LABORATORY EVALUATION OF POLYMER AND MULTI-GRADE ASPHALT BINDERS

FINAL REPORT
MLR-90-5

APRIL 1992

Highway Division

Iowa Department of Transportation

TECHNICAL REPORT TITLE PAGE

1. REPORT NO. MLR-90-5	2. REPORT DATE February 1992
3. TITLE AND SUBTITLE Laboratory Evaluation of Polymer and Multi-Grade Asphalt Binders	4. TYPE OF REPORT & PERIOD COVERED Final Report February 1992
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7. ACKNOWLEDGEMENT OF COOPERATING ORGANIZATIONS	

8. ABSTRACT

A number of claims have been made that polymer modified asphalt cements, multi-grade asphalt cements, and other modifications of the liquid asphalt will prevent rutting and other deterioration of asphalt mixes, thereby, extending the service life of asphalt pavements.

This laboratory study evaluates regular AC-20 asphalt cement, PAC-30 polymer modified asphalt cement and AC-10-30 multi-grade asphalt cement. PAC-30 was also evaluated with 15% Gilsonite and 15% Witcurb in a 75% crushed stone - 25% sand mix.

These mixtures were evaluated for all Marshall properties along with indirect tensile, resilient modulus, and creep resistance.

9. KEY WORDS Polymers, Asphalt Cement, Asphalt Concrete, Asphalt Stabilizers	10. NO. OF PAGES 30

INTRODUCTION

The polymer modified asphalt cements have been around for years. The primary selling point is that they have a higher viscosity at higher temperatures and a lower viscosity at lower temperatures than regular asphalt cements. In other words, the temperature-viscosity curves are flatter than with regular asphalt cements. The same claims are made for the multi-grade.

Laboratory tests on these individual materials do show flatter temperature-viscosity curves than for nonmodified asphalt cements.

The intent is that the viscosity for these materials will be higher in the hot summer and lower in the cold weather. This is reported to deter cold weather cracking and hot weather rutting.

The added cost of the polymer modified being twice that of regular asphalt cements has deterred any heavy uses. The multi-grade is quite new in our area, but is reported to be less costly than the polymer modified asphalt cements.

MATERIALS

PAC-30

PAC-30 polymer modified asphalt cement is primarily a regular asphalt cement, of some grade, to which has been added a polymer, in this case, a Styrene Butadene Styrene (SBS) polymer. The percent of SBS added is approximately 3% by weight, which is dependent on the grade of asphalt cement, the compatibility of the asphalt cement and SBS and, of course, the specification that is to be met.

The SBS usually is not combined with the asphalt cement at the paving site. The PAC materials available in the Iowa area are combined using special equipment permanently located at asphalt terminals and/or refineries. Iowa Department of Transportation specifications for PAC grades are included in Appendix D.

<u>Multi-grade AC-10-30</u>

Multi-grade asphalt cements are manufactured from some regular AC grade with the addition of refined "tall oil" (tree sap), a by-product of the paper industry, along with other nontoxic chemicals.

The amount of tall oil added is approximately 5% by weight of the AC. Any multi-grade AC used here in Iowa likely would be shipped from Bituminous Materials located in Indiana. Specifications for multi-grade asphalt cements are included in Appendix E.

<u>Witcurb</u>

Witcurb is a dry powdered asphalt manufactured from asphalt cement. It is used primarily to harden asphalt cement mixtures so they will perform better than regular asphalt cement mixtures when used in curbs. It is also used in mixtures to help deter rutting and shoving at intersections, toll booths, etc.

This material is generally added by the contractor to the asphalt cement or into the pugmill or asphalt mixer at the rate of 15% of the weight of the asphalt cement in the mixture.

It is sold by Witco Chemical Corp., Pioneer Division, Lawrenceville, Illinois and can be purchased in bags or bulk.

An 85-100 penetration AC at 92 penetration will drop to 67 penetration mixed at 15% Witcurb. It will drop to 55 penetration when mixed at 25% Witcurb (1).

Gilsonite

Gilsonite is a natural powdered asphalt. It is a natural hydrocarbon, black as coal, mined from vertical seams which run for miles in the Unitah Basin in eastern Utah. These seams are 3 to 6 feet wide and may be 1500 feet deep. This material has many uses in various industries.

The Gilsonite is incorporated into mixtures approximately the same way as described above for Witcurb and for the same purposes. An 85-100 penetration AC at 92 penetration will drop to 26 penetration mixed at 15% Gilsonite. At 25% Gilsonite the penetration will drop to 7 (1).

A.C. VISCOSITY-PENETRATION RELATIONSHIPS

Each asphalt cement and modified asphalt cement has a uniquely characteristic viscosity-penetration relationship. This relationship is not just for each grade, but also each grade from each crude source. Each grade from each different crude source has a different characteristic when combined with each of the many different modifiers. This creates a multitude of different binders with small to large differences. A general polymerized asphalt cement (PAC) specification is included in Appendix D.

Penetration viscosity number (PVN) will also be different for each of the above binder variables. PVN is an indicator of the temperature susceptibility of the material. The viscosity and penetration of the original asphalt and thin film residue of the material are plotted. The penetrations are run at 77 degrees F, 100 gms, 5 Sec. and the viscosities are Absolute at 140 degrees F and 300mm Hg. A few different binders are plotted on a PVN graph in Appendix F.

The PVN susceptibility lines are shown as Penetration Index-Penetration Viscosity Number (PI-PVN) as 0, -1.0, and -1.5. The 0 is the least temperature susceptible and the -1.5 is the most temperature susceptible. Note the PAC's usually plot near or above the 0 line. As a general rule regular AC's will plot between the -1.0 and 0 with a few slightly below the -1.0. The old "Sugar Creek" (high temp susceptible) Amoco asphalt cement plotted below the -1.5 and was not used in some cases, due to tenderness and generally slow setting compared to asphalt cements from other sources. The Kansas City refinery that produced the old "Sugar Creek" asphalt cement was closed several years ago at approximately 70 years of age.

Generally, most of the regular AC grades produced from any one crude source through any one refinery will all have approximately the same temperature susceptibility or PVN.

The results for all of the mixture design criteria and also the special testing are shown in Appendix A.

It is interesting to note that the testing showed the PAC-30 design had the lowest indirect tensile, lowest resilient modulus and lowest creep factor numbers. There are companies espousing the high benefits of polymerized AC's, yet this mix design does not show any benefits with these particular tests over the regular AC-20 or the multi-grade AC-10-30. In fact, the AC-20 showed equal or higher results in the Marshall test, resilient modulus and creep tests.

The Gilsonite and Witcurb additives had higher Marshall test results than the other 50 blow designs. This would be expected. The Gilsonite additive had much higher indirect tensile and resilient modulus values than the others.

The calculated film thicknesses are essentially the same for the 50 blow mixes. The original 75 blow mix had a lower AC film calculation due to a lower asphalt cement content, because of lower voids in the mineral aggregate (VMA) due to the higher compactive effort.

The creep factors are essentially the same for the 50 blow mixes because the creep factor is primarily dependent on the size and crushed particle contents of the aggregates. The higher the percentage of crushed aggregate in the mix and the larger the size of the major portion of the aggregate, the higher the creep factor. The higher the factor the more resistance to deformation at 104 degrees F.

Results of the indirect tensile test from the highest to the lowest PSI show that the AC-10-30 had 198 PSI, the AC-20 had 181 PSI, and the PAC-30 had 145 PSI. PAC-30 with Gilsonite had 266 PSI and PAC-30 with Witcurb had 186 PSI.

Creep resistance was approximately the same for all mixes ranging from 82 to 84, except the PAC-30 with Gilsonite tested at 74. Resilient modulus was highest for AC-20 at 850 KSI followed by AC-10-30 at 770 KSI and PAC-30 with 340 KSI. The PAC-30 with 15% Gilsonite had 1,020 KSI and PAC-30 with 15% Witcurb had 510 KSI.

These results are only related to a particular mix design gradation, aggregate type, crushed particle, percentage, aggregate absorption and, etc.

MIX DESIGN

The aggregate used in this research was the same as used in mix design #ABD0-1011 project M-2808(4)--81-77 in Polk County. This mix design was a 1/2" dense graded, Type A surface course, 75 blow Marshall Design. We used the same aggregates and proportions with a 50 blow design. It was made up of 50%, 1/2" crushed limestone from Martin-Marietta, Ames Mine; 25%, 3/8" limestone chips from Martin-Marietta, Ferguson, Marshall County; and 25% sand from Martin-Marietta, Johnston, Polk County. Gradations are shown in Table I.

Table I

Sieve Size	1/2" Limestone	3/8" Limestone Chips	Sand	Combined
3/4	100	100	100	100
1/2	92	100	100	96
3/8	67	97	100	83
#4	37	32	94	50
#8	26	5.0	85	36
#16	22	2.1	72	30
#30	18	1.7	44	20
#50	14	1.5	12	10
#100	11	1.4	1.0	6.1
#200	9.0	0.5	0.5	4.8

A 0.45 power gradation chart is shown with the final mix gradation plotted in Appendix B.

Three point conventional Marshall (50 blow) mix designs were performed with regular AC-20 and then "parallel" mix designs were made using the PAC-30 and also the multi-grade AC-10-30.

Further, one point designs were made adding 15% Witcurb to the PAC-30 liquid and 15% Gilsonite to the PAC-30 liquid. These two mixtures were tested for the same criteria. Only one point was made for each due to a shortage of aggregates.

The optimum liquid contents in the mix designs were chosen to correspond to approximately 4.0% air voids. The above Gilsonite and Witcurb mixes came out at approximately 3% voids when the aggregate supply was depleted, therefore, these were not redone to achieve 4% voids.

PROCEDURE

These designs were performed in accordance with Iowa Materials Lab Test Method No. 502A.

Six lab specimens were made with each of these different AC binders at 4% lab voids as a target.

Three specimens of each different AC binder were tested for indirect tensile and the other three specimens for each set were tested for resilient modulus and then further tested for creep resistance, because the resilient modulus is supposed to be a nondestructive test.

CONCLUSIONS

Based on these results, the extra cost for PAC-30 at two times the cost of regular asphalt cement and the extra cost for the multi-grade, also at 50% more cost over regular asphalt cement, may not be cost effective at least for the short term.

We will need pavement test sections and it may take several years of observation of performance to determine if these materials will be cost effective over regular asphalt cements.

Many conclusions will result from the study of the many test results shown here.

ACKNOWLEDGEMENTS

Appreciation is extended to the efforts put forth by Willard Oppedal, Mike Coles, Steve McCauley, Dan Seward and Dennis Walker of the Materials Lab Bituminous Section for performing the lab work required for this study. The work of Mark Trueblood in obtaining the aggregates and Kathy Davis in report preparation is also appreciated.

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Appendix A
Final Mixture Design Criteria and Test Results

Comparison of Test Parameters of the
Six Mixes at Optimum Mixture Criteria

	ABDO-1011 Orig.Mix Design AC-10	ABDO-0148 AC-20	ABDO-0150 AC-10-30 Multi-grade	ABDO-0149 PAC-30	ABDO-0149C PAC-30 15% Gilsonite	ABDO-0149D PAC-30 15% Witcurb
% Binder in Mix	4.50	5.00	5.00	5.25	5.10	5.10
No. Marshall Blows	75	50	50	50	50	50
Marshall Stability lbs.	2,877	2,336	2,328	2,247	2,780	3,100
Flow - 0.01 IN.	8.5	8.3	7.3	8.6	13	12
Lab Density	2.381	2.380	2.391	2.374	2.366	2.369
Bulk Sp. Gr. Dry Aggregate	2.644	2.653	2.666	2.675	2.675	2.675
Calc. Solid Sp. Gr.	2.512	2.496	2.501	2.502	2.507	2.507
% Voids-Calc.	5.05	4.60	4.391	5.09	5.64	5.52
Rice Sp. Gr.	2.472	2.497	2.490	2.473	2.473	2.444
% Voids-Rice	4.00	3.92	3.96	4.06	2.91	3.07
% Water Absorp. Aggregate	1.50	1.37	1.21	1.17	1.17	1.17
% Voids in Mineral Agg.	14.0	15.03	14.87	15.84	16.06	15.96
% V.M.A. Filled with AC	62.80	68.94	70.00	68.04	64.87	65.39
Calc. Asphalt Film Microns	7.7	9.3	9.4	10.0	9.7	9.7
Indirect Tensile PSI	*	181	198	145	266	186
(Resilient) at 50 lbs.	*	820,000	800,000	---	---	600,000
(Modulus) at 75 lbs.	*	850,000	770,000	340,000	1,020,000	510,000
Creep Factor (0-100)	*	84	84	82	74	83

*Not done on original mix.

Appendix B
Individual Mix Designs

ABDO-1011
BD

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT MIX DESIGN
LAB LOCATION - AMES

LAB NO....:ABDO-1011

MATERIAL........:TYPE A
INTENDED USE....:BINDER/SURFACE
PROJECT NO......:CST-TSF-415-1(32)--92-77
FM-TSF-0077(1)--5B-77
M-2808(4)--81-77
COUNTY..........:POLK
SPEC NO.........:1092.00
SAMPLED BY......:
CONTRACTOR:DES MOINES ASPHALT
SIZE......:1/2
SENDER NO.:
DATE SAMPLED: DATE RECEIVED: DATE REPORTED: 06/05,
PROJ. LOCATION: NE 46 AVE AT NE 22 ST.

AGG SOURCES: CR. LMST- MARTIN MARIETTA, AMES MINE, STORY CO; CHIPS- MARTIN MAREITTA, FERGUSON, MARSHALL CO; SAND- MARTIN MARIETTA, JOHNSTON, POLK CO.

JOB MIX FORMULA-COMB. GRADATION

1 1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.2
		100.0	96.0	83.0	50.0	36.0	30.0	20.0	10.0	6.1	4.60

TOLERANCE /100 :

100	7	7	5			4			

MATERIAL MIX	A85006	A64002	A77502		
% AGGR. PROP.	50.00	25.00	25.00	0.00	0.00

ASPHALT SOURCE AND APPROXIMATE VISCOSITY POISES	TAMA			
% ASPHALT IN MIX	4.00	5.00	6.00	0.0(
NUMBER OF MARSHALL BLOWS	75	75	75	0
MARSHALL STABILITY - LBS.	2970	2777	2575	0
FLOW - 0.01 IN.	8	9	10	0
SP GR BY DISPLACEMENT (LAB DENS)	2.373	2.389	2.405	0.0(
BULK SP. GR. COMB. DRY AGG.	2.644	2.644	2.644	0.0(
SP. GR. ASPH. @ 77 F.	1.023	1.023	1.023	0.0(
CALC. SOLID SP. GR.	2.531	2.492	2.455	0.0(
% VOIDS - CALC.	6.23	4.15	2.05	0.0(
RICE SP.GR.	2.509	2.452	2.442	0.0(
% VOIDS - RICE	5.42	2.56	1.51	0.0(
% WATER ABSORPTION - AGGREGATE	1.50	1.50	1.50	0.0(
% VOIDS IN MINERAL AGGREGATE	13.84	14.16	14.50	0.0(
% V.M.A. FILLED WITH ASPHALT	54.98	70.70	85.87	0.0(
CALC. ASPH. FILM THICK. MICRONS	6.66	8.71	10.75	0.0(

BULK SP. GR. OF COMBINED AGG. CALCULATED FROM DATA ON INDIVIDUAL SOURCES; 1% WATER ABSORPTION ALSO.

COPIES TO:

CENTRAL LAB	D. HEINS	~~R. MONROE~~	
DES MOINES ASPH.	W. OPPEDAL	POLK	CO.
DIST. 1			

DISPOSITION: AN ASPHALT CONTENT OF 4.5% IS RECOMMENDED TO START THE JOB. TOLERANCE ON #200 ALSO CONTROLLED BY BILLER/BITUMEN RATIO.

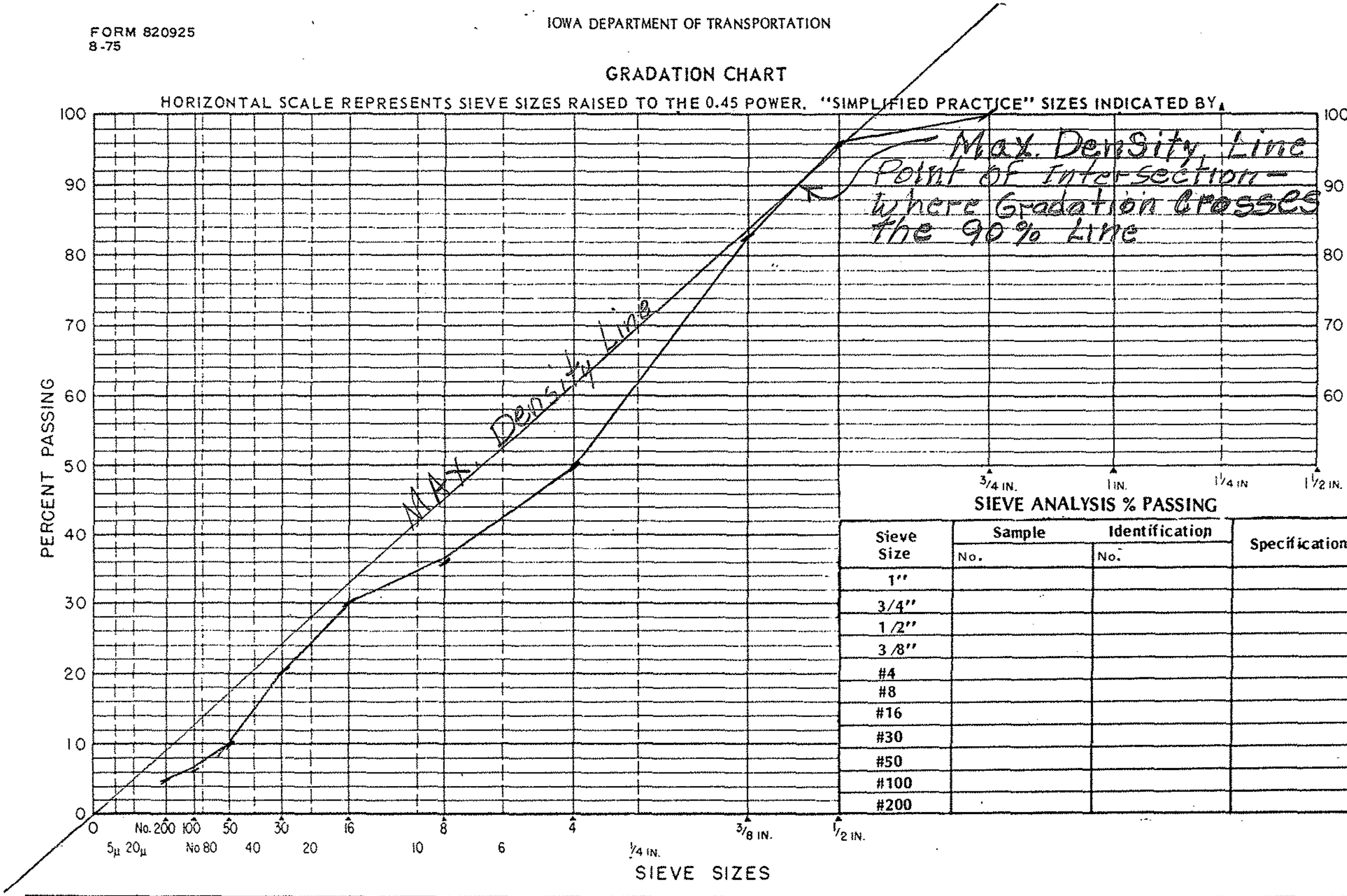
SIGNED: ORRIS J. LANE,
TESTING ENGINEER

FORM 820925
8-75

IOWA DEPARTMENT OF TRANSPORTATION

GRADATION CHART

HORIZONTAL SCALE REPRESENTS SIEVE SIZES RAISED TO THE 0.45 POWER. "SIMPLIFIED PRACTICE" SIZES INDICATED BY ▲



SIEVE ANALYSIS % PASSING

Sieve Size	Sample No.	Identification No.	Specification
1"			
3/4"			
1/2"			
3/8"			
#4			
#8			
#16			
#30			
#50			
#100			
#200			

Co. PROJECT NO.

TYPE CONST; LOCATION ON PROJECT

TYPE, SOURCE, PRODUCER OF AGG.

Plott of gradation used. - MLR-90-5

SAMPLED FROM	SAMPLED BY	DATE	QUANT. REPRESENTED	SIEVED BY	DATE	SIEVE METHOD	REMARKS

A800-0148
BD

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT MIX DESIGN
LAB LOCATION - AMES

LAB NO....:ABD0-0148

INTENDED USE....:RESEARCH

CONTRACTOR:VERN MARKS

SAMPLED BY......:
SENDER NO.:

DATE SAMPLED: DATE RECEIVED: DATE REPORTED: 07/31/9

JOB MIX FORMULA-COMB. GRADATION

1 1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.20
		100.0	97.0	83.0	51.0	37.0	28.0	18.0	9.0	6.0	4.6

TOLERANCE /100 :

MATERIAL MIX
% AGGR. PROP. 0.00 0.00 0.00 0.00 0.00

ASPHALT SOURCE AND	DIA. SHAM.			
APPROXIMATE VISCOSITY ~~POISES~~	2055			
% ASPHALT IN MIX	4.00	4.75	5.50	0.00
NUMBER OF MARSHALL BLOWS	50	50	50	0
MARSHALL STABILITY - LBS.	2272	2378	2253	0
FLOW - 0.01 IN.	7	8	9	0
SP GR BY DISPLACEMENT (LAB DENS)	2.340	2.379	2.383	0.000
BULK SP. GR. COMB. DRY AGG.	2.653	2.653	2.653	0.000
SP. GR. ASPH. @ 77 F.	1.016	1.016	1.016	0.000
CALC. SOLID SP. GR.	2.533	2.504	2.475	0.000
% VOIDS - CALC.	7.63	4.99	3.74	0.00
RICE SP.GR.	2.517	2.487	2.459	0.000
% VOIDS - RICE	7.03	4.34	3.09	0.00
% WATER ABSORPTION - AGGREGATE	1.37	1.37	1.37	0.00
% VOIDS IN MINERAL AGGREGATE	15.33	14.59	15.12	0.00
% V.M.A. FILLED WITH ASPHALT	50.23	65.77	75.29	0.00
CALC. ASPH. FILM THICK. MICRONS	7.10	8.71	10.31	0.00

F/B 0.93

(4.0 % voids at 4.95% A.C.)

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V. MARKS

DISPOSITION:

SIGNED: ORRIS J. LANE, JR
TESTING ENGINEER

/////

A300-0150
BD

MIX DESIGN

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT MIX DESIGN
LAB LOCATION - AMES

LAB NO....:ABD0-0150

INTENDED USE....:RESEARCH

CONTRACTOR:VERN MARKS

SAMPLED BY......:
SENDER NO.:

DATE SAMPLED: DATE RECEIVED: DATE REPORTED: 08/10/90

ASPHALT - MULTIGRADE

JOB MIX FORMULA-COMB. GRADATION

1 1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.200
		100.0	97.0	83.0	51.0	37.0	28.0	18.0	9.0	6.0	4.6

TOLERANCE /100 :

MATERIAL MIX

% AGGR. PROP.	0.00	0.00	0.00	0.00	0.00

% ASPHALT IN MIX	4.00	4.75	5.50	0.00
NUMBER OF MARSHALL BLOWS	50	50	50	0
MARSHALL STABILITY - LBS.	2073	2320	2342	0
FLOW - 0.01 IN.	7	7	8	0
SP GR BY DISPLACEMENT (LAB DENS)	2.342	2.384	2.406	0.000
BULK SP. GR. COMB. DRY AGG.	2.666	2.666	2.666	0.000
SP. GR. ASPH. @ 77 F.	1.018	1.018	1.018	0.000
CALC. SOLID SP. GR.	2.540	2.511	2.482	0.000
% VOIDS - CALC.	7.80	5.05	3.07	0.00
RICE SP.GR.	2.536	2.503	2.465	0.000
% VOIDS - RICE	7.65	4.75	2.39	0.00
% WATER ABSORPTION - AGGREGATE	1.21	1.21	1.21	0.00
% VOIDS IN MINERAL AGGREGATE	15.67	14.83	14.72	0.00
% V.M.A. FILLED WITH ASPHALT	50.21	65.93	79.15	0.00
CALC. ASPH. FILM THICK. MICRONS	7.27	8.87	10.47	0.00
FILLER/BITUMEN RATIO	0.00	0.92	0.00	0.00

3.96% VOIDS @ 5.0% AC

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DOUG HEINS

DISPOSITION:

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

ABDO-~~2149~~ 149
BD

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT MIX DESIGN
LAB LOCATION - AMES

LAB NO....:ABD0-0149

INTENDED USE....:RESEARCH

CONTRACTOR:VERN MARKS

SAMPLED BY......:
SENDER NO.:

DATE SAMPLED: DATE RECEIVED: DATE REPORTED: 07/31/90

JOB MIX FORMULA-COMB. GRADATION

1 1/2"	1"	3/4"	1/2"	3/8"	NO.4	NO.8	NO.16	NO.30	NO.50	NO.100	NO.200
		100.0	97.0	83.0	51.0	37.0	28.0	18.0	9.0	6.0	4.6

TOLERANCE /100 :

MATERIAL MIX					
% AGGR. PROP.	0.00	0.00	0.00	0.00	0.00

ASPHALT SOURCE AND PAC-30	ELF			
APPROXIMATE VISCOSITY POISES	3440			
% ASPHALT IN MIX	4.00	4.75	5.50	0.00
NUMBER OF MARSHALL BLOWS	50	50	50	0
MARSHALL STABILITY - LBS.	2393	2187	2280	0
FLOW - 0.01 IN.	7	8	9	0
SP GR BY DISPLACEMENT (LAB DENS)	2.340	2.355	2.384	0.000
BULK SP. GR. COMB. DRY AGG.	2.675	2.675	2.675	0.000
SP. GR. ASPH. @ 77 F.	1.032	1.032	1.032	0.000
CALC. SOLID SP. GR.	2.550	2.521	2.492	0.000
% VOIDS - CALC.	8.23	6.58	4.35	0.00
RICE SP.GR.	2.516	2.491	2.467	0.000
% VOIDS - RICE	7.00	5.46	3.36	0.00
% WATER ABSORPTION - AGGREGATE	1.17	1.17	1.17	0.00
% VOIDS IN MINERAL AGGREGATE	16.02	16.14	15.78	0.00
% V.M.A. FILLED WITH ASPHALT	48.66	59.26	72.42	0.00
CALC. ASPH. FILM THICK. MICRONS	7.31	8.91	10.51	0.00

F/B 1.13

4.06% voids at 5.25% A.C.

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V. MARKS

DISPOSITION:

/////

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TESTING ENGINEER

Appendix C
Liquid Asphalt Tests

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT
LAB LOCATION - AMES

LAB NO.....:AB 0-0136

ATERIAL.......:AC MULTIGRADE 10/30
NTENDED USE....:TRIAL MIXES
RODUCER.........:ASPHALT MATERIALS INC.
ROJECT NO.......:DEPT. INFO.
UANTITY.........:5 GAL.
RAND............:PETROLEUM ASPHALT
OURCE...........:INDIANAPOLIS, INDIANA
AMPLED BY.......:, SENDER NO.:
ATE SAMPLED: DATE RECEIVED: 08/06/90 DATE REPORTED: 08/13/90

ENETRATION # 39 F. 200 GMS. 60 SEC.:	27
IS. RATIO:	1.49

LAB NUMBER AB 0-0136	
PENETRATION @ 77 F. 100 GMS. 5 SEC	83
ABS. VIS. OF ORIGINAL ASPH. @ 140 DEGREE F. & 300 MM HG	2815
THIN FILM LOSS ON HEATING 5 HRS. @325 DEGREES F.	0.17
% ORIGINAL PENETRATION (THIN FILM RES.)	71
PENETRATION OF RES. 77 DEGREE F. 100 GMS. 5 SEC.	59
DUCTILITY @077 DEGREE F. (THIN FILM RES.)	42
ABS. VIS. OF THIN FILM RESIDUE @ 140 DEGREE F. & 300 MM HG	4199

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TESTING ENGINEER

/////

B 0-0290A

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT
LAB LOCATION - AMES

LAB NO....:AB 0-0290A - AB 0-0290B

ATERIAL........:PAC 30 WITH WITCURB
NTENDED USE....:TRIAL MIXES
ROJECT NO......:MLR-90-5
NIT OF MATERIAL:ABO-34 WITH WITCURB ADDED (15%)
AMPLED BY......: SENDER NO.:
ATE SAMPLED: 10/25/90 DATE RECEIVED: DATE REPORTED: 12/13/90

WITH WITCURB (15%) *
** WITHOUT WITCURB **

LAB NUMBER AB 0-0290A

TESTING LAB AMES LAB *	
PENETRATION @ 77 F. 100 GMS. 5 SEC	43
SP. GR. @ 060 DEGREE F./ 060 DEGREE F.	1.1830
SOLUBLE IN C2HC13	99.70
ABS. VIS. OF ORIGINAL ASPH. @ 140 DEGREE F. & 300 MM HG	19799
KINEMATIC VISCOSITY @ 275 DEGREE F.	1604
THIN FILM LOSS ON HEATING 5 HRS. @325 DEGREES F.	0.13
% ORIGINAL PENETRATION (THIN FILM RES.)	56
PENETRATION OF RES. 77 DEGREE F. 100 GMS. 5 SEC.	24

LAB NUMBER AB 0-0290B

TESTING LAB AMES LAB**	
PENETRATION @ 77 F. 100 GMS. 5 SEC	102
SP. GR. @ 060 DEGREE F./ 060 DEGREE F.	1.0290
SOLUBLE IN C2HC13	99.92
ABS. VIS. OF ORIGINAL ASPH. @ 140 DEGREE F. & 300 MM HG	4011
KINEMATIC VISCOSITY @ 275 DEGREE F.	655
THIN FILM LOSS ON HEATING 5 HRS. @325 DEGREES F.	0.11
% ORIGINAL PENETRATION (THIN FILM RES.)	73
PENETRATION OF RES. 77 DEGREE F. 100 GMS. 5 SEC.	74
ABS. VIS. OF THIN FILM RESIDUE @ 140 DEGREE F. & 300 MM HG	8713
F ELASTIC RECOVERY %	73.0
ABSOLUTE VISCOSITY RATIO	2.17

F: FAILED, BROKE @ 10 CM.
COPIES TO:
CENTRAL LAB R. MONROE D. HEINS
D. HINES

DISPOSITION: FOR INFORMATION

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

/////

B 0-0289A

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT
LAB LOCATION - AMES

LAB NO....:AB 0-0289A - AB 0-0289B

ATERIAL........:PAC 30 WITH GILSONITE
NTENDED USE....:TRIAL MIXES
ROJECT NO......:MLR 90-5
'NIT OF MATERIAL:AB0-34 WITH GILSONITE ADDED (15%)
AMPLED BY......: SENDER NO.:
ATE SAMPLED: 10/25/90 DATE RECEIVED: 12/05/90 DATE REPORTED: 12/13/90

WITH GILSONITE ADDED (15%)*
** WITHOUT GILSONITE**

LAB NUMBER AB 0-0289A

TESTING LAB AMES LAB *	
PENETRATION @ 77 F. 100 GMS. 5 SEC	55
SP. GR. @ 060 DEGREE F./ 060 DEGREE F.	1.2001
SOLUBLE IN C2HC13	99.96
ABS. VIS. OF ORIGINAL ASPH. @ 140 DEGREE F. & 300 MM HG	16807
KINEMATIC VISCOSITY @ 275 DEGREE F.	1510
THIN FILM LOSS ON HEATING 5 HRS. @325 DEGREES F.	0.13
% ORIGINAL PENETRATION (THIN FILM RES.)	62
PENETRATION OF RES. 77 DEGREE F. 100 GMS. 5 SEC.	34

LAB NUMBER AB 0-0289B

TESTING LAB AMES LAB**	
PENETRATION @ 77 F. 100 GMS. 5 SEC	102
SP. GR. @ 060 DEGREE F./ 060 DEGREE F.	1.0290
SOLUBLE IN C2HC13	99.92
ABS. VIS. OF ORIGINAL ASPH. @ 140 DEGREE F. & 300 MM HG	4011
KINEMATIC VISCOSITY @ 275 DEGREE F.	855
THIN FILM LOSS ON HEATING 5 HRS. @325 DEGREES F.	0.11
% ORIGINAL PENETRATION (THIN FILM RES.)	73
PENETRATION OF RES. 77 DEGREE F. 100 GMS. 5 SEC.	74
ABS. VIS. OF THIN FILM RESIDUE @ 140 DEGREE F. & 300 MM HG	8713
F ELASTIC RECOVERY %	73.0
ABSOLUTE VISCOSITY RATIO	2.17

F: FAILED, BROKE AT 13 CM.
COPIES TO:
CENTRAL LAB D. HEINS D. HINES
R. MONROE

DISPOSITION: FOR INFORMATION

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

/////

Appendix D
Polymerized Asphalt Specifications

Specification SS-1084
(Replaces 1041)

Iowa Department of Transportation

SUPPLEMENTAL SPECIFICATION
for
POLYMERIZED ASPHALT CEMENT

June 27, 1989

THE STANDARD SPECIFICATIONS, SERIES OF 1984, ARE AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE SUPPLEMENTAL SPECIFICATIONS, AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

1084.01 DESCRIPTION. This specification describes a polymerized asphalt cement, intended for use in special asphalt cement concrete mixtures. This material is not accepted on the basis of certification. A supply of material intended to be delivered to a project shall be tested and approved by the Engineer before incorporation into the project. Additional random samples shall be taken at the project site and tested as the project is progressing, at the discretion of the District Materials Engineer.

1084.02 MATERIAL. The polymerized asphalt cement shall meet the following requirements when tested by the appropriate AASHTO Test Methods, with exception to the Elastic Recovery Test, which shall be tested in accordance with Iowa Test Method No. 631. The viscosities at 60°C. (140°F.) shall be determined with a Modified Coppers Viscometer using a shear rate of 1 second -1. The Contractor shall furnish a report of the asphalt supplier's test results with each shipment of material delivered to the project.

TEST	PAC-2.5	PAC-5	PAC-10	PAC-20	PAC-30	PAC-40
Viscosity, 60°C (140°F), poises	250±50	500±100	1000±200	2000±400	3000±600	4000±800
Viscosity, 135°C (275°F), Cs, min.	125	200	250	300	350	400
Penetration, 25°C (77°F), 100 g, 5 sec, min.	220	140	80	60	50	40
Flash Point, COC, C(F), min.	163(325)	176(350)	232(450)	232(450)	232(450)	232(450)
Ash, %, max.	1	1	1	1	1	1
Test on Residue from Thin-Film Oven Test: Viscosity Ratio, max. (Residue Viscosity, p @ 60°C (140°F) / Original Viscosity, p @ 60°C (140°F))	3.0	3.0	3.0	3.0	3.0	3.0
Elastic Recovery, %, min.	55	60	60	60	58	58

1084.03 CONSTRUCTION. The polymerized asphalt cement shall be incorporated in the Asphalt Cement Concrete mixture to be placed in the locations designated on the plans, in lieu of the asphalt cement specified for other mixtures for the project. The mixture shall be prepared and placed according to requirements of the Standard Specifications.

The Contractor shall furnish facilities and use a procedure that keep this material separate from other asphalt cement used on the project during storage and incorporation into the mixture.

1084.04 MEASUREMENT AND PAYMENT. Polymerized Asphalt Cement of the grade specified, satisfactorily incorporated into the work, will be separately measured and paid for in accord with 2303.27B and 2303.28B. The quantity shall be for mixture in the areas designated on the plans and such additional mixture as was necessary to cover the designated areas using full truck loads of mixture. This payment shall be full compensation for furnishing and incorporating this material into the mixture and for the special facilities and procedures necessary to accomplish this.

The quantity of Asphalt Cement Concrete mixture with polymerized asphalt cement, furnished and placed as designated, will be included with the other quantities of Asphalt Cement Concrete mixture and will be paid for accordingly.

Appendix E
Multi-Grade Asphalt Cement Specifications

Specification
Multigrade Asphalt Cement

Tests	MG 5-20 Min.	MG 5-20 Max.	MG 10-30 Min.	MG 10-30 Max.	MG-20-40 Min.	MG-20-40 Max.
	Specification Limits					
Apparent Viscosity at 140° F. and 300 mm Hg Vacuum with Shear Rate of 1 sec. - 1, poises	500	3000	1000	4000	2000	6000
Apparent Viscosity at 275° F. and 30 mm Hg Vacuum with Shear Rate of 10 sec. - 1, poises	3	15	5	20	10	30
Penetration at 77° F., 100 gm. 5 sec.	75	175	55	95	35	65
Penetration at 39° F., 200 gm. 60 sec.	35	65	24	45	15	35
Flash Point (C.O.C.), ° F	475		475		475	
Solubility in Trichloroethylene, %	99		99		99	
Softening Point (R and B), ° F.	120		120		120	
Apparent Viscosity after Thin Film Oven test, poises	500	6000	1000	8000	2000	10000
Viscosity Ratio $\frac{\text{Viscosity after TFOT}}{\text{Viscosity before TFOT}}$		2.5		2.5		2.5

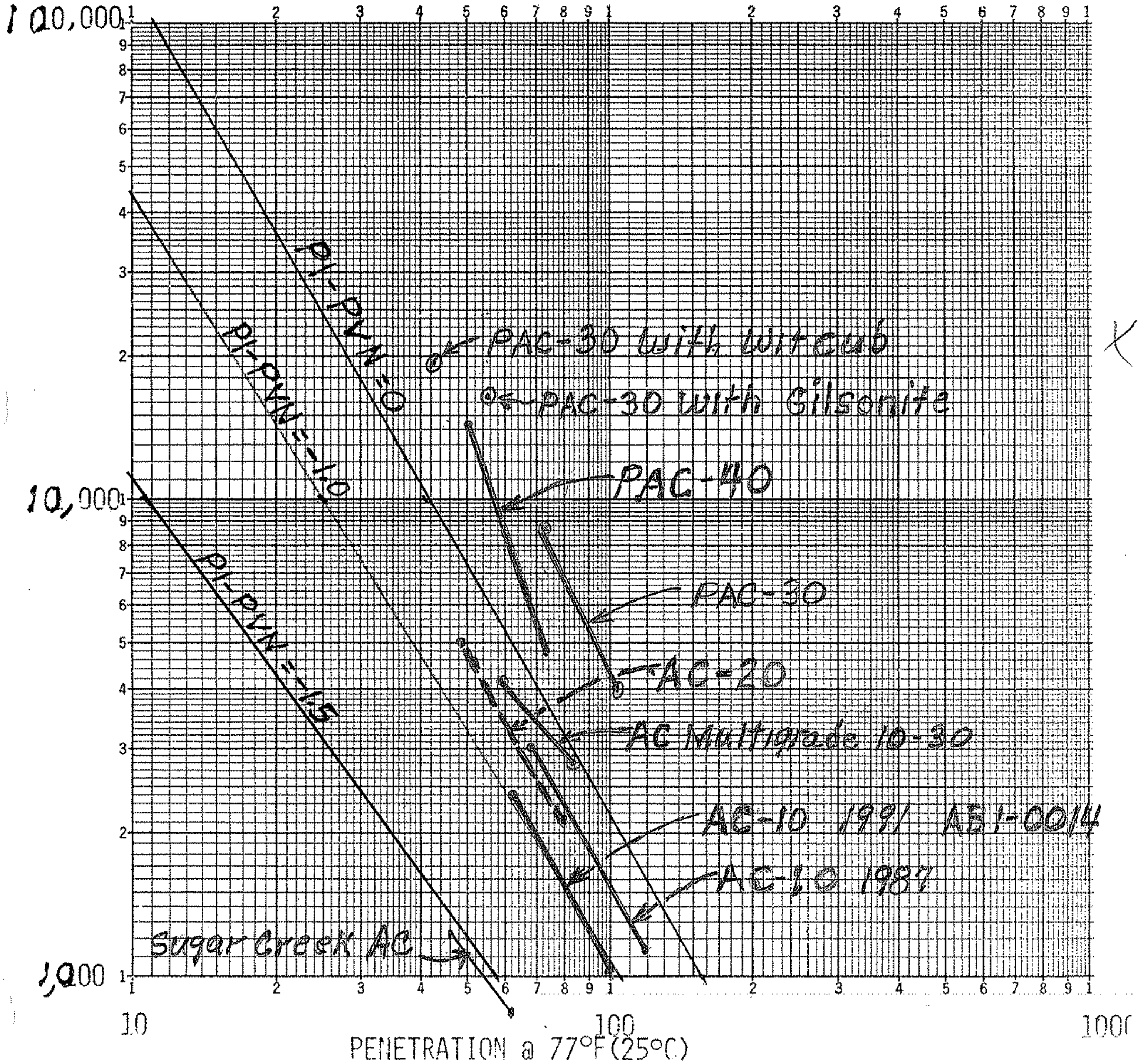
Note 1: Viscosities shall be determined in accordance with ASTM D4957. Normally a #200 Modified Koppers Viscometer (MKV) is used for tests at 140° F. The B zone is not used in the calculation of viscometer or shear rate. A #50 MKV is typically used for tests at 275° F.

Note 2: Sample Preparation -
Sample handling for all applicable AASHTO and ASTM procedures described in the specification shall be as follows. Heat the sample for testing in an oven maintained at 383 ± 4° F., stir occasionally at 1 revolution/second for 10 seconds. A forced air oven is recommended. Pour from this container into suitable containers for the applicable tests. In the case of viscosity, a preheated 50 ml glass beaker is recommended. After pouring, place the 50 ml glass beaker back in the oven until it reaches 356 ± 4° F. At this point, it can be poured into the preheated viscometer tubes for testing. This same procedure is recommended for all other tests.

Appendix F
AC Viscosity-Penetration Relationships

ASPHALT CEMENT
VISCOSITY-PENETRATION RELATIONSHIPS

PAC = Polymor Modified AC



Appendix G
Formulas
Indirect Tensile
Resilient Modulus
Creep Resistance Factor

Indirect Tensile Strength

Indirect Tensile Strength (S_t) = $\frac{2P}{\pi td}$

Where: S = tensile strength (psi)
P = maximum load (pounds)
t = specimen thickness (inches)
d = specimen diameter (inches)

Resilient Modulus

Test Parameters: 77 $\pm$ 1 degree F
90 degrees rotation at 20 cycles ea.
Frequency .33 hz
Load Time 0.1 sec.
Tested at 50 lb. & 75 lb.

Creep Resistance Factor

Creep Resistance Factor (CRF) = $\frac{t}{325}\left[100 - c\,(1000)\right]$

Where: CRF is Creep Resistance Factor
t is time in minutes until failure
c is change in height (in.) or 0.05 inch if failure occurs