Transportation
Infrastructure Engineering

INTERSECTII
INTERSECTIONS
http://www.ce.tuiasi.ro/intersections

Studies on the bitumen behavior at low-temperature

Vasilica Beica

Romanian Center for Road Engineering Studies-CESTRIN, Bucharest-Romania

Summary

Because the Romanian climate is a continental one, with rough winters and hot summers, this work is a study upon low temperature behavior of the indigenous bitumen with 60/80 and 80/100 penetration grade, original and modified, coming from two different refineries, using Fraass breaking test and SHRP creep test with Bending Beam Rheometer.

The study shows a different behavior at low temperature for two original bitumens. Polymer modification improves these bitumen's breaking properties on both bitumen, but it affects differently the PG performance grade, respectively for RP bitumen, the modification doesn't bring important changes on low temperature PG, the PG remaining the same and for RA bitumen the PG to low temperature is improved by polymer modification.

As in Romania the minimum pavement surface temperature is different, depending on the area, bitumen having the proper PG must be used for each area.

Keywords: low-temperature, polymers, SHRP, stiffness, thermal cracking

1. INTRODUCTION

At high temperature the bitumen behaves like a liquid and flow and at low temperature it behaves like an elastic solid and becomes stiff [1]. At the temperature in which most pavements endure the traffic, the bitumen is a viscoelastic material that is it behaves like a viscous liquid and elastic solid simultaneously.

As in Romania the pavement are working in rough climate condition (very hot summers and low temperature winters) as we know the bitumen stiffness at low temperature leads to the apparition of cracking in the pavement, this study's purpose is the original Romanian and polymer modified bitumen's low temperature behavior, using Fraass breaking point test and SHRP creep test with Bending Beam Rheometer.

With the BBR equipment there have been determined the S stiffness module and the m-slope at a 60 s loading time. These parameters have served at PG

ISSN 1582-3024

Transportation
Infrastructure Engineering
INTERSECTII
INTERSECTIONS
http://www.ce.tuiasi.ro/intersections

classification in concordance with SHRP specification. It is reminded that to prevent the bitumen's stiffness caused cracking phenomenon the SHRP specification recommend a max. Value of 300 MPa for "S' and minimum value of 0, 3 for "m". Bitumen which fulfills these requirements criteria will be less stiff and able to relax thermal stress build-up at low temperature [2].

This paper shows the results obtained at BBR on 60/80 and 80/100 penetration grade bitumen samples coming from two different refineries in Romania. It is also presented a correlation between the Fraass breaking point's value (which is sometime a contested indicator and cannot be correctly correlated with the pavement's behavior [3]) and TS=300MPa , Tm=0,3, temperatures determined by interpolation of the curve plotting log S(60s) and log m (60s) as function log temperature [4].

2. MATERIALS AND PROCEDURES

2.1 Materials

Samples of Romanian bitumen RP and RA with 60/80 and 80/100 penetration grade obtained from two different refineries were studied. The bitumens were studied in original state and SBS polymer modified. For the modification there were used the SBS polymer with characteristics presented in table 1.

SBS modified bitumen's were prepared at 180^{0}C, with an shear mixer, with 2000 rot/min. the rotation rate , 2 hours blending time , using 4% and 5% SBS polymer.

Table 1: The SBS polymer characteristics

Crt. No.	Characteristic	U.M.	CAROM TL 30
1.	Chain shape	-	linear
2.	Styrene content	%	30 ± 2
3.	Volatiles	%	0,7

2.2 Test Methods

Fraass breaking test were determined in accord with Romanian STAS 113/1974, using the PETROTEST equipment.

BBR test were determined in accord with SHRP specification, AASHTO Designation: TP1, at different temperatures

(-24, -18, -12 and –6^{0}C for RA bitumen and –30, -24, -18^{0}C for RP bitumen), using the equipment BBR, from ATS.

ISSN 1582-3024

3. RESULTS AND DISCUSSIONS

The results obtained for RP bitumen are shown in the no. 2 and no.4 tables.

This bitumen has low values for Fraass Breaking Point. The Creep Stiffness and m-value, obtained for - 24°C and -30°C testing temperature, classify this bitumen in PG: -34. Isomodule temperature $T_{S=300\ MPa}$ is lower than Fraass Breaking Point and higher than $T_{m=0.3}$.

Table 2: RP and RA bitumen characteristics

Bitumen	**Characteristics**					
	Penetration at 25⁰C, dmm	**Softening point, ⁰C**	**Fraass breaking point, ⁰C**	**$T_{S=300MPa}$ ⁰C**	**$T_{m=0,3}$ ⁰C**	**PG**
RP1	60,5	49,7	-23,7	-28,3	-26,4	64-34
RP2	64,5	48,2	-23,7	-29	-30,5	64-34
RP3	70,2	46	-23	-27,7	-33,2	64-34
RP4	80,6	45	-24	-28,3	-29,3	58-34
RP5	84	46	-21	-28,7	-30,4	58-34
RA1	63,4	48,7	-16	-13,2	-8,2	58-16
RA2	60	47,2	-15,7	-19,3	-21,3	64-28
RA3	61	44,7	-15	-17,5	-25,8	58-22
RA4	80,7	43,8	-15,1	-15,24	-11,6	52-16
RA5	102,3	44,5	--17	-18,5	-	58-28

The results obtained for RA bitumen are shown in the no. 2 and no.4 tables.

This bitumen has a variable behavior at low temperature. The Fraass Breaking Point values are in -16°C ±1°C domain; the Creep Stiffness and m-value obtained for testing temperature, classify this bitumen in PG: -16, -22, -28 domain.

The results shown in the no. 3 table was obtained for the SBS polymer modified bitumen. The modification with polymer improved the Fraass Breaking Point for RP 5 and RA 3 bitumen. After modification, the RP bitumen performance grade remains the same (PG:-34), but the RA bitumen performance grade was improved (from PG: -22 to PG: -28).

Table 3: SBS modified bitumen's characteristics

Bitumen	**Characteristics**					
	Penetration at 25^0C, dmm	**Softening point, ^{0}C**	**Fraass breaking point, ^{0}C**	**$T_{S=300MPa}$, ^{0}C**	**$T_{m=0,3}$, ^{0}C**	**PG**
RP3+4%SBS	38	58,5	-24	-29,2	-35,4	76-34
RP3+5%SBS	33	64,4	-24	-29,6	-33,2	76-34
RP5+4%SBS	51,3	58,5	-24	-28,8	-30,7	76-34
RA3+4%SBS	45,6	50	-18	-19	-25,8	70-28

Table 4: S and m SHRP parameters for original and SBS modified bitumen

Bitumen	**Temperature ^{0}C and SHRP parameters**				
	-6 S/m	**-12 S/m**	**-18 S/m**	**-24 S/m**	**-30 S/m**
RP1	-	-	81,2/0,357	182/0,322	373/0,287
RP2	-	-	124,5/0,385	225,2/0,355	320/0,302
RP3	-	-	79,2/0,392	180,6/0,372	378/0,336
RP3+4%SBS	-	-	50,8/0,390	179,6/0,367	342,8/0,340
RP3+5%SBS	-	-	50,8/0,390	121,2/0,364	322,6/0,332

RP4			102/0,370	161,2/0,340	387,2/0,294
RP5	-	-	116,2/0,364	169/0,331	352/0,302
RP5+4%SBS	-	-	120/0,380	168/0,328	330/0,302
RA1	108,3/ 0,315	219,8/ 0,278	369,5/0,238	-	-
RA2	-	-	249,8/0,423	474,5/0,281	-
RA3	-	174/0, 378	317/0,340	458/0,312	-
RA3+4%SBS	-	169/0, 345	279,6/0,320	432/0,308	-
RA4	101,2/ 0,325	193,7/ 0,295	419,6/0,245	-	-

4. CONCLUSIONS

Romanian bitumen studied has a varied behavior at low- temperatures.

RP bitumen presents a better low temperature behavior than RA bitumen, having lower values for Fraass Breaking Point and Creep Stiffness, S. The PG for 60/80 and 80/100 penetration grade RP bitumen is PG: -34. The SHRP limiting temperature $T_{S\,=\,300\,MPa}$ is higher than $T_{m=0.3}$ and lower than Fraass Breaking Point.

RA bitumen presents a not so good behavior at low temperature, having a higher stiffness. The PG for 60/80 and 80/100 penetration grade RA bitumen is situated in -16;-22;-28 domain. Between $T_{S\,=\,300\,MPa}$, $T_{m=0.3}$ and Fraass Breaking Point there cannot be a correspondence.

Polymer modification improves the stiffness of studied bitumen (see S value in no. 4 table). After modification the PG grade for RP bitumen remains PG: -34 and for RA bitumen is improved from PG:-16 to -28. The improved stiffness parameters should lead to increased resistance of asphalt to thermal cracking in service period.

For both bitumen the $T_{S\,=\,300\,MPa}$ is lower than testing temperature for which S=max. 300 MPa, that indicates that the 6°C steps between testing temperatures of the SHRP program are too big, smaller steps being necessary.

As in Romania the minimum pavement surface temperature is between -9°C and -30°C [5], depending on the area, bitumen having the proper PG must be used for each area.

Transportation
Infrastructure Engineering

INTERSECTII
INTERSECTIONS
http://www.ce.tuiasi.ro/intersections

References

1. U.S. Department of Transportation, Federal Highway Administration – Background of SUPERPAVE. Asphalt binder test methods, 1994.
2. J.Carswell, M.J.Claxton, P.J.Green – "The classification of bitumen and polymer modified bitumen within the SHRP performance grading system", 2nd Eurasphalt & Eurobitume Congress, Barcelona 2000.
3. F.Migliori;J.C. Molinengo- "Caracterisation des bitumes francais a basse temperature. Application de l'essai BBR", Eurasphalt & Eurobitume Congress, 1996.
4. L.Champion-Lapalu, J.P.Planche, D.Martin, D.Anderson, J.F.Gerard – "Low-temperature rheological and fracture properties of polymer modified bitumens", 2nd Eurasphalt & Eurobitume Congress, Barcelona 2000.
5. Radu, Andrei – "Performance testing specification for bituminous binders & mixes in Romania five years of experience", 2nd Eurasphalt & Eurobitume Congress, Barcelona 2000.

ISSN 1582-3024