April 2012

Tech Notes

Engineering and Regional Operations
Construction Division
State Materials Laboratory

Hamburg Wheel Tracking Device Update

Introduction

The Hamburg Wheel Tracking Device (HWTD) is a laboratory testing machine used to measure rutting and moisture damage of asphalt paving mixtures by rolling a steel wheel across the surface of a sample specimen while immersed in water.

The HWTD was originally developed in the 1970's by Esso A.G. of Hamburg, Germany to measure rutting susceptibility, based on a similar British device that utilized a rubber tire. Later, the City of Hamburg began testing samples in temperature controlled water instead of an environmental chamber and discovered that some mixtures began to deteriorate from moisture damage, especially when subjected to a higher number of passes with the steel wheel.

Technician preparing samples for testing in HWTD

Close-up of HMA sample after wheel loading.

How is WSDOT using the Hamburg?

In 2009, the State Materials Laboratory began evaluating the HWTD to determine its ability to predict premature failure of hot mix asphalt (HMA) and warm mix asphalt (WMA) caused by weakness in aggregate structure, inadequate binder stiffness, and moisture susceptibility (rutting and raveling). After purchasing a HWTD in 2010 the Bituminous Materials Section began testing mix designs submitted for verification testing prior to production paving. Each mix design was tested with and without anti-stripping additive in an effort to identify rutting and moisture susceptibility and to identify improvements made from the use of anti-strip additives. Typically HWTD mix design test results show rutting or raveling in mixtures when the mechanisms previously mentioned exist; however, the majority show improvement when treated with anti-strip additives.

Washington State
Department of Transportation

PG Binder Test Data		MSCR		Elastic Recovery
		Non-Recoverable Creep Compliance (Jnr) @ 3.2 kPa		
		Jnr kPa-1	% diff	% ER
GRADE	FORMULATION			
PG64-28	"Original" Formulation	2.3	79	25
PG64-28	"Polymer Modified"	1.1	31	74
Provisional AASHTO MSCR Specification Requirements		4.0 max.	75 max.	
WSDOT 2012 Elastic Recovery (ER) Specification				60 min.

Table 1 - MSCR and ER test data "Original Formulation and Polymer Modified" binder

Cross section of rutted HMA sample after HWTD testing.

Implementing Change

The compatibility problem discovered as a result of the HWTD testing and confirmation using the MSCR and ER research testing identified the importance of testing asphalt binders for modification. A review of the test results for the asphalt binders used in the mix designs with compatibility problems showed that they all met the standard AASHTO M 320 binder specifications (currently used by WSDOT). In order to identify suspect PG binder modification products or processes the State Materials Laboratory is implementing an elastic recovery (ER) specification in 2012. The new specification will require that the PG grades 64-28, 70-28, 76-28 and 70-22 meet a minimum of 60% ER in addition to the standard AASHTO M 320 binder specification requirements. The "ER" specification will require manufacturers to use polymer modification in lieu of lesser quality products or processes.

Cost Avoidance (Cost Savings):

Based on current service life estimates of 11 years for the estimated 200 lanes miles of HMA pavements constructed with the grades of asphalt binders previously identified, each year the service life can be extended WSDOT stands to gain $450 per lane mile per year for one additional year, $1800 for two additional years, $2950 for three additional years and $3940 for four additional years. For every 200 lane miles constructed, this equates to an annual savings of $90,000, $360,000, $590,000 or $788,000 if the service life of our pavements are extended one, two three or four years, respectively.

Annual Cost Avoidance (Annual Cost Savings):

- One Additional Year - $450 per lane mile or $90,000*
- Two Additional Years- $1800 per lane mile or $360,000*
- Three Additional Years - $2950 per lane mile or $590,000*
- Four Additional Years - $3940 per lane mile or $788,000*

*Estimate based on paving 200 lane miles per year

Future Work

The State Materials Laboratory will continue testing hot mix asphalt (HMA) and warm mix asphalt (WMA) samples (with the HWTD) to identify accurate and realistic material property limits for the purpose of developing mix design verification and production acceptance specifications. The HWTD specification must be capable of identifying premature failure of hot mix asphalt (HMA) and warm mix asphalt (WMA) caused by weakness in aggregate structure, inadequate binder stiffness, and moisture susceptibility (rutting and raveling) to eliminate substandard materials from use in the construct our asphalt concrete pavements.

For more information

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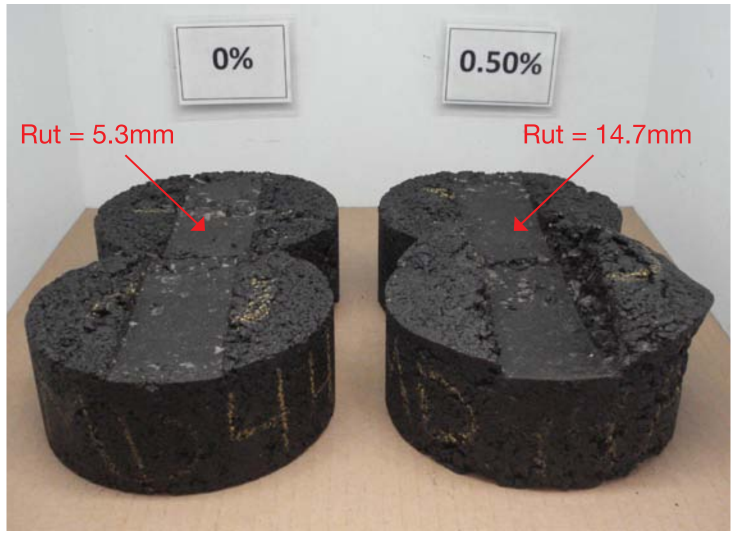


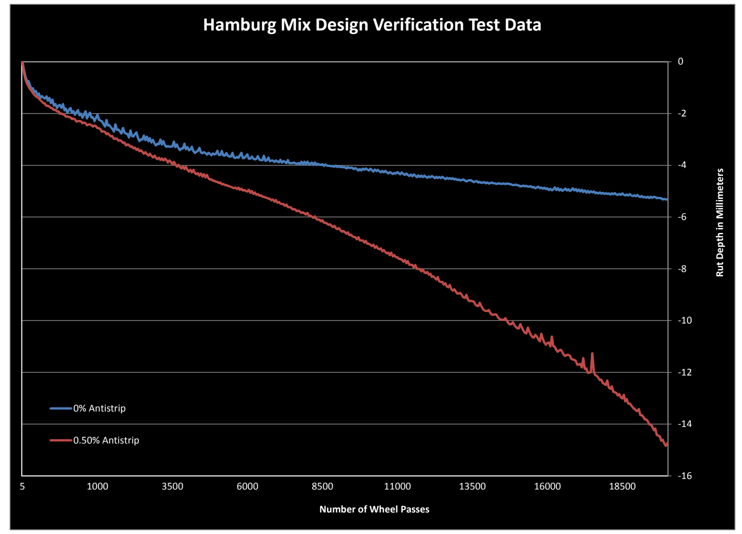


Photo 1 - Mix design samples after 20,000 HWTD wheel passes (sample on left 0% anti-strip, sample on right 0.50% anti-strip)
Note: The increased rutting when 0.50% anti-strip added

Chart 1 - HWTD test data for mix design in Photo 1
Note: The increased rutting when 0.50% anti-strip added

What the Hamburg Testing Data Identified

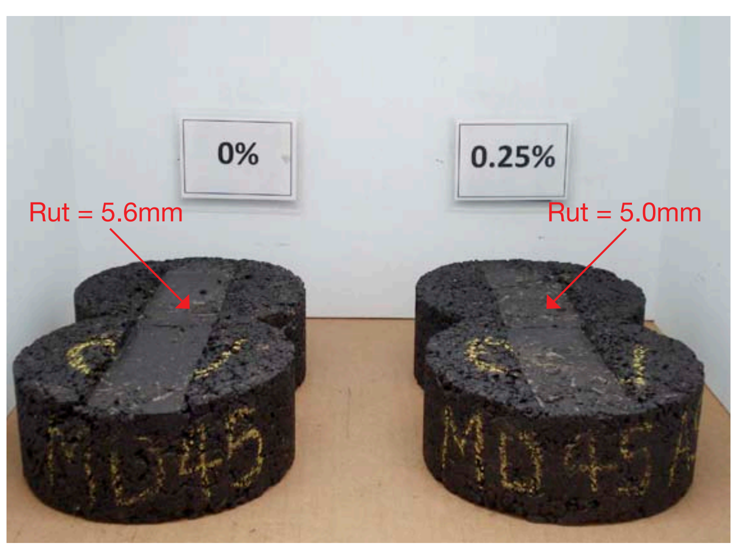
During an analysis of the 2010, 2011 mix design test data the HWTD helped identify a compatibility problem between certain asphalt binders and the anti-stripping additives that are used to deter the effects of moisture susceptibility that cause the loss of bond between the asphalt and the aggregate interface. The mix designs with compatibility problems showed significant rutting and raveling on the samples treated with anti-strip while the samples with no anti-strip performed considerably better. Photo 1 and Chart 1 show a visual and graphical representation of the HWTD test data for one of these mix designs. Photo 2 and Chart 2 show a visual and graphical representation of the HWTD test data for a typical mix design with no compatibility problems.

Each of the mix designs that demonstrated compatibility problems was designed and tested with a performance graded (PG) asphalt binder that likely required some form of modification in order to meet the standard AASHTO PG binder specification requirements.

Typically, asphalt manufactures produce neat (unmodified) asphalt binders that meet specification for grades such as PG58-22 and PG64-22 and then modify the asphalt in order to meet the higher temperature requirements of grades such as PG64-28, PG70-22, PG70-28, etc.

The typical modification processes include air blowing, polyphosphoric acid (PPA) modification and use of polymer modifiers such as plastomers or elastomers to increase the high temperature stiffness of the asphalt binder to help mitigate permanent deformation or rutting of asphalt pavements.

Availability and cost will likely determine which product or process the asphalt manufacturer uses to produce a binder capable of meeting the administrating agency's specification requirements.



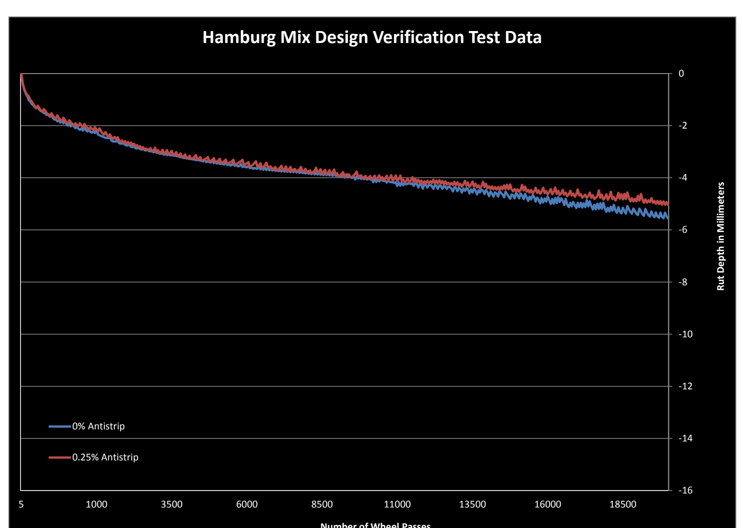


Photo 2 - Typical mix design samples after HWTD 20,000 passes (sample on left 0% anti-strip, sample on right 0.25% anti-strip)
Note: The decreased rutting when 0.25% anti-strip added

Chart 2 - HWTD test data for mix design in Photo 2
Note: The decreased rutting when 0.25% anti-strip added

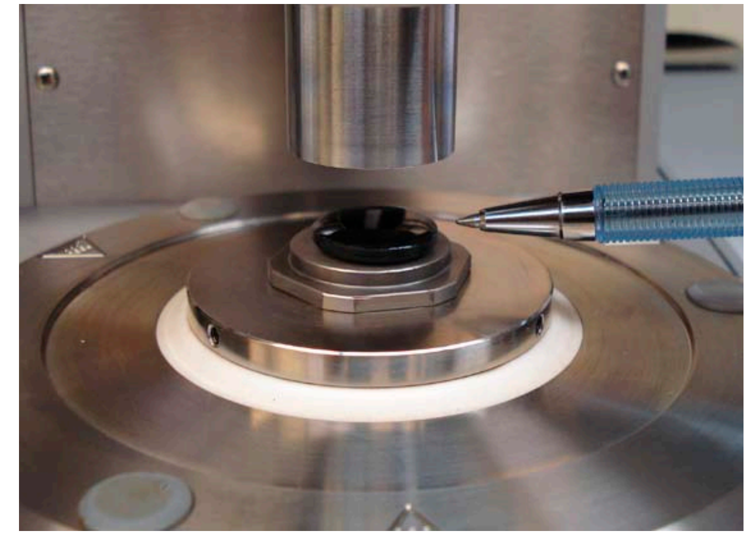


Photo 3 - Close-up of PG asphalt binder DSR test sample

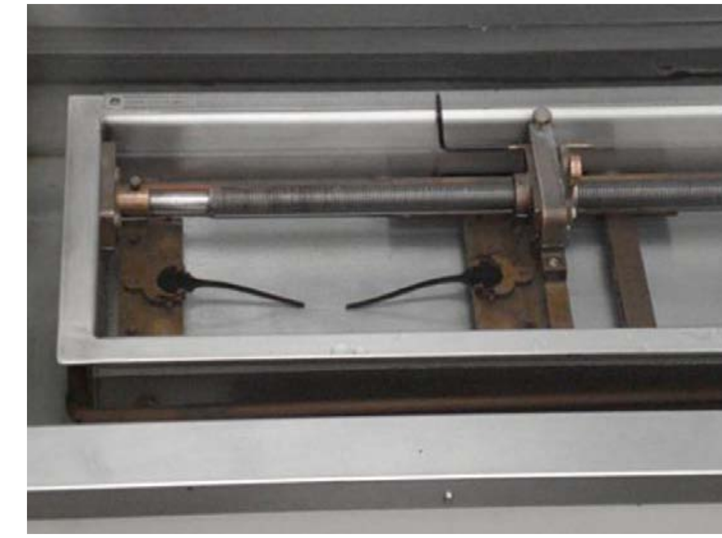


Photo 4 - Sample of PG asphalt binder after ER testing

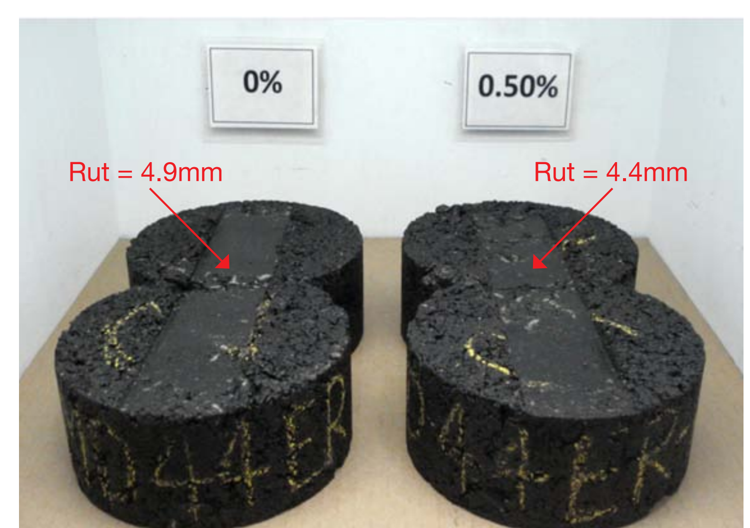
What the Hamburg Testing Data Identified, cont.

In addition to the HWTD evaluation the State Materials Laboratory has been conducting multiple stress creep recovery (MSCR) research testing using a dynamic shear rheometer (DSR, Photo 3) and elastic recovery (ER) research testing using a ductility tester (Photo 4) on many of the PG asphalt binders being used on WSDOT paving projects. Both the MSCR and ER testing confirmed the HWTD findings that the PG binders used in these mix designs was modified with something other than polymer and this modified binder could not meet the recommended specification requirements of either research test protocol.

As an experiment to validate the suspect PG binder modification product or process, the same mix design that exhibited the compatibility problem was remixed with a polymer modified PG binder and tested in the HWTD with and without anti-strip additive. As seen in Photo 5 and Chart 3 the polymer modified binder performed significantly better than the original binder.

In addition to the HWTD experiment, samples of the polymer modified binder were tested using the MSCR and the ER test protocols. The results of this testing is shown in Table 1 along with the original binder test data. As seen in Table 1 the "Original Formulation" binder would not meet the recommended MSCR percent difference (% diff) or the Elastic Recovery (%ER) specification requirement of either test but the "Polymer Modified" binder succeeded in meeting both.

Use of asphalt binders like the PG64-28 used in the mix design that demonstrated compatibility problems can reduce the service life of the pavement or reach a point of complete failure from stripping and raveling under traffic and inclement weather.



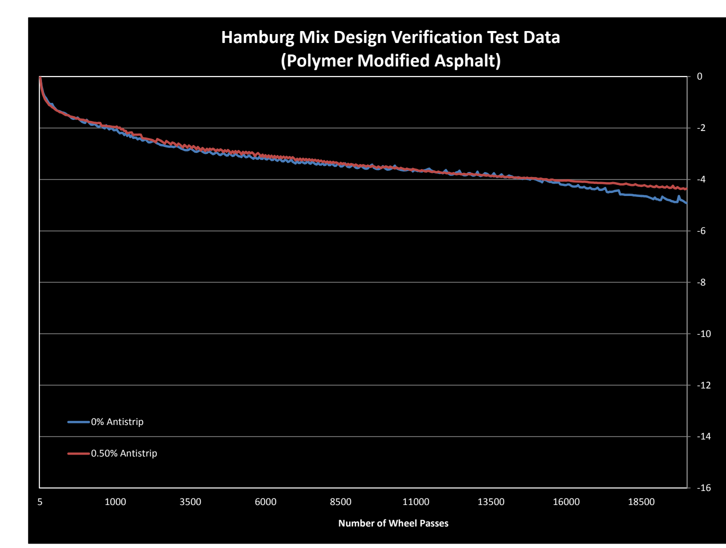


Photo 5 - Polymer modified mix design samples after 20,000 HWTD passes (sample on left 0% anti-strip, sample on right 0.50% anti-strip)
Note: The decreased rutting when 0. 05% anti-strip added

Chart 3 - HWTD test data for mix design in Photo 5
Note: The decreased rutting when 0.50% anti-strip added