 T/hr. Sixty-nine percent (by weight) of the mixture was old asphalt, 16% was virgin base and 15% was salvage base. Moisture content of the old material was 7%. There were no provisions for measuring the pressure drop across the venturi scrubber orifice.

Plant Operational Status

The percent of maximum operating capacity was 33% and the percent of normal operating capacity was 67%, see page 5 for additional information on plant status.

PARTICULATE SUMMARY OF RESULTS

NAME OF STACK/DUCT Scrubber Stack

Account Number 903-028-0 Emission Point Number 1

	Sample One & two	Sample three	Sample four	Sample five	Average Value
Time Date	Sample two was voided due to plant shut down. Sample one was voided due to low percent isokinetic.	1221-1434 9-21-77	1521-1729 0807-1011 9/21-22/77	1056-1238 9-22-77	
Stack Temperature Deg F		164	161	161	162
Port Velocity Ft/Sec		67.8	63.4	63.6	65.7
Percent Water		35.0	32.6	32.4	33.7
Total Flow Rate ACFM		45,100	42,200	42,400	43,800
Effective Stack Height in Feet		63.3	60.5	60.6	61.9
Standard Effective Stack Height in Feet		44.7	43.7	43.7	44.2
Allowable Emission Rate in lb/hr Rule 105.1		36.9	35.4	35.5	36.2
Pollutant Mass Rate in lb/hr		14.4	16.2	24.2	19.3
Percent Isokinetic		102	100	98.3	100
Percent of Allowable		39.0	45.7	68.2	53.3

*Sample four had possible filter contamination due to broken filter holder. Leak occurred after sample completion. Filter did not appear to have any glass particles when examined prior to being placed in sample envelope. Filter was examined with angled sunlight by team leader and an assistant. Sample four is included for information only and was not used to calculate the average values shown on this page.

SULFUR DIOXIDE SUMMARY OF RESULTS

NAME OF STACK/DUCT Scrubber

Account Number 903-028-0 Emission Point Number 1

	Sample One	Sample Two	Sample Three	Sample Four	Average Value
Time Date		0818-1014 9-21-77	1221-1434 9-21-77	1521-1729 0807-1011 9/21-22/77	
Stack Temperature Deg F		161	164	161	162
Port Velocity Ft/Sec		71.0	67.8	63.4	67.4
Percent Water		32.6	35.0	32.6	33.4
Total Flow Rate SCFM		36,600	34,800	32,600	34,700
Effective Stack Height in Feet		64.9	63.3	60.5	62.9
Standard Effective Stack Height in Feet		NO TEXAS AIR CONTROL BOARD RULE APPLIES TO THIS SOURCE FOR SO_2			
Allowable Emission Rate in lb/hr Rule N/A		NO TEXAS AIR CONTROL BOARD RULE APPLIES TO THIS SOURCE FOR SO_2			
Pollutant Mass Rate in lb/hr *		0.41	0.39	0. 45	0.42
Percent of Allowable		NO TEXAS AIR CONTROL BOARD RULE APPLIES TO THIS SOURCE FOR SO_2			

*Hand calculated values. Only two significant figures are valid. See hand calculations on page A-13 of this report.

Texas Air Control Board
8520 Shoal Creek Boulevard
Austin, Texas 78758

PLANT OPERATIONAL STATUS FORM

Sampling Periods

Date 9-22-77 Account Number 903-028-0

Plant Name J. H. Strain & Sons Location Roscoe, Tx.

Stack Name Scrubber stack

Proportional or Isokinetic Sampling Isokinetic

Sample Number	Duration of Sample (Show Start time and Stop time)			Date of Sample
2.2	From	0818	To 1014	9-21-77
2.3	From	1221	To 1434	9-21-77
2.4 (1st half)	From	1521	To 1729 (2nd half: From 0807 To 1011)	9-21-77 (9-22-77)
4.5	From	1056	To 1238	9-22-77

Special Conditions Sample #4 done about ½ on 9-21-77; finished it on 9-22-77 as indicated. All samples stopped intermittently as plant stopp

Signature Marvin H. Pinter

Title Engineering Assistant II

The above portion is to be completed by the Air Control Board representative. The following portion is to be completed by the plant representative.

Plant Status During Sampling Periods Shown Above

Type of Process Boeing Plant, Recycle Asph. Stab. Base

Abatement Controls Boeing Thermal shield, Wet Scrubber & Damper C

Stack Height 26 1/2 ft (Above ground Level) Stack Exit Diameter 3 ft 3" X 4 ft

Emission Point Number 1 (Plant Boeing Model 40

Sample Number	Percent of Maximum Capacity	Percent of Normal Operating Capacity	Special Conditions
2.2	33%	67%	See Note below
2.3	33%	67%	
2.4	33%	67%	
4.5	33%	67%	

Additional Information During the sampling we were at the end of our stockpile and the material had dryed out and we had trouble with cold feeds.

I certify that the above statements are true to the best of my knowledge and belief:

Signature James A. Strain

Title Vice-President

APPENDIX A

Explanation of Computer Printout

1. Sample two ran "separately" and the output or calculation results have been used as input to the hand calculation of SO_2 pollutant mass rate. No data from sample two was used to produce page A-10 of this report.

2. Sample four also ran "separately". This sample was also eliminated from the averages shown on page A-10 because of possible filter contamination.

INPUT DATA

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO TWO DATE 9-21-77 TIME 0818 TO 1014

NOZ.AREA: .0001244 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 83.0 MIN. VOL. DRY GAS METER: 22.78 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 23.8 FT

ORSAT ANALYSIS: CO2 .050, O2 .125, CO .001, N2 .824, DGMCF= .9980

TEMP IN DEG F: DRY GAS METER AVER. 84.00, STACK AVER. 161.00

MASS IN GRAMS: TOTAL IMP. GAIN 216.80 TOTAL PARTICULATE .1472

PARTICULATE IN IMP. .0112, SO2 .0025, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 27.18 IN.HG, STACK -.650 IN.H2O, AV.DELTA H .189 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.400	1.300	1.300	1.100	.900	.650	.450	1.500
1.200	1.000	.920	.730	.750	.580	1.500	1.200
1.100	1.000	.980	1.200	.830	1.400	1.300	1.200
1.200	1.300	1.300	.820	1.400	1.360	1.300	1.300
1.400	1.300	1.300	1.300	.700	1.200	1.200	1.300
1.200	.700						

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED @@@@@@

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO TWO DATE 9-21-77 TIME 0818 TO 1014

32.56 % H2O BW2 .337 NOZ.VOL. 38.576 CUFT EACF 1.000

AV.VEL.PORT 71.002 FT PER SEC M.WT. 25.62 EF.STK.HT. 64.9 FT

ACFM 47303.1 SCFM 36609.8 (NO EXCESS AIR CORRECTION)

INPUT DATA

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO THREE DATE 9-21-77 TIME 1221 TO 1434

NOZ.AREA: .0001244 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 83.0 MIN. VOL. DRY GAS METER: 24.36 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 23.8 FT

ORSAT ANALYSIS: CO2 .048, O2 .132, CO .000, N2 .821, DGMCF= .9980

TEMP IN DEG F: DRY GAS METER AVER. 87.50, STACK AVER. 164.00

MASS IN GRAMS: TOTAL IMP. GAIN 254.30 TOTAL PARTICULATE .1029

PARTICULATE IN IMP. .0045, SO2 .0028, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 27.18 IN.HG, STACK -.450 IN.H2O, AV.DELTA H .212 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.300	1.300	1.300	1.400	1.400	1.100	.730	1.400
1.000	.990	1.100	1.200	.710	1.300	.980	.900
1.300	1.300	1.300	1.400	1.200	.750	1.300	1.100
.830	.830	.830	.750	1.300	1.000	.900	.750
.600	.520	.450	1.200	1.200	1.000	.880	.730
.550	.400						

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO THREE DATE 9-21-77 TIME 1221 TO 1434

34.99 % H2O BW2 .360 NOZ.VOL. 42.694 CUFT EACF 1.000

AV.VEL.PORT 67.760 FT PER SEC M.WT. 25.34 EF.STK.HT. 63.3 FT

ACFM 45143.2 SCFM 34789.0 (NO EXCESS AIR CORRECTION)

RULE 105.1

39.0 % OF ALLOWABLE %ISO. 101.7 STD.EF.STK.HT. 44.7 FT

EMISS.RATES,LBS/HR: ALLOWABLE 36.9, POLL.MASS 14.4

INPUT DATA

J.H.STRAIN AND SONS .ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO FOUR DATE 9/21-22/77 TIME 1521-1729;0807-1011

NOZ.AREA: .0001244 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 83.0 MIN. VOL. DRY GAS METER: 23.38 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 23.8 FT

ORSAT ANALYSIS: CO2 .049, O2 .130, CO .000, N2 .821, DGMCF= .9980

TEMP IN DEG F: DRY GAS METER AVER. 87.50, STACK AVER. 161.00

MASS IN GRAMS: TOTAL IMP. GAIN 217.90 TOTAL PARTICULATE .1139

PARTICULATE IN IMP. .0090, SO2 .0032, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 27.12 IN.HG, STACK -.680 IN.H2O, AV.DELTA H .189 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.200	1.000	.960	.920	.750	.520	.400	.950
1.200	.820	.700	.550	.520	.430	1.200	.900
.800	.740	.750	.750	.600	1.100	.930	1.010
.920	1.100	.990	.580	1.100	1.100	1.100	1.200
1.200	.990	.650	1.200	.975	.950	1.100	1.100
.970	.600						

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO FOUR DATE 9/21-22/77 TIME 1521-1729;0807-1011

32.56 % H2O BW2 .335 NOZ.VOL. 39.335 CUFT EACF 1.000

AV.VEL.PORT 63.393 FT PER SEC M.WT. 25.62 EF.STK.HT. 60.5 FT

ACFM 42233.6 SCFM 32611.3 (NO EXCESS AIR CORRECTION)

RULE 105.1

45.7 % OF ALLOWABLE %ISO. 100.1 STD.EF.STK.HT. 43.7 FT

EMISS.RATES,LBS/HR: ALLOWABLE 35.4, POLL.MASS 16.2

INPUT DATA

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO FIVE DATE 9-22-77 TIME 1056 TO 1238

NOZ.AREA: .0001244 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 83.0 MIN. VOL. DRY GAS METER: 22.99 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 23.8 FT

ORSAT ANALYSIS: CO2 .045, O2 .134, CO .000, N2 .821, DGMCF= .9980

TEMP IN DEG F: DRY GAS METER AVER. 86.00, STACK AVER. 160.80

MASS IN GRAMS: TOTAL IMP. GAIN 216.60 TOTAL PARTICULATE .1673

PARTICULATE IN IMP. .0040, SO2 .0000, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 27.20 IN.HG, STACK -.920 IN.H2O, AV.DELTA H .186 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.100	1.100	1.200	1.050	1.050	.950	.630	1.100
1.100	1.100	1.100	1.200	1.100	.660	1.200	1.050
.910	.920	1.000	1.000	.680	1.100	.950	.830
.770	.710	.750	.430	1.100	.980	.850	.730
.600	.550	.440	1.050	1.150	.990	.900	.780
.600	.360						

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

SAMPLE NO FIVE DATE 9-22-77 TIME 1056 TO 1238

32.41 % H2O BW2 .336 NOZ.VOL. 38.718 CUFT EACF 1.000

AV.VEL.PORT 63.587 FT PER SEC M.WT. 25.61 EF.STK.HT. 60.6 FT

ACFM 42363.1 SCFM 32797.2 (NO EXCESS AIR CORRECTION)

RULE 105.1

68.2 % OF ALLOWABLE %ISO. 98.3 STD.EF.STK.HT. 43.7 FT

EMISS.RATES,LBS/HR: ALLOWABLE 35.5, POLL.MASS 24.2

AVERAGE RESULTS

J.H.STRAIN AND SONS ROSCOE SEPT 1977

SCRUBBER STACK STARCHE

33.70 % H2O BW2 .348 NOZ.VOL. 40.706 CUFT EACF 1.000

AV.VEL.PORT 65.674 FT PER SEC M.WT. 25.48 EF.STK.HT. 61.9 FT

ACFM 43753.1 SCFM 33793.1 (NO EXCESS AIR CORRECTION)

RULE 105.1
53.6 % OF ALLOWABLE %ISO. 100.0 STD.EF.STK.HT. 44.2 FT
EMISS.RATES,LBS/HR: ALLOWABLE 36.2, POLL.MASS 19.3
PERCENT OF ALLOWABLE FROM AVERAGE RESULTS: 53.3

HAND CALCULATED PARTICULATE POLLUTANT MASS RATES WITHOUT IMPINGER CATCH FOR "NSPS" TYPE SAMPLING

$$PMR_{\text{(particulate) concentration method}} = \frac{G_m \text{ Part. (ACFM) } 60}{\text{Noz. Vol } (453.592)} \text{ lb/hr}$$

Sample Three

$$\frac{0.0984\ (45143.2)\ 60}{42.694\ (453.592)} = 13.8 \text{ lb/hr}$$

Sample Four

$$\frac{0.1049\ (42233.6)\ 60}{39.335\ (453.592)} = 14.9 \text{ lb/hr}$$

Sample Five

$$\frac{0.1633\ (42363.1)\ 60}{38.718\ (453.592)} = 23.6 \text{ lb/hr}$$

Average 18.7 lb/hr (Sample four not included in average PMR; see note on summary of results page 3).

CONVERSION OF TEXAS AIR CONTROL BOARD DATA TO IN-STACK CONCENTRATION WITH UNITS OF GRAINS PER DRY STANDARD CUBIC FOOT

$$\frac{\text{grains}}{\text{DSCF}} = \frac{7000 \ \frac{\text{grains}}{\text{lb}} \times PMR_c \ \text{lb/hr}}{\text{SCFM} \times \text{DGF} \times 60 \ \text{min/hr}}$$

where DSCF is dry std. cubic feet, SCFM is standard cubic feet per minute, DGF is the fraction of dry gas in the stack, and PMR_c is the pollutant mass rate based on concentration and does not include the impinger catch; see page A-11.

Sample Three

$$\frac{7000 \quad (13.8)}{34{,}789.0 \quad (0.6501) \quad 60} = 0.07119 \ \frac{\text{grains}}{\text{DSCF}}$$

Sample Four

$$\frac{7000 \quad (14.9)}{32{,}611.3 \quad (0.6744) \quad 60} = 0.07904 \ \frac{\text{grains}}{\text{DSCF}}$$

Sample Five

$$\frac{7000 \quad (23.6)}{32{,}797.2 \quad (0.6759) \quad 60} = 0.1242 \ \frac{\text{grains}}{\text{DSCF}}$$

Average $\underline{0.0977} \ \frac{\text{grains}}{\text{DSCF}}$ (Sample four not included in average concentration, see note on summary of results, page 3).

HAND CALCULATION OF SULFUR DIOXIDE POLLUTANT MASS RATE

$$PMR_{SO_2} = \frac{Gm \ SO_2 \quad (ACFM) \quad 60}{\text{Noz. Vol.} \quad (453.592)}, \quad \text{lb/hr}$$

Sample Two (voided for isokinetic sampling but valid for SO_2 sampling)

$$\frac{0.0025 \quad (47303.1) \quad 60}{38.576 \quad (453.592)} = 0.4055 \ \text{lb/hr}$$

Sample Three

$$\frac{0.0028 \quad (45143.2) \quad 60}{42.694 \quad (453.592)} = 0.3916 \ \text{lb/hr}$$

Sample Four (voided for particulate sampling but valid for gaseous sampling)

$$\frac{0.0032 \quad (42233.6) \quad 60}{39.335 \quad (453.592)} = 0.4545 \ \text{lb/hr}$$

Average = $\underline{0.42}$

Note: sample five did not include provisions for measuring SO_2 PMR

CALCULATION OF AVERAGE ORSAT VALUES
AND PERCENT EXCESS AIR FOR EACH SAMPLE
AND FROM AVERAGE VALUES

ORSAT RESULTS AND PERCENT EXCESS AIR

Orsat No.	XCO2	XO2	XCO	XN2	% Excess Air
1	0.043	0.139	0.0	0.818	180.6
2	0.042	0.136	0.0	0.822	167.9
3	0.057	0.114	0.002	0.827	107.3
4	0.047	0.132	0.0	0.821	155.8
5	0.049	0.131	0.0	0.820	153.3
6	0.050	0.130	0.0	0.820	150.3
7	0.047	0.131	0.0	0.822	152.3
8	0.045	0.134	0.0	0.821	161.9
Avg.	0.048	0.131	0.0	0.821	153.7

$$\% \text{ EA} = \frac{(X02 - 0.5\ (XCO))\ 100}{0.264\ (XN2) - (X02 - 0.5\ (XCO))}$$

substituting average orsat values into this equation gives.

$$\% \text{ EA} = \frac{0.131 \times 100}{(0.264 \times 0.821) - 0.131} = 152.8\%$$

STACK SAMPLE

at

J. H. STRAIN & SONS, INC.

Roscoe, Texas

on

November 2, 1977

Account No. 903-028-0

December 6, 1977

PREPARED BY THE STAFF OF THE

TEXAS AIR CONTROL BOARD

QUALITY ASSURANCE
EVALUATION

The attached report has been evaluated in terms of adherence to standard procedures, practices defensible by sound engineering logic and compliance with established Quality Assurance policies.

As a result of this evaluation, this report is classified as a STACK SAMPLE and the following discrepancies are noted as a matter of record:

J. H. Strain & Sons, Inc.
Plant

Roscoe, Texas
Location

November 2, 1977
Date of Sampling

Manny H. Pointer
Team Leader

12-19-77
Date of Signature

James B. Draper, P.E.
Quality Assurance, Source Evaluat

19 Dec. 1977
Date of Signature

TABLE OF CONTENTS

*Appendices are available upon request.

Introduction

On November 2, 1977, a team from the Source Evaluation Section of the Texas Air Control Board sampled the scrubber stack on the portable hot mix asphalt plant owned by J. H. Strain and Sons, Inc. At this time the plant was located near Roscoe, Texas and was processing recycled asphalt. This source was sampled to determine particulate in-stack concentrations according to the Environmental Protection Agency Method 5.

Impinger catch has not been included in the calculation of Environmental Protection Agency (EPA) in-stack concentrations but has been used to calculate Texas Air Control Board pollutant mass rates. No excess air corrections have been made to any of the data shown in this report. Only two samples were taken because the plant shut down for extensive repairs prior to obtaining the third sample.

The team leader was Manny Pointer, Engineering Assistant, he was assisted by Nick Starche and Jim Knipstein, P.E.

Sample Matrix

Forty-eight points were sampled through six ports on the shorter side of the nearly square cross-sectioned stack; this required eight sample points on each of the six traverses. Each element measured 0.445 by 0.520 feet. This matrix layout was required because of the six existing ports and the short distance between the ports and the stack exit. It is acceptable by Texas Air Control Board standards but does not meet EPA requirements for a balanced matrix.

Conclusion

This source did not meet EPA New Source Performance Standards (NSPS) allowable in-stack concentration of 0.04 grains per dry standard cubic foot. Average EPA in-stack concentration was 0.0645 grains per dry standard cubic foot which does not include impinger catch.

Texas Air Control Board, Rule 105.1 average allowable emission rate was 41.0 lb/hr while average pollutant mass rate was 20.5 lb/hr which includes impinger catch.

Sample Time Correction

Plant power provided by a portable generator did not produce 60 H_z current. Necessary corrections have been made to the sample time shown on the raw data before it was input into the computer program.

Percent Asphalt in Catch

The laboratory report, page B-21, shows the percent of asphalt found in each portion of the sample catch. This percentage was determined by extracting dried sample with methylene chloride (CH_2Cl_2), evaporating the solvent and weighing the residue. This procedure gave 102% and 105% asphalt on the filters used in samples one and two respectively, and 33.9% and 37.1% asphalt in the probe washes for samples one and two respectively.

Plant Operational Status

The percent of maximum operating capacity was 35 percent and the percent of normal operating capacity was 70 percent.

Information on Plant Operation

This source was previously sampled on September 21 and 22, 1977 and at that time additional information on plant operation was obtained for the sampling report. On November 2, 1977, the same information was requested for this report. Plant personnel reported that the source was operating essentially the same as it was during the September sampling; the following information is therefore repeated here: burner fuel was propane; "average" temperature of the mix at the drum exit was 225° F; nominal production rate was 200 T/hr; sixty-nine percent of the mixture was old asphalt, 16 percent was virgin base and 15 percent was salvage base; moisture content of the old material was seven percent.

Prior to the sampling, a representative from Boeing adjusted the venturi scrubber orifice. Pressure drop across the scrubber was not measured because the adjustment was based on velocity at the venturi orifice. Average values of carbon dioxide, oxygen, carbon monoxide, and nitrogen were obtained from four separate orsat analysis of the stack gas, these were used to calculate the percent of excess air as shown on page A-7. Percent of excess air was 302%.

PARTICULATE SUMMARY OF RESULTS

NAME OF STACK/DUCT SCRUBBER STACK

Account Number 903-028-0 Emission Point Number 1

	Sample One	Sample Two	Sample Three	Sample Four	Average Value
Time Date	1115-1257 11-2-77	1414-1555 11-2-77			
Stack Temperature Deg F	141	142			142
Port Velocity Ft/Sec	78.3	82.3			80.3
Percent Water	19.8	20.5			20.1
Total Flow Rate ACFM	52,200	54,900			53,500
Effective Stack Height in Feet	69.9	72.3			71.1
Standard Effective Stack Height in Feet	47.0	47.9			47.4
Allowable Emission Rate in lb/hr	40.4	41.6			41.0
Rule 105.1	EPA allowable in-stack concentration is 0.04 grains per dry standard cubic foot				
* Pollutant Mass Rate in lb/hr	17.4	23.7			20.5
** Con. in grains/dry Std. Cu. Ft.	0.0567	0.0723			0.0645
Percent Isokinetic	102	102			102
Percent of Allowable	39.9	51.3			45.7

*this pollutant mass rate includes impinger catch
**this concentration does not include impinger catch

Texas Air Control Board
8520 Shoal Creek Boulevard
Austin, Texas 78758

PLANT OPERATIONAL STATUS FORM

Sampling Periods

Date 11-2-77 Account Number 903-028-0

Plant Name J. H. Strain & Sons, Inc. Location 2 mi. S. of Roscoe, Tx.

Stack Name Scrubber Stack

Proportional or Isokinetic Sampling Isokinetic

Sample Number	Duration of Sample (Show Start time and Stop time)		Date of Sample
1.	From 11:15	To 12:57	11-2-77
2.	From 14:14	To 15:55	11-2-77
3.	From	To	
4.	From	To	

Special Conditions Samples taken after plant running [illegible] (10-15 min after startup) & terminated well before plant shutdown.

Signature Manny H. Painter

Title Engineering Assistant III

The above portion is to be completed by the Air Control Board representative. The following portion is to be completed by the plant representative.

Plant Status During Sampling
Periods Shown Above

Type of Process Recycle Asphalt Pavement w/ Drum Mix Asphalt Plant

Abatement Controls Venturi Scrubber w/ Boeing Proprietary Thermal Sh[illegible]

Stack Height 26' 10" ft Stack Exit Diameter 37 3/8" X 42 7/8" Inside ~~ft~~

Emission Point Number 1 (AC Plant Boeing Model [illegible]

Sample Number	Percent of Maximum Capacity	Percent of Normal Operating Capacity	Special Conditions
1.	35	70	
2.	35	70	
3.			
4.			

Additional Information

I certify that the above statements are true to the best of my knowledge and belief:

Signature [illegible]

Title Vice President

APPENDIX A

INPUT DATA

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO ONE DATE 11-2-77 TIME 1115 TO 1257

NOZ.AREA: .0002057 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 94.6 MIN. VOL. DRY GAS METER: 66.32 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 26.8 FT

ORSAT ANALYSIS: CO2 .031, O2 .161, CO .000, N2 .808, DGMCF= 1.0000

TEMP IN DEG F: DRY GAS METER AVER. 75.50, STACK AVER. 141.00

MASS IN GRAMS: TOTAL IMP. GAIN 352.90 TOTAL PARTICULATE .2176

PARTICULATE IN IMP. .0173, SO2 .0000, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 26.90 IN.HG, STACK -.670 IN.H2O, AV.DELTA H 1.470 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.100	.980	1.200	1.100	.930	.850	.850	.700
1.500	1.400	1.300	1.200	1.200	1.450	1.450	.800
1.600	1.400	1.500	1.600	1.650	2.000	2.000	1.100
1.600	1.600	1.750	1.850	1.900	2.100	2.100	1.400
1.500	1.700	1.700	1.700	1.900	1.900	1.900	1.100
1.300	1.400	1.450	1.750	1.800	1.750	1.600	.850

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO ONE DATE 11-2-77 TIME 1115 TO 1257

19.75 % H2O BW2 .220 NOZ.VOL. 93.296 CUFT EACF 1.000

AV.VEL.PORT 78.347 FT PER SEC M.WT. 26.94 EF.STK.HT. 69.9 FT

ACFM 52195.9 SCFM 41307.8 (NO EXCESS AIR CORRECTION)

RULE 105.1
39.9 % OF ALLOWABLE %ISO. 102.0 STD.EF.STK.HT. 47.0 FT
EMISS.RATES,LBS/HR: ALLOWABLE 40.4, POLL.MASS 16.1

INPUT DATA

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO TWO DATE 11-2-77 TIME 1414 TO 1555

NOZ.AREA: .0002057 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 94.7 MIN. VOL. DRY GAS METER: 70.51 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 26.8 FT

ORSAT ANALYSIS: CO2 .030, O2 .160, CO .000, N2 .810, DGMCF= 1.0000

TEMP IN DEG F: DRY GAS METER AVER. 87.40, STACK AVER. 142.50

MASS IN GRAMS: TOTAL IMP. GAIN 401.60 TOTAL PARTICULATE .2893

PARTICULATE IN IMP. .0312, SO2 .0000, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 26.90 IN.HG, STACK -.820 IN.H2O, AV.DELTA H 1.630 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.400	1.300	1.400	1.600	1.800	1.800	1.650	.950
1.600	1.650	1.750	1.800	1.950	2.050	2.000	1.100
1.800	1.700	1.800	1.950	2.000	2.100	2.200	1.400
1.600	1.600	1.800	1.950	2.100	2.100	2.100	1.300
1.500	1.400	1.350	1.650	1.800	1.950	1.800	1.100
1.100	1.200	1.100	1.100	1.200	1.300	1.250	.860

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO TWO DATE 11-2-77 TIME 1414 TO 1555

20.54 % H2O BW2 .235 NOZ.VOL. 98.318 CUFT EACF 1.000

AV.VEL.PORT 82.332 FT PER SEC M.WT. 26.84 EF.STK.HT. 72.3 FT

ACFM 54851.0 SCFM 43283.2 (NO EXCESS AIR CORRECTION)

RULE 105.1
51.3 % OF ALLOWABLE %ISO. 102.2 STD.EF.STK.HT. 47.9 FT
EMISS.RATES,LBS/HR: ALLOWABLE 41.6, POLL.MASS 21.3

NOV 1977

N.STARCHE

95.807 CUFT. EACF 1.000

T. 26.89 EF.STK.HT. 71.1 FT

NO EXCESS AIR CORRECTION)

02.1 STD.EF.STK.HT. 47.4 FT
41.0, POLL.MASS 18.7
RESULTS: 45.7

INPUT DATA

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO ONE DATE 11-2-77 TIME 1115 TO 1257

NOZ.AREA: .0002057 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 94.6 MIN. VOL. DRY GAS METER: 66.32 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 26.8 FT

ORSAT ANALYSIS: CO2 .031, O2 .161, CO .000, N2 .808, DGMCF= 1.0000

TEMP IN DEG F: DRY GAS METER AVER. 75.50, STACK AVER. 141.00

MASS IN GRAMS: TOTAL IMP. GAIN 352.90 TOTAL PARTICULATE .2349

PARTICULATE IN IMP. .0173, SO2 .0000, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 26.90 IN.HG, STACK -.670 IN.H2O, AV.DELTA H 1.470 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.100	.980	1.200	1.100	.930	.850	.850	.700
1.500	1.400	1.300	1.200	1.200	1.450	1.450	.800
1.600	1.400	1.500	1.600	1.650	2.000	2.000	1.100
1.600	1.600	1.750	1.850	1.900	2.100	2.100	1.400
1.500	1.700	1.700	1.700	1.900	1.900	1.900	1.100
1.300	1.400	1.450	1.750	1.800	1.750	1.600	.850

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

CALCULATION RESULTS

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO ONE DATE 11-2-77 TIME 1115 TO 1257

19.75 % H2O Bw2 .220 NOZ.VOL. 93.296 CUFT EACF 1.000

AV.VEL.PORT 78.347 FT PER SEC M.WT. 26.94 EF.STK.HT. 69.9 FT

ACFM 52195.9 SCFM 41307.8 (NO EXCESS AIR CORRECTION)

RULE 105.1
43.0 % OF ALLOWABLE %ISO. 102.0 STD.EF.STK.HT. 47.0 FT
EMISS.RATES,LBS/HR: ALLOWABLE 40.4, POLL.MASS 17.4

INPUT DATA

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

SAMPLE NO TWO DATE 11-2-77 TIME 1414 TO 1555

NOZ.AREA: .0002057 SQFT PITOT CALIB. FACTOR: .8370

TRAV. DURATION 94.7 MIN. VOL. DRY GAS METER: 70.51 CUFT

STACK: DIA,EXIT 3.76 FT, PORT 3.76 FT, HEIGHT 26.8 FT

ORSAT ANALYSIS: CO2 .030, O2 .160, CO .000, N2 .810, DGMCF= 1.0000

TEMP IN DEG F: DRY GAS METER AVER. 87.40, STACK AVER. 142.50

MASS IN GRAMS: TOTAL IMP. GAIN 401.60 TOTAL PARTICULATE .3205

PARTICULATE IN IMP. .0312, SO2 .0000, H2S .0000,

H2SO4 .0000, FLUORIDE IONS .0000, SO3 .0000,CL2 .0000

PRESS: ATMOS 26.90 IN.HG, STACK -.820 IN.H2O, AV.DELTA H 1.630 IN.H2O

PITOT TUBE DELTA P'S IN IN.H2O:

1.400	1.300	1.400	1.600	1.800	1.800	1.650	.950
1.600	1.650	1.750	1.800	1.950	2.050	2.000	1.100
1.800	1.700	1.800	1.950	2.000	2.100	2.200	1.400
1.600	1.600	1.800	1.950	2.100	2.100	2.100	1.300
1.500	1.400	1.350	1.650	1.800	1.950	1.800	1.100
1.100	1.200	1.100	1.100	1.200	1.300	1.250	.860

RULE 107 PROCESS WEIGHT RATE .0 POUNDS PER HOUR

RULE 105.3 & 201.5 HEAT INPUT .0 MILLION BTU PER HOUR

RULES SELECTED 105.1

EXCESS AIR FLAG OFF PARTICAL SIZE FLAG SMALL

MOISTURE FRACTION WAS BASED ON SATURATED CONDITIONS

RULE 105.1

56.8 % OF ALLOWABLE %ISO. 102.2 STD.EF.STK.HT. 47.9 FT

EMISS.RATES,LBS/HR: ALLOWABLE 41.6, POLL.MASS 23.7

AVERAGE RESULTS

J.H.STRAIN AND SONS ROSCOE NOV 1977

SCRUBBER STACK N.STARCHE

20.14 % H2O BW2 .228 NOZ.VOL. 95.807 CUFT EACF 1.000

AV.VEL.PORT 80.339 FT PER SEC M.WT. 26.89 EF.STK.HT. 71.1 FT

ACFM 53523.5 SCFM 42295.5 (NO EXCESS AIR CORRECTION)

RULE 105.1
49.9 % OF ALLOWABLE %ISO. 102.1 STD.EF.STK.HT. 47.4 FT
EMISS.RATES,LBS/HR: ALLOWABLE 41.0, POLL.MASS 20.5
PERCENT OF ALLOWABLE FROM AVERAGE RESULTS: 50.0

CONVERSION OF TEXAS AIR CONTROL BOARD DATA
TO IN-STACK CONCENTRATION WITH UNITS OF
GRAINS PER DRY STANDARD CUBIC FOOT

$$\frac{\text{grains}}{\text{DSCF}} = \frac{7000 \frac{\text{grains}}{\text{lb}} \times PMR_c \text{ lb/hr}}{\text{SCFM} \times \text{DGF} \times 60 \text{ min/hr}}$$

where DSCF is dry std. cubic feet, SCFM is standard cubic feet per minute, DGF is the fraction of dry gas in the stack, and PMR_c is the pollutant mass rate based on concentration and does not include the impinger catch.

Sample One

$$\frac{7000}{41{,}307.8} \frac{16.1}{(0.8025)\ 60} = 0.05667 \frac{\text{grains}}{\text{DSCF}}$$

Sample Two

$$\frac{7000}{43{,}283.2} \frac{21.3}{(0.7946)\ 60} = 0.07225 \frac{\text{grains}}{\text{DSCF}}$$

Average 0.06446 $\frac{\text{grains}}{\text{DSCF}}$

CALCULATION OF AVERAGE ORSAT VALUES
AND PERCENT EXCESS AIR FOR EACH SAMPLE
AND FROM AVERAGE VALUES

ORSAT RESULTS AND PERCENT EXCESS AIR

Orsat No.	XCO2	XO2	XCO	XN2	% Excess Air
1	0.035	0.155	0.0	0.810	263
2	0.026	0.167	0.0	0.807	363
3	0.031	0.157	0.0	0.812	274
4	0.029	0.163	0.0	0.808	324
Avg.	0.0303	0.1605	0.0	0.809*	306

*used 1.00 - (.0303 + .1605)

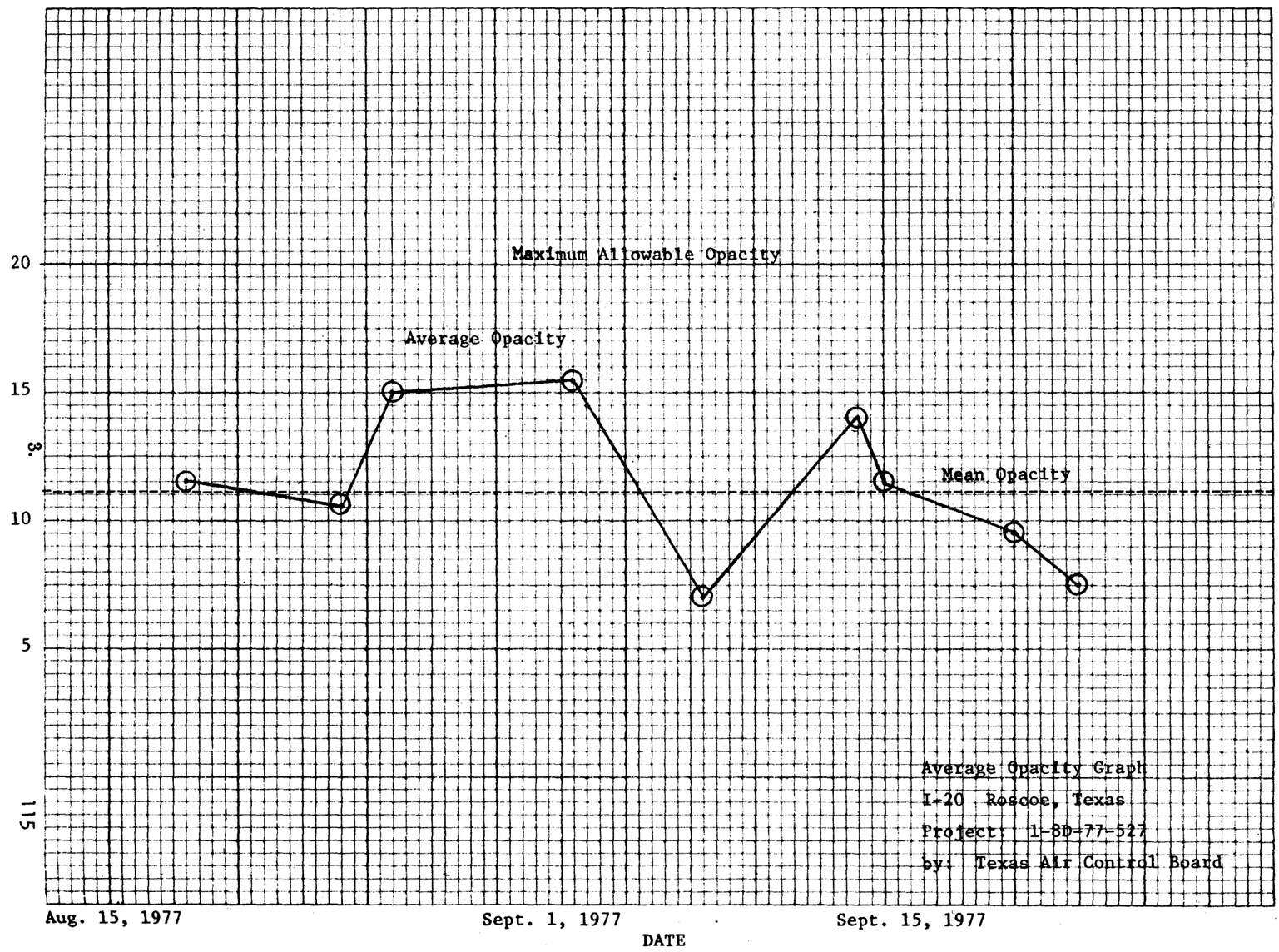
$$\% \text{ EA} = \frac{(XO2 - 0.5\ (XCO))\ \ 100}{0.264\ (XN2) - (XO2 - 0.5\ (XCO))}$$

substituting average orsat values into this equation gives.

$$\% \text{ EA} = \frac{0.1605 \times 100}{(0.264 \times 0.8092) - 0.1605} = 302\%$$

APPENDIX X

OPACITY



APPENDIX XI
DYNAFLECT REPORTS

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-29-78

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770004	I20	08-14-77	29

REASONS FOR MEASUREMENTS AND COMMENTS — TOTAL PAV DEPTH

EX - 19.00 INCHES

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(IN)
ASPHALT PAVEMENT	5.00
BASE	14.00

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS EAST WITH MILEPOINTS

MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE A

	DESCRIPTION OF LOCATION	ODOMETER READING	MILEPOINT
FROM-	MILE POST 235		06.120
	MILE POST 237		08.120
TO-	EXIT 20 SIGN		09.520

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770004	I20	08-14-77	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.430	0.360	0.300	0.260	0.220	0.070	0.25	0.67	MILE POST 235
0.200	1.080	0.900	0.600	0.390	0.300	0.180	0.21	0.60	FILL SECTION
0.400	1.080	0.750	0.380	0.260	0.210	0.330	0.25	0.45	FILL SECTION
0.600	1.200	0.900	0.690	0.480	0.400	0.300	0.23	0.49	
0.800	0.990	0.690	0.440	0.320	0.250	0.300	0.25	0.46	
1.000	1.380	1.020	0.750	0.480	0.360	0.360	0.23	0.47	MILE POST 236
1.200	1.020	0.780	0.420	0.300	0.240	0.240	0.23	0.51	
1.400	1.140	0.810	0.500	0.390	0.310	0.330	0.24	0.46	FILL SECTION
1.600	0.990	0.750	0.410	0.300	0.230	0.240	0.24	0.51	FILL SECTION
1.800	0.930	0.780	0.450	0.330	0.260	0.150	0.22	0.62	
2.000	1.380	0.990	0.660	0.420	0.330	0.390	0.23	0.45	MILE POST 237
2.200	1.470	1.080	0.690	0.450	0.340	0.390	0.23	0.46	
2.400	1.230	0.840	0.500	0.380	0.300	0.390	0.24	0.44	FILL SECTION
2.600	1.020	0.840	0.600	0.390	0.300	0.180	0.22	0.59	FILL SECTION
2.800	1.560	1.140	0.720	0.430	0.310	0.420	0.22	0.46	
3.000	1.500	1.050	0.690	0.440	0.310	0.450	0.23	0.44	MILE POST 238
3.200	1.170	0.900	0.690	0.470	0.360	0.270	0.23	0.51	
3.400	1.080	0.840	0.500	0.360	0.270	0.240	0.23	0.52	EXIT 20 M.P. SIGN
AVERAGES	1.147	0.857	0.555	0.381	0.294	0.291	0.23	0.51	
STANDARD DEVIATION						0.103	0.01	0.07	

NUMBER OF POINTS IN AVERAGE = 18

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENY OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENY OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-29-78

****

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770004	I20	08-14-77	29

REASONS FOR MEASUREMENTS AND COMMENTS: EX -

TOTAL PAV DEPTH: 19.00 INCHES

****

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(IN)
ASPHALT PAVEMENT	5.00
BASE	14.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS EAST WITH MILEPOINTS

MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE A

	DESCRIPTION OF LOCATION	ODOMETER READING	MILEPOINT
FROM-	MILE POST 235		06.120
	MILE POST 237		08.120
TO-	EXIT 20 SIGN		09.520

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

****

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770004	I20	08-14-77	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.450	0.360	0.300	0.260	0.220	0.070	0.25	0.67	MILE POST 235
0.200	1.080	0.900	0.600	0.390	0.300	0.180	0.21	0.60	FILL SECTION
0.400	1.080	0.750	0.380	0.260	0.210	0.330	0.25	0.45	FILL SECTION
0.600	1.200	0.900	0.690	0.480	0.400	0.300	0.23	0.49	
0.800	0.990	0.690	0.440	0.320	0.250	0.300	0.25	0.46	
1.000	1.380	1.020	0.750	0.480	0.360	0.360	0.23	0.47	MILE POST 236
1.200	1.020	0.780	0.420	0.300	0.240	0.240	0.23	0.51	
1.400	1.140	0.810	0.500	0.390	0.310	0.330	0.24	0.46	FILL SECTION
1.600	0.990	0.750	0.410	0.300	0.230	0.240	0.24	0.51	FILL SECTION
1.800	0.930	0.780	0.450	0.330	0.260	0.150	0.22	0.62	
2.000	1.380	0.990	0.660	0.420	0.330	0.390	0.23	0.45	MILE POST 237
2.200	1.470	1.080	0.690	0.450	0.340	0.390	0.23	0.46	
2.400	1.230	0.840	0.500	0.380	0.300	0.390	0.24	0.44	FILL SECTION
2.600	1.020	0.840	0.600	0.390	0.300	0.180	0.22	0.59	FILL SECTION
2.800	1.560	1.140	0.720	0.430	0.310	0.420	0.22	0.46	
3.000	1.500	1.050	0.690	0.440	0.310	0.450	0.23	0.44	MILE POST 238
3.200	1.170	0.900	0.690	0.470	0.360	0.270	0.23	0.51	
3.400	1.080	0.840	0.500	0.360	0.270	0.240	0.23	0.52	EXIT 20 M.P. SIGN
AVERAGES	1.147	0.857	0.555	0.381	0.298	0.291	0.23	0.51	
STANDARD DEVIATION						0.103	0.01	0.07	

NUMBER OF POINTS IN AVERAGE = 18

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-28-78

****

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770044	I.H.20	07-11-78	29

REASONS FOR MEASUREMENTS AND COMMENTS — TOTAL PAV DEPTH
EX - 21.50 INCHES

****

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(IN)
ASPHALT PAVEMENT	9.50
BASE	12.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS EAST WITH MILEPOINTS
MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE A

DESCRIPTION OF LOCATION — ODOMETER READING — MILEPOINT

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770044	I.H.20	07-11-78	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.990	0.870	0.720	0.480	0.400	0.120	0.20	0.65	EXIT NO.233
0.200	0.750	0.720	0.600	0.380	0.320	0.030	0.18	1.01	
0.400	1.020	0.900	0.720	0.460	0.370	0.120	0.20	0.65	
0.600	0.900	0.780	0.600	0.340	0.260	0.120	0.21	0.63	
0.800	0.900	0.780	0.600	0.350	0.220	0.120	0.21	0.63	FILL
1.000	0.840	0.720	0.390	0.300	0.200	0.120	0.21	0.62	FILL
1.200	1.080	0.900	0.660	0.380	0.300	0.180	0.21	0.56	
1.400	1.260	0.990	0.750	0.450	0.320	0.270	0.22	0.50	
1.600	1.200	1.020	0.780	0.600	0.360	0.180	0.20	0.58	
1.800	0.990	0.840	0.660	0.410	0.330	0.150	0.21	0.59	
2.000	0.960	0.840	0.660	0.410	0.320	0.120	0.20	0.64	FILL
2.200	1.290	1.080	0.810	0.630	0.420	0.210	0.20	0.56	0.2 MI W.EXIT NO.237
AVERAGES	1.015	0.870	0.662	0.432	0.318	0.145	0.20	0.63	
STANDARD DEVIATION						0.060	0.01	0.13	

NUMBER OF POINTS IN AVERAGE = 12

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-29-78

****

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PRSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770054	I20	02-14-77	29

REASONS FOR MEASUREMENTS AND COMMENTS TOTAL PAV DEPTH
EX - 19.00 INCHES

****

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(IN)
ASPHALT PAVEMENT	5.00
BASE	14.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS EAST WITH MILEPOINTS
MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE 8

	DESCRIPTION OF LOCATION	ODOMETER READING	MILEPOINT
FROM-	MILE POST 235		06.120
	MILE POST 237		08.120
TO-	EXIT 20 SIGN		09.520

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PRSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770054	I20	02-14-77	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.410	0.340	0.280	0.230	0.200	0.070	0.26	0.67	MILE POST 235
0.200	1.110	0.750	0.450	0.340	0.260	0.360	0.25	0.44	FILL SECTION
0.400	1.380	0.870	0.600	0.400	0.320	0.510	0.25	0.40	FILL SECTION
0.600	0.960	0.810	0.600	0.400	0.310	0.150	0.22	0.62	
0.800	0.960	0.780	0.420	0.330	0.260	0.180	0.22	0.57	
1.000	1.260	1.050	0.780	0.600	0.380	0.210	0.21	0.39	MILE POST 236
1.200	0.870	0.720	0.380	0.270	0.200	0.150	0.23	0.60	
1.400	0.900	0.720	0.400	0.290	0.230	0.180	0.23	0.56	FILL SECTION
1.600	0.930	0.720	0.400	0.300	0.240	0.210	0.24	0.53	FILL SECTION
1.800	0.660	0.430	0.300	0.230	0.144	0.230	0.28	0.47	
2.000	0.930	0.780	0.480	0.380	0.300	0.150	0.22	0.62	MILE POST 237
2.200	1.080	0.870	0.500	0.390	0.300	0.210	0.22	0.56	
2.400	1.050	0.870	0.600	0.400	0.300	0.180	0.22	0.59	FILL SECTION
2.600	1.020	0.780	0.430	0.340	0.270	0.240	0.23	0.51	FILL SECTION
2.800	0.900	0.720	0.430	0.330	0.240	0.180	0.23	0.56	
3.000	0.960	0.780	0.480	0.370	0.300	0.180	0.22	0.57	MILE POST 238
3.200	1.140	0.900	0.690	0.460	0.350	0.240	0.22	0.53	
3.400	1.140	0.720	0.420	0.320	0.250	0.420	0.26	0.41	EXIT 20 M.P. SIGN
AVERAGES	0.981	0.756	0.480	0.354	0.270	0.225	0.23	0.55	
STANDARD DEVIATION						0.106	0.02	0.07	

NUMBER OF POINTS IN AVERAGE = 18

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-26-78

****

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	6	2	1770044	I.H.20	07-11-78	29

REASONS FOR MEASUREMENTS AND COMMENTS — TOTAL PAV DEPTH

EX - 21.50 INCHES

****

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(IN)
ASPHALT PAVEMENT	9.50
BASE	12.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS EAST WITH MILEPOINTS
MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE 8

DESCRIPTION OF LOCATION — ODOMETER READING — MILEPOINT

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

****

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	6	2	1770044	I.H.20	07-11-78	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.810	0.690	0.600	0.440	0.450	0.120	0.22	0.61	EXIT NO.235
0.200	0.870	0.780	0.600	0.390	0.330	0.090	0.20	0.70	
0.400	1.020	0.870	0.690	0.430	0.360	0.150	0.21	0.60	
0.600	0.960	0.810	0.600	0.370	0.310	0.150	0.21	0.59	
0.800	0.960	0.810	0.600	0.360	0.300	0.150	0.21	0.59	
1.000	0.900	0.720	0.410	0.320	0.290	0.180	0.23	0.54	FILL
1.200	0.960	0.810	0.440	0.320	0.250	0.150	0.21	0.59	
1.400	1.110	0.930	0.690	0.430	0.340	0.180	0.21	0.57	
1.600	1.170	0.990	0.720	0.450	0.390	0.180	0.20	0.58	
1.800	0.870	0.780	0.600	0.370	0.270	0.090	0.20	0.70	FILL
2.000	0.990	0.840	0.630	0.400	0.350	0.150	0.21	0.59	FILL
2.200	0.990	0.840	0.660	0.410	0.270	0.150	0.21	0.59	
2.400	0.930	0.810	0.600	0.400	0.330	0.120	0.21	0.64	EXIT NO 237 $100
AVERAGES	0.965	0.822	0.603	0.392	0.326	0.143	0.21	0.60	
STANDARD DEVIATION						0.030	0.01	0.05	

NUMBER OF POINTS IN AVERAGE = 13

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-29-78

****

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770004	I20	02-14-77	29

REASONS FOR MEASUREMENTS AND COMMENTS — TOTAL PAV DEPTH

EX - 19.00 INCHES

****

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(INS)
ASPHALT PAVEMENT	5.00
BASE	14.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS WEST OPPOSITE MILEPOINTS

MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE A

	DESCRIPTION OF LOCATION	ODOMETER READING	MILEPOINT
FROM-	MIDDLE COLUMN OF OVERPASS US 84		09.520
	MILE POST 237		08.120
TO-	MILE POST 235		06.120

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770004	I20	02-14-77	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.930	0.690	0.410	0.300	0.240	0.240	0.24	0.50	ID COL OVERPASS US84
0.200	1.710	1.170	0.750	0.480	0.350	0.540	0.23	0.42	
0.400	1.650	1.140	0.690	0.420	0.310	0.510	0.23	0.42	MILE POST 238
0.600	0.810	0.690	0.430	0.310	0.260	0.120	0.22	0.65	
0.800	0.720	0.500	0.380	0.290	0.230	0.220	0.27	0.49	FILL SECTION
1.000	1.200	0.840	0.500	0.360	0.270	0.360	0.24	0.45	FILL SECTION
1.200	1.170	0.870	0.600	0.410	0.360	0.300	0.23	0.49	
1.400	1.740	1.140	0.750	0.490	0.370	0.600	0.24	0.40	MILE POST 237
1.600	1.260	0.870	0.460	0.320	0.240	0.390	0.24	0.44	
1.800	0.990	0.720	0.400	0.300	0.240	0.270	0.24	0.48	FILL SEC SGN LP 327
2.000	1.200	0.810	0.420	0.300	0.230	0.390	0.25	0.43	FILL SECTION
2.200	1.200	0.870	0.440	0.310	0.230	0.330	0.24	0.47	
2.400	1.650	1.260	0.870	0.690	0.450	0.390	0.21	0.48	MILE POST 236
2.600	1.140	0.780	0.430	0.310	0.250	0.360	0.25	0.44	
2.800	1.080	0.810	0.470	0.360	0.300	0.270	0.24	0.50	
3.000	0.930	0.720	0.370	0.270	0.230	0.210	0.24	0.33	FILL SECTION
3.200	0.870	0.630	0.330	0.250	0.200	0.240	0.25	0.49	FILL SECTION
3.400	0.840	0.720	0.500	0.400	0.350	0.120	0.22	0.66	MILE POST 235
AVERAGES	1.172	0.846	0.511	0.365	0.284	0.324	0.24	0.49	
STANDARD DEVIATION						0.133	0.01	0.07	

NUMBER OF POINTS IN AVERAGE - 18

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 10-03-78

****

PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PRSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770044	I,H,20	07-11-78	29

REASONS FOR MEASUREMENTS AND COMMENTS
EX -

TOTAL PAV DEPTH
22.50 INCHES

****

EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK,(IN)
ASPHALT PAVEMENT	10.50
BASE	12.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS WEST OPPOSITE MILEPOINTS
MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE A

DESCRIPTION OF LOCATION ODOMETER READING MILEPOINT

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PRSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770044	I,H,20	07-11-78	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0,000	0,960	0,840	0,630	0,390	0,320	0,120	0,20	0,63	EXIT NO,237 & 100 F
0,200	0,600	0,480	0,350	0,290	0,240	0,120	0,24	0,56	
0,400	0,930	0,810	0,660	0,410	0,360	0,120	0,20	0,62	FILL
0,600	0,960	0,810	0,600	0,380	0,320	0,150	0,21	0,57	
0,800	1,080	0,900	0,720	0,460	0,410	0,180	0,21	0,55	
1,000	0,900	0,780	0,600	0,380	0,320	0,120	0,21	0,62	
1,200	0,870	0,720	0,440	0,350	0,280	0,150	0,22	0,56	FILL
1,400	0,810	0,720	0,440	0,350	0,290	0,090	0,20	0,67	FILL
1,600	0,900	0,780	0,600	0,350	0,280	0,120	0,21	0,62	
1,800	1,110	0,990	0,780	0,630	0,330	0,120	0,19	0,65	
2,000	0,810	0,690	0,430	0,350	0,280	0,120	0,21	0,60	
2,200	1,020	0,870	0,690	0,450	0,400	0,150	0,21	0,58	EXIT NO,235
AVERAGES	0,912	0,782	0,578	0,399	0,319	0,130	0,21	0,60	
STANDARD DEVIATION						0,023	0,01	0,04	

NUMBER OF POINTS IN AVERAGE = 12

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-29-78

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PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770054	I20	08-14-77	29

REASONS FOR MEASUREMENTS AND COMMENTS — TOTAL PAV DEPTH
EX - 19.00 INCHES

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EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK,INS
ASPHALT PAVEMENT	5.00
BASE	14.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS WEST OPPOSITE MILEPOINTS
MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE 8

	DESCRIPTION OF LOCATION	ODOMETER READING	MILEPOINT
FROM-	MIDDLE COLUMN OF OVERPASS US84		09.520
	MILE POST 237		08.120
TO-	MILE POST 235		06.120

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770054	I20	08-14-77	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0.000	0.720	0.570	0.420	0.300	0.220	0.150	0.24	0.57	ID COL OVERPASS US84
0.200	1.260	0.960	0.690	0.460	0.340	0.300	0.23	0.50	
0.400	1.260	0.900	0.630	0.400	0.300	0.360	0.24	0.46	MILE POST 238 W LANE
0.600	1.080	0.780	0.600	0.380	0.280	0.300	0.24	0.47	
0.800	0.960	0.780	0.480	0.350	0.270	0.180	0.22	0.57	FILL SECTION
1.000	0.960	0.780	0.460	0.320	0.250	0.180	0.22	0.57	FILL SECTION
1.200	1.050	0.810	0.480	0.360	0.290	0.240	0.23	0.52	
1.400	1.110	0.900	0.660	0.420	0.320	0.210	0.22	0.56	MILE POST 237
1.600	1.020	0.780	0.500	0.320	0.240	0.240	0.23	0.51	
1.800	1.170	0.840	0.470	0.310	0.240	0.330	0.24	0.47	FILL SEC SGN LP 327
2.000	0.990	0.780	0.500	0.350	0.270	0.210	0.23	0.54	FILL SECTION
2.200	1.200	0.960	0.470	0.320	0.230	0.240	0.22	0.54	
2.400	1.530	1.140	0.810	0.600	0.400	0.390	0.22	0.47	MILE POST 236
2.600	1.020	0.750	0.400	0.300	0.230	0.270	0.24	0.49	
2.800	0.960	0.780	0.480	0.370	0.320	0.180	0.22	0.57	
3.000	0.690	0.630	0.400	0.300	0.260	0.060	0.21	0.83	
3.200	0.960	0.810	0.600	0.380	0.290	0.150	0.22	0.62	
3.400	0.400	0.330	0.270	0.230	0.200	0.070	0.26	0.66	MILE POST 235
AVERAGES	1.019	0.793	0.518	0.339	0.279	0.226	0.23	0.55	
STANDARD DEVIATION						0.091	0.01	0.09	

NUMBER OF POINTS IN AVERAGE - 18

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

TEXAS HIGHWAY DEPARTMENT

DISTRICT 08 -DESIGN SECTION

DYNAFLECT DEFLECTIONS AND CALCULATED STIFFNESS COEFFICIENTS

THIS PROGRAM WAS RUN - 09-28-78

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PROJECT IDENTIFICATION

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770048	I.H.20	07-11-78	29

REASONS FOR MEASUREMENTS AND COMMENTS
EX -

TOTAL PAV DEPTH
22.50 INCHES

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EXISTING PAVEMENT

MATERIAL TYPE	LAYER THICK.(IN)
ASPHALT PAVEMENT	10.50
BASE	12.00

****

GENERAL LOCATION INFORMATION

DIRECTION OF TRAVEL IS WEST OPPOSITE MILEPOINTS
MEASUREMENTS ARE 06 FEET FROM THE RIGHT SIDE OF LANE 6

DESCRIPTION OF LOCATION ODOMETER READING MILEPOINT

****

PLOTS WERE REQUESTED WITH THIS PROGRAM.

DIST.	COUNTY	CONT.	SECT.	PPSN	HIGHWAY	DATE	DYNAFLECT
08	NOLAN	0006	02	1770048	I.H.20	07-11-78	29

DYNAFLECT DATA

ODOMETER	W1	W2	W3	W4	W5	SCI	AS2	AP2	REMARKS
0800031	0.100	0.600	*****	3.300	0.0	1.500	0.14	0.43	EXIT NO. 237 4100 FT
0800.200	0.600	0.700	SCI ZERO OR LESS,OTHER CALCULATIONS OMITTED						
0800.400	1.230	0.990	0.750	0.460	0.390	0.240	0.21	0.51	FILL
0800.600	1.050	0.840	0.490	0.370	0.300	0.210	0.22	0.52	
0800.800	1.050	0.900	0.690	0.420	0.200	0.150	0.20	0.59	
0801.000	0.990	0.870	0.630	0.370	0.280	0.120	0.20	0.63	
1.200	0.960	0.780	0.600	0.360	0.280	0.180	0.22	0.54	FILL
1.400	0.840	0.720	0.440	0.340	0.300	0.120	0.21	0.61	FILL
1.600	0.930	0.780	0.600	0.470	0.310	0.150	0.21	0.57	
1.800	0.960	0.900	0.690	0.410	0.330	0.060	0.18	0.82	
2.000	0.930	0.840	0.690	0.430	0.360	0.090	0.19	0.70	
2.200	1.170	0.990	0.780	0.600	0.440	0.180	0.20	0.56	
2.400	0.900	0.810	0.660	0.440	0.380	0.090	0.20	0.69	EXIT NO.239
AVERAGES	1.592	1.335	1.585	0.664	0.297	0.257	0.20	0.60	
STANDARD DEVIATION						0.395	0.02	0.10	

NUMBER OF POINTS IN AVERAGE = 12

W1-5 DEFLECTIONS AT GEOPHONES 1,2,3,4,&5
SCI SURFACE CURVATURE INDEX (W1 MINUS W2)
AS2 STIFFNESS COEFFICIENT OF THE SUBGRADE
AP2 STIFFNESS COEFFICIENT OF THE PAVEMENT

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