Asphalt Pavement Analyzer
Equipment Acquisition
Final Report

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Connecticut Advanced Pavement Lab
Connecticut Transportation Institute
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A study conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration

16. Abstract

In the design of Hot Mix Asphalt (HMA) there are tests performed on the aggregates such as resistance to abrasion, specific gravity and sieve/gradation analysis to ensure the aggregates are of sound quality prior to use in HMA. There are also tests performed on liquid binder such as temperature grading which ensure that the correct binder is being used and that its temperature performance is sufficient to withstand environmental impacts. Until recently there have been no performance tests that in a laboratory that indicate what sort of long-term resistance to deformation-type failures a HMA-pavement mix will provide. Researchers, users and producers of HMA have long sought a performance test that could be performed in the laboratory that would give an accurate indication of field performance. The asphalt pavement analyzer is a multifunctional testing device intended to provide a suite of tests that give an indication of field performance. This report describes CAP Lab's acquisition, set up and initial testing experience with the Asphalt Pavement Analyzer.

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The authors would also like to thank Pavement Technologies Inc. for their assistance in the set up and troubleshooting of this equipment.

Conversion Factors

SI* (MODERN METRIC) CONVERSION FACTORS				
APPROXIMATE CONVERSIONS TO SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa
APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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Introduction

The Superpave system, which is used to design hot-mix asphalt (HMA) pavements, does not currently include performance testing of the HMA material. There is currently a large national effort to develop a “simple performance test” or "asphalt performance test" as it has recently been described to be used on mixes designed according to the Superpave system. The development of a simple performance test has been a much larger task than was originally envisioned. The current methods being proposed for the “simple performance test” are difficult to perform and require a great deal of time to complete. In lieu of a “simple performance test”, many State Highway Agencies have adopted the AASHTO Provisional specification TP-63 requiring their mixes to be tested using rut testing equipment to measure the susceptibility of the mix to permanent deformation (rutting in the wheel paths). In essence, this procedure involves applying a repeated wheel loading to a pavement sample for a period of time simulating the real world loading that is experienced over years. Research is required for these laboratory measurements to be correlated to the observed performance of HMA in the field, in a particular region, before these requirements can be implemented in a specification. Several highways in Connecticut have experienced significant rutting problems over the years which demonstrated the importance of the need for a HMA performance testing mechanism/device.

There are several types of rut testing equipment available. Many of them require pavement specimens to be tested while submerged in water to control the specimen temperature. This methodology is very good for detecting an HMA mixture’s ability to withstand stripping. Stripping occurs when water breaks the bond between the asphalt and the aggregate. However, testing specimens submerged in water may not adequately characterize the ability of the HMA mix to resist permanent deformation, as the material is most likely to experience this during the warmest summer months while the pavement is dry.

The Asphalt Pavement Analyzer (APA), along with the asphalt vibratory compactor (See Figures #1 and #2) and the asphalt vibratory compactor sound-proof shield were selected for purchase because they provide the capability to test specimens in both wet and dry conditions.

Figure 1. Asphalt Pavement Analyzer

Figure #2. Asphalt Pavement Analyzer Vibratory Compactor

This equipment allows more realistic real world conditions to be simulated in the laboratory including temperature control. It allows materials to be tested for resistance to permanent deformation (rutting) as well as stripping. This testing can be conducted prior to construction. Examples of the functions as well as the units used to describe the results of these different functions are shown in Table 1. Inclusion of the asphalt vibratory compactor, to compact HMA beam specimens, allows fatigue testing of HMA mixes to be performed with the APA. The fatigue measurement tests that this machine performs on fabricated beam specimens are still in development and as such, not included in Table 1. The versatility of the APA was the driving reason for its selection.

Governing Organization Test Method Designation No.	Test Name & Function	Measurements & Units Reported
AASHTO TP 63	Determining Rutting Susceptibility of Hot Mix Asphalt (HMA) Using the Asphalt Pavement Analyzer	Rut depth reported in standard units of length, typically (mm)
AASHTO T324	Hamburg Wheel Track Test	Rut depth reported in standard units of length, typically (mm). Stripping Inflection Point (SIP) – Number of passes at which permanent moisture damage begins to accrue.

Table 1. Asphalt Pavement Analyzer Functions & Capabilities

AASHTO TP 63 Determining Rutting Susceptibility of HMA

AASHTO TP 63 utilizes pressurized rubber hoses laid across three dual-series sets of test specimens as shown in Figures 3 and 4.

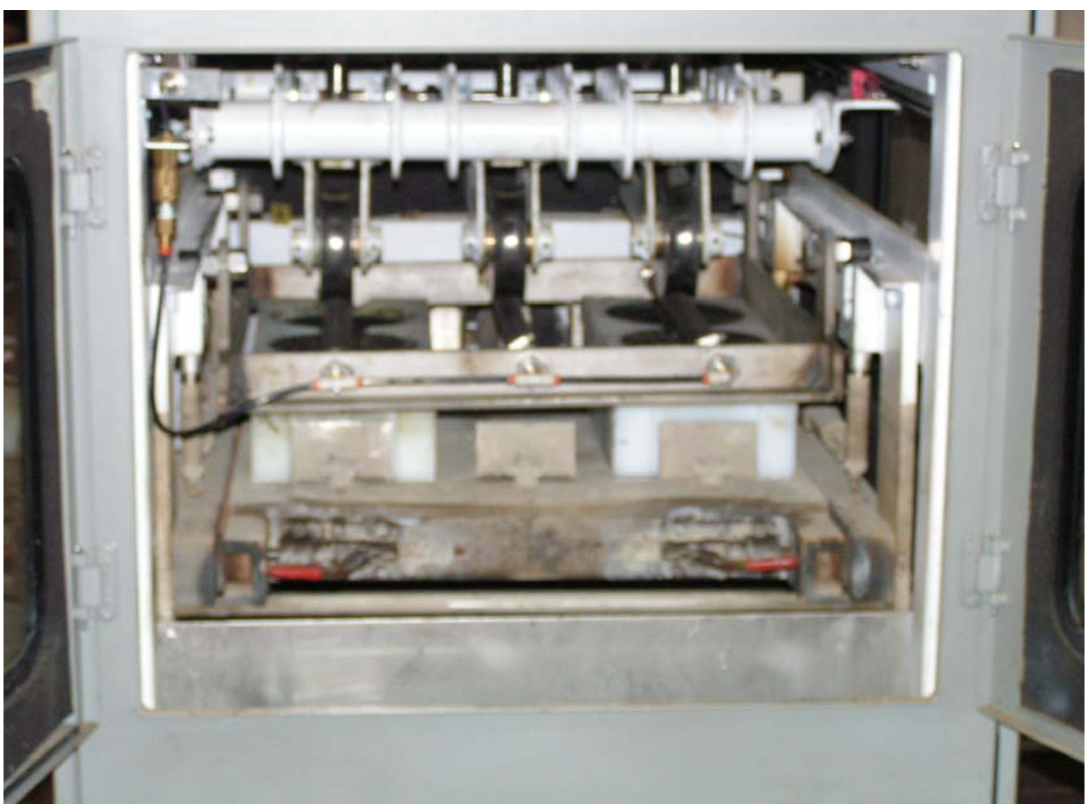

Figure 3. AASHTO TP 63 Set Up

Figure 4. AASHTO TP 63 Close-up Pressurized Tube Over Test Specimen

Once the test specimens have been fabricated they are placed in the testing chamber and conditioned as desired under the pressurized rubber tube rack. The tubes are pressurized to 100 ±5 psi. When conditioning of the specimens has completed, the test begins. The test consists of the wheels passing back and forth over the three sets of specimens up to 8,000 times. A raw data chart is generated during the course of the test indicating the number of completed cycles, rut depths and cabin temperature for each of the three sets of specimens. Also generated within the same program is a final data sheet (Figure 5.) indicating temperature, rut depth per specimen and average rut depth for 0, 25, 4000 and 8000 cycles respectively. In the last column is the percent change in average rut depth between 25 and 4000 cycles and then from 4000 to 8000 cycles respectively.

RUTTING TEST DATA SHEET (60 Cycles Per Minute)

Project No.	APA Demo	Test No.	1	Temperature	64
Mix ID No.	#2	Test Date	5-Mar	Wheel Load	100lb.
Mix Type	Level 3	Data File		Hose Pressure	100psi
Mold Type		Operator	JD	Lab ID	CAP lab

Left Sample ID		71 58			Bulk S Gravity				% Air Void	7.3
	Temperature		Depth Gauge Reading							
STROKE COUNT	F	C	1	2	3	4	5	Man Average Depth	APA Average	Percent Change
0	32	0						0		
25	145.4	63	0.926628113	0.328804016	0	0.313858032	0.313858032		0.470787048	
4000	145.4	63	3.542114258	2.959228516	0	3.16847229	3.288032532		3.239461899	85.47%
8000	145.4	63	3.781242371	2.914390564	0	2.749992371	3.407600403		3.213306427	-0.81%
8000	32	0						0		

Center Sample ID		72 77			Bulk S Gravity				% Air Void	7.0
	Temperature		Depth Gauge Reading							
STROKE COUNT	F	C	1	2	3	4	5	Man Average Depth	APA Average	Percent Change
0	32							0		
25	145.4	63	1.043319702	0.074523926	0	0.596176147	0.283187866		0.49930191	
4000	145.4	63	3.264091492	2.116447449	0	1.997207642	2.280395508		2.414535522	79.32%
8000	145.4	63	3.413139343	3.278999329	0	2.280387878	2.518867493		2.872848511	15.95%
8000	32							0		

Right Sample ID		78 79			Bulk S Gravity				% Air Void	7.0
	Temperature		Depth Gauge Reading							
STROKE COUNT	F	C	1	2	[illegible]	4	5	Man Average Depth	APA Average	Percent Change
0	32							0		
25	145.4	63	1.471282959	0.300262451	[illegible]	0.150131226	0.615539551		0.634304047	
4000	145.4	63	3.75327301	2.236953735	0	1.996742249	3.047660828		2.758657455	77.01%
8000	145.4	63	3.768287659	2.792442322	0	2.116844177	3.002624512		2.920049667	5.53%
8000	32							0		

Figure 5. Screen Capture of AASHTO TP 63 Test Data Screen

Finally the last screen generated over the duration of the test is a graphical depiction of the rut depth accumulation versus the number of cycles as shown in Figure 6.

There has been no universally accepted rut depth for use in acceptance specifications with materials tested in accordance with AASHTO TP63. Several State Transportation Agencies have implemented maximum allowable rut depths that vary with the anticipated traffic loadings of the pavement. These requirements vary from Agency to Agency.

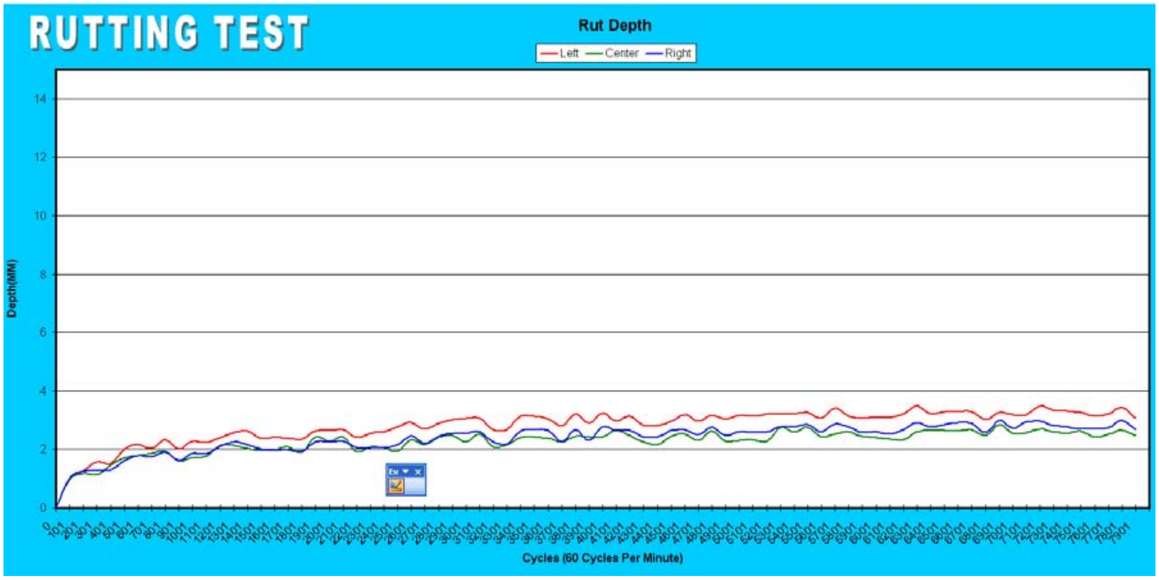

Figure 6. Rut Depth Accumulation Chart

AASHTO T324 Hamburg Wheel Track Test Discussion

This test is performed on three dual-series specimens under wheel loadings similarly to TP 63 described previously. Unlike TP 63, this test does not utilize the pressurized rubber tubes as the interface of the loaded wheels and the test specimens. The Hamburg Wheel Track Test is a much more destructive test and involves direct contact between the loaded wheels and the fabricated test specimens as shown in Figure 7. These wheels are of a larger width and diameter than the TP 63 wheels as well. Another notable difference between these two tests is that the Hamburg Wheel Track Test is performed while the specimens are submerged under water at a desired temperature. Once the test specimens have been conditioned under water for at least 30 minutes, they are subjected to a wheel load of 157 -159 lb. This load is passed over the specimens up to 20,000 times. One cycle back and forth is considered two passes. The 20,000 pass mark indicates completion of the test as does a rut depth in excess of 40.9 mm. Once one of these criteria is met, the test is stopped automatically.

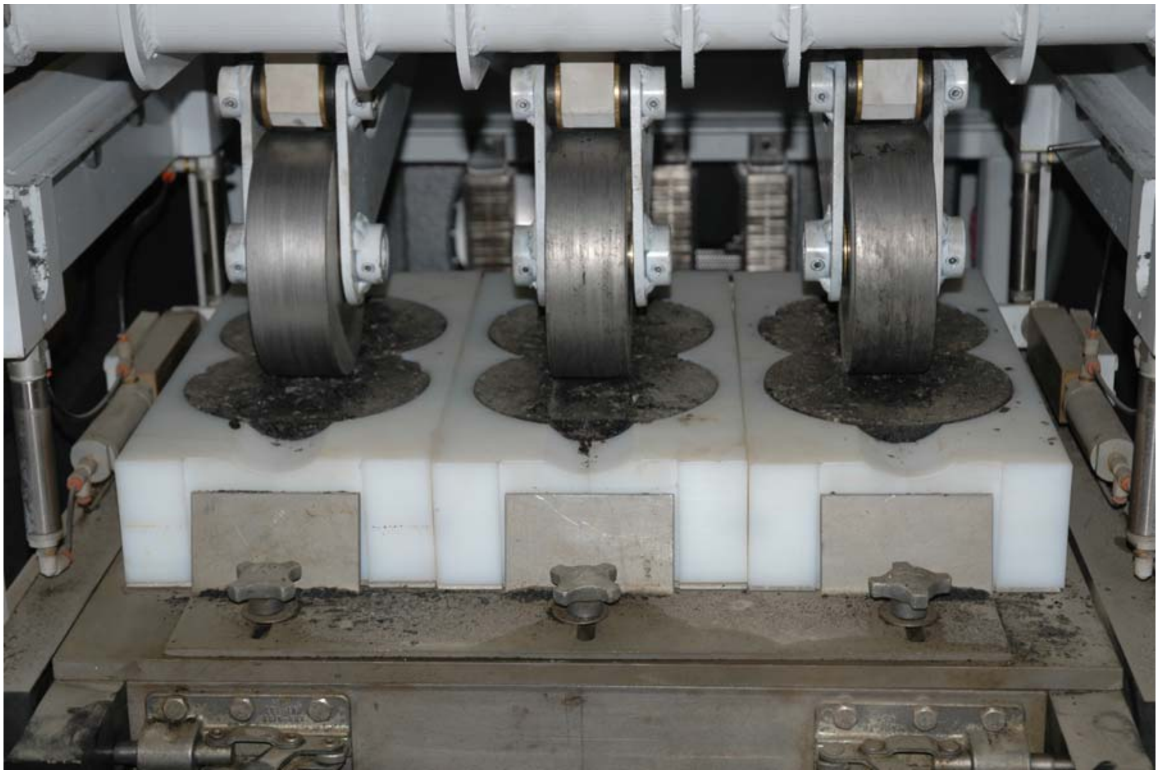

Figure 7. Hamburg Wheel Track Test

The destructive nature of this test is a result of the presence of water, increased loading and direct contact between the wheel loads and the test specimens. Figure 8 shows an image of the result of a Hamburg Wheel Track Test specimen once the test has been completed.

Figure 8. Hamburg Wheel Track Specimen after Testing

Data is collected and compiled by the APA computer similarly to the TP 63 test. In addition to the raw data and end results sheet, there is another significant determination that can be made which is known as the stripping inflection point. Graphically, this inflection point is the intersection of the tangents of the creep slope and the stripping slope. The creep slope represents the permanent deformation in the HMA being caused by the repeated loading prior to the onset of permanent damage caused by stripping due to water damage. The stripping slope represents the total damage being caused by the repeated loading and the water as soon as water damage begins to accumulate. The intersection of these two slopes is the inflection point and is determined as shown in Figure 9.

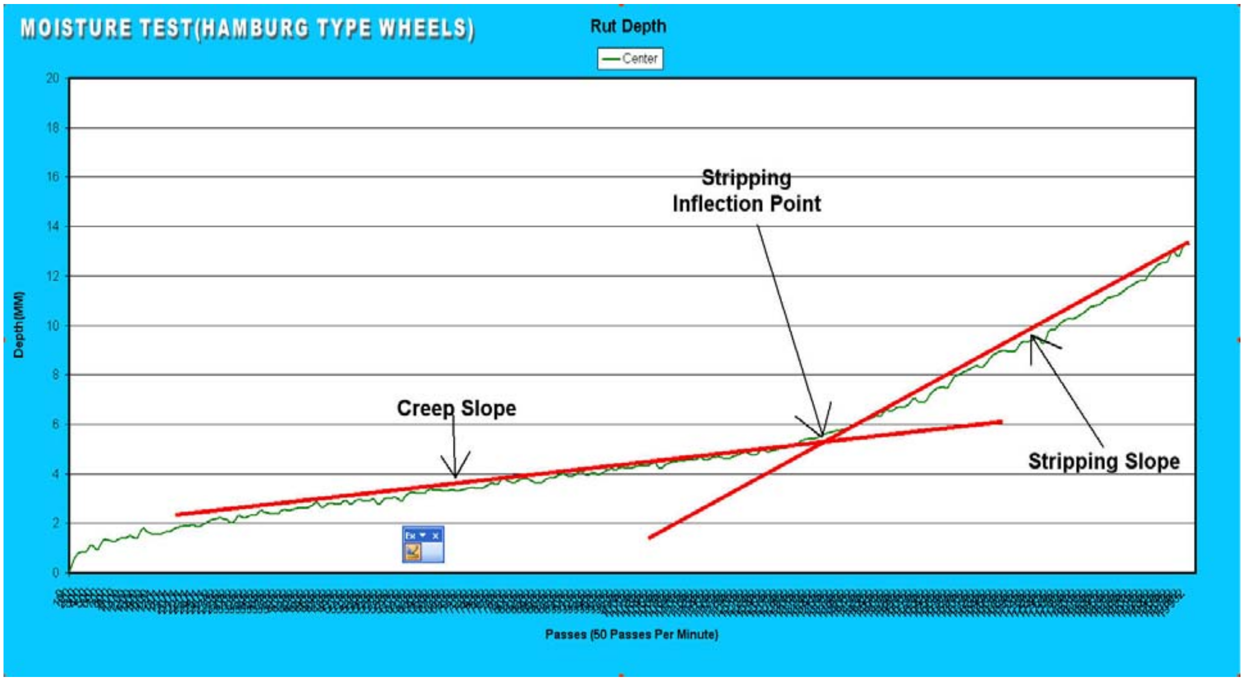

Figure 9. Stripping Inflection Point Determination

Equipment Acquisition

The purchase order for the Asphalt Pavement Analyzer was processed on May 2, 2006 and the equipment was received on June 1, 2006. After receiving the equipment, work orders were placed with Uconn Facilities for the installation of compressed air lines and electrical power for the machine.

On-site Training

The original installation and on-site training for the CAP Lab staff members was scheduled to occur on June 5-8, 2006. In order to expedite the installation and training on the equipment, Pavement Technology Inc. rented a diesel electrical generator at their own expense to provide the needed electrical power for the equipment. This was necessitated from the delay in getting the permanent electrical power installed by Uconn Facilities.

When the technician from Pavement Technology Inc. arrived to setup the equipment, he discovered several major problems with the testing equipment that prevented the equipment from functioning properly. The technician worked on the problems during the time he was here in June but was not able to fully resolve the problems and so he left at the end of the week without the equipment functioning. The technician returned on July 11, 2006 with the necessary parts to get the equipment up and running. He repaired the equipment on the first day and then was able to provide the training during the rest of the week.

Equipment Problems

During the 2006-2007 Winter, the Asphalt Pavement Analyzer equipment began to stop unexpectedly while running a test. This problem persisted for several months during which time CAP Lab personnel worked with Pavement Technologies Inc. via telephone and electronic communication for several intermittent days to resolve the problem. Pavement Technologies sent a technician out to work on the problem. Eventually, the problem was traced back to a communication malfunction between the electronic controller and the electric motor used to generate the passes of the loaded wheels across the test specimens. This problem caused a delay in the work on several research projects that required the rut testing equipment.

The temperature controller for the water bath used in the Hamburg Loaded Wheel test began to malfunction during the late Spring 2007 timeframe. CAP Lab personnel worked with Pavement Technologies Inc. and this problem was resolved rather quickly after a new temperature controller was shipped to CAP Lab and installed by CAP Lab personnel.

Even after the installation of the new temperature control module, the machine would not stabilize its temperature. New thermocouples have been installed and the problem persists and is still currently an issue. To run the test within the specified temperature range requires use of a separate independent temperature monitoring unit and constant adjustment by the operator.

During testing of specimens in the Fall 2007 timeframe, the video card on the controlling PC for the APA failed. CAP Lab acquired a new video card and this issue was resolved.

Within days of the video card replacement, there appeared to be a display issue on the APA control screen. While attempting to mitigate this issue over the phone with Pavement Technologies Inc. the hard drive on the controlling PC for the APA failed and the unit was shipped back to Pavement Technologies Inc. for repair. After receiving the unit back within a few days of that failure the machine has functioned properly since then.

Equipment Demonstration

An equipment demonstration was held on July 13, 2007 at the CAP Lab. The CAP Lab invited personnel from ConnDOT's Research and Materials Lab as well as the CAP Lab Advisory Board. The general concept of operation of the equipment was discussed as well as its testing capabilities.

Figure 10. James Mahoney Demonstrates Use of the New Equipment

AASHTO TP 63, The Asphalt Pavement Analyzer (APA) test was demonstrated as well the compaction of asphalt beam specimens using the vibratory compactor acquired as part of this project. Specimens that had been run through the complete testing process for the APA and the Hamburg Loaded Wheel Test were displayed.

Equipment Uses

The equipment purchased in this project has been used on several projects already and is scheduled to be used on several on-going and up-coming projects.

The equipment was used for testing on the following projects:

- Comparison of HMA mixtures that were made using PG 64-22 and PG 64-28

- An assessment of durability issues that might be associated with a specific fine aggregate
- Part of research project sponsored by Tilcon-Connecticut to examine the effect of increasing the RAP content of ConnDOT HMA mixes.

The equipment is currently being used for testing on the following projects:

- Evaluating the possibility of reducing the number of traffic levels used for designing Superpave mixes
- A New England Transportation Consortium study to examine the effect of using virgin modified asphalts with RAP to ensure the properties of the virgin modified binder are not compromised with the addition of the RAP
- The rut testing equipment is also going to be used to evaluate the effects of the current ConnDOT specifications with regard to minimum asphalt binder content.

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