

US FEDERAL HIGHWAY ADMINISTRATION STUDY ON MOISTURE SENSITIVITY OF MODIFIED BITUMEN



12/11/01

National Cooperative Highway Research Program

(NCHRP) Project 90-07

Understanding the Performance of Modified Asphalt Binders in Mixtures:

Evaluation of Moisture Sensitivity

FHWA-RD-02-029

[View Table of Contents](#)

by

Kevin D. Stuart
John S. Youtcheff, Ph.D.
Federal Highway Administration
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296
Telephone: (202) 493-3073
FAX: (202) 493-3161

and

Walaa S. Mogawer, Ph.D., P.E.
Civil and Environmental Engineering Department
University of Massachusetts Dartmouth
North Dartmouth, MA 02747
Telephone: (508) 999-8468
FAX: (508) 999-8964

FOREWORD

This report documents the effects of polymer-modified asphalt binders on moisture sensitivity. It is part of a research study titled "Understanding the Performance of Modified Asphalt Binders in Mixtures." Funding for this study is from National Cooperative Highway Research Program (NCHRP) Project 90-07. The objective of NCHRP 90-07 is to determine if asphalt binder performance is captured by the Superpave asphalt binder specification developed under the 1987 to 1993 Strategic Highway Research Program, with an emphasis on evaluating the performances of mixtures containing polymer-modified asphalt binders with identical Superpave performance grades but varied chemistries. Asphalt binder tests developed under NCHRP Project 09-10, titled "Superpave Protocols for Modified Asphalt Binders," are also being evaluated. NCHRP Project 09-10 was completed in February 2001.

T. Paul Teng, P.E.
Director, Office of
Infrastructure
Research and
Development

1. **Objective and Background:** The objective of this study was to determine the effects of 11 asphalt binders on the moisture sensitivity of a mixture using the Hamburg Wheel-Tracking Device (Hamburg WTD). The Hamburg WTD tests a slab of hot-mix asphalt submerged in hot water by rolling a steel wheel across its surface. The device tests two slabs simultaneously using two reciprocating solid steel wheels. The rut depth in each slab is measured continuously over a length of 200 mm by a linear variable differential transformer. The standard maximum number of wheel passes is 20,000. This requires approximately 6.5 h. The pass/fail rut depth is 10 mm at 20,000 passes. The device is shown in figure 1. Each mixture was short-term oven aged (STOA) for 2 h at 135°C prior to compaction. Two hours of STOA was found to provide the average amount of short-term aging that occurred in pavements constructed with similar materials.
2. **Diabase Mixture:** The data from the Hamburg WTD at 58°C using a diabase aggregate are shown in figure 2. This aggregate without an antistripping additive is moderately susceptible to moisture damage in Superpave high-temperature climates around 58 to 64°C. Tables 1 and 2 provide the average wheel

US FEDERAL HIGHWAY ADMINISTRATION STUDY ON MOISTURE SENSITIVITY OF MODIFIED BITUMEN

passes based on rut depths of 5.0 and 10.0 mm, respectively. The replicate data are given in table 3. Normally, the rut depths at 20,000 wheel passes are evaluated. In this study, most of the mixtures performed poorly. Hence, most of the tests had to be terminated before 20,000 wheel passes.

3. **Conclusions:** Provided by the Diabase Mixture at 58°C. Based on the number of wheel passes needed to obtain the failure rut depth of 10 mm, only the Elvaloy mixture performed significantly better than the control mixture with the unmodified PG 70-22 asphalt binder at a 5-percent level of significance. **The Elvaloy mixture was the only mixture that was not susceptible to moisture damage. All mixtures with EVA and styrene-butadiene-styrene (SBS) performed poorly regardless of geometry and whether or not they were grafted.**



Figure 1. Hamburg WTD without water.

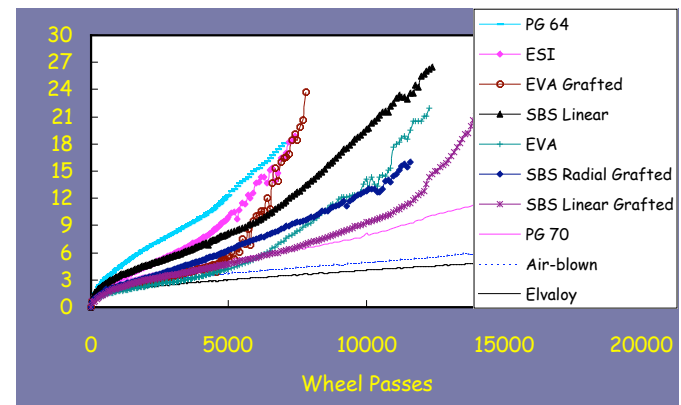


Figure 2. Rut depth vs. wheel passes from the Hamburg WTD at 58°C.

US FEDERAL HIGHWAY ADMINISTRATION STUDY ON MOISTURE SENSITIVITY OF MODIFIED BITUMEN

Table 1. Hamburg WTD results with the materials listed from highest to lowest resistance to moisture damage based on a rut depth of 5.0 mm.

Asphalt Binder or Mixture Designation	Asphalt Binder Property After Rolling Thin-Film Oven Aging		Wheel Passes at 58°C and a Rut Depth of 5.0 mm	Ranking for Wheel Passes		
	High-Temp PG (°C)	G*/sind, 0.125 rad/s at 58°C (Pa)				
Elvaloy	77	639	15,800	A		
Air Blown	74	387	10,150	A	B	
CMCRA	76	482	9,420		B	
EVA	75	751	6,180		B	C
SBS Linear Grafted	72	297	5,600		B	C
PG 70-22 ¹	71	213	5,020			C
EVA Grafted	74	727	4,660		B	C
SBS Radial Grafted	71	249	4,290		B	C
SBS Linear	72	248	2,520			C
ESI	76	321	2,380			C
PG 64-28	67	114	1,250			C

¹PG 70-22 does not fall into group B because the additional specimens tested for this mixture provided more confidence in the average value.

Best Performer



Worst Performer

Table 2. Hamburg WTD results with the materials listed from highest to lowest resistance to moisture damage based on a rut depth of 10.0 mm.¹

Asphalt Binder or Mixture Designation	Asphalt Binder Property After Rolling Thin-Film Oven Aging		Wheel Passes at 58°C and a Rut Depth of 10.0 mm	Ranking for Wheel Passes		
	High-Temp PG (°C)	G*/sind, 0.125 rad/s at 58°C (Pa)				
Elvaloy	77	639	30,950	A		
Air Blown	74	387	19,550		B	
CMCRA	76	482	17,900		B	
PG 70-22	71	213	14,990		B	C
SBS Linear Grafted	72	297	10,380		B	C
EVA	75	751	8,750			C
SBS Radial Grafted	71	249	8,740			C
SBS Linear	72	248	6,400			D
EVA Grafted	74	727	6,120			D
ESI	76	321	5,260			D
PG 64-28	67	114	4,070			D

US FEDERAL HIGHWAY ADMINISTRATION STUDY ON MOISTURE SENSITIVITY OF MODIFIED BITUMEN

Table 3. Hamburg WTD results at 58°C.

Asphalt Binder or Mixture Designation	Wheel Passes at a Rut Depth of 5.0 mm				Wheel Passes at a Rut Depth of 10.0 mm			
	Slab 1	Slab 2	s	CV	Slab 1	Slab 2	s	CV
Elvaloy	14,200	17,400	2,300	15	27,000	34,900	5,600	18
Air Blown	7,400	12,900	3,900	38	21,440	17,660	2,700	14
CMCRA	14,600	5,100			24,000	12,700		
CMCRA (repeat)	13,500	4,480	5,400	57	21,300	13,600	5,600	31
PG 70-22 ¹	3,390	4,200			8,010	13,705		
PG 70-22 (repeat) ¹	2,270	7,280	2,450	49	9,895	24,000	6,450	43
PG 70-22 (repeat) ¹	8,700	4,300			21,700	12,650		
SBS Linear Grafted	7,130	4,065	2,200	39	11,680	9,075	1,800	17
EVA	7,615	4,750	2,000	32	6,890	10,610	2,600	30
SBS Radial Grafted	5,400	3,175	1,600	37	11,155	6,325	3,400	39
SBS Linear	3,115	1,925	840	33	5,340	7,450	1,500	23
EVA Grafted	4,600	4,720	85	2	5,700	6,550	600	10
ESI	2,460	2,300	110	5	5,795	4,730	750	14
PG 64-28	1,260	1,245	11	1	3,795	4,340	390	10

Best Performer



Worst Performer

Table 4. Hamburg WTD results at 58°C vs. base asphalt binder.

Asphalt Mixture	Base Asphalt Binder		Wheel Passes at a Rut Depth of 10.0 mm	Ranking for Wheel Passes	
	Percent PG 54-33	Percent PG 67-28			
Elvaloy	50	50	30,950	A	
CMCRA	0	100	17,900		B
SBS Linear Grafted	59	41	10,380		C
EVA	100	0	8,750		C
SBS Radial Grafted	59	41	8,740		C
SBS Linear	59	41	6,400		C
EVA Grafted	100	0	6,120		C
ESI	100	0	5,260		C