CONCENTRATED POLYMER MODIFIED BITUMEN IN PELLETS. PART 2

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Resistance to rutting

Cracking but also rutting is for sure the pathology most commonly observed on the roads throughout the world. Some try to solve the rutting issue by increasing the modulus of asphalt mixes. This leads to a damaging effect on cracking in the surface layer. Improve asphalt mixes modulus must be restricted to reinforcement of roads with structural problems. Some countries attempt to predict the resistance to rutting by establishing more restrictions on binder requirements. However, this indirect method disregards the asphalt mixture composition. Indeed, 95 % of the asphalt mixture is aggregates.

Nevertheless, resistance to rutting of asphalt mixes can be evaluated directly in the laboratory. Among standardized test methods such as the European standard EN 12697-22, American standards AASHTO T340-1 (APA rut test), and AASHTO T324-14 (Hamburg wheel tracking test).

The European standard EN 12697-22 is a test method used to appreciate asphalt mixes resistance to permanent deformations. It consists in measuring the rut depth on a sample of asphalt mix formed by repeated passes of a loaded wheel at a constant temperature.

Both asphalt formulations were evaluated.

In the Table 4, the results are obtained on the asphalt mix AC_2 which is particularly sensitive to rutting. This formulation is very interesting to bring light to efficiency of the product.

Table 4

Resistance to permanent deformation AC_2

Rutting resistance (EN 12697-22)		AC_2	$AC_2^{P.PMB}$	Surface course French requirement – EN 13108-1
Voids (%)		8.4	4.8	
Rut depth (%)	3,000 cycles	10.6	3.9	n.r
	0,000 cycles	13.7	4.5	n.r
	0,000 cycles	17.91	6.2	≤ 10

n.r: No Requirement

As expected, the AC_2 asphalt mix, with neat bitumen, is very sensitive to permanent deformation. Obviously, no one would use this asphalt mix as a surface course, even for low traffics. In contrast, the PMB in pellets form highly improves the resistance to rutting. The performance widely exceed the lowest French requirement (≤ 10 % - Class 1).

The table below presents results from the asphalt mix AC_1. The PMB produced in the binder plant is compared with the PMB in pellets. Both are similar and very resistant to rutting.

Table 5

Resistance to permanent deformation AC_1

Rutting resistance (EN 12697-22)		**AC_1^{PMB}**	**$AC_1^{P.PMB}$**	**Surface course French requirement – EN 13108-1**
Voids (%)		8.4	5.0	
Rut depth (%)	3,000 cycles	2.5	2.2	n.r
	0,000 cycles	2.9	2.5	n.r
	0,000 cycles	3.1	2.7	≤ 5

n.r: No Requirement

As observed further on, modified bitumen with SBS does not increase drastically the asphalt mix modulus. However, thanks to these results it could be asserted the efficiency to improve resistance against rutting. In addition, the elastic characteristic boosts the resistance to cracking.

Stiffness modulus

Bituminous materials' behavior is viscoelastic thanks to the hydrocarbon binder. In this way, the stiffness modulus of the asphalt mix depends on temperature and frequency.

Results obtained on various asphalt mixes are summarized in the Table 6.

Table 6

Stiffness modulus

Stiffness modulus (EN 12697-26)	**AC_1^{PMB}**	**$AC_1^{P.PMB}$**	**Surface course French requirement – EN 13108-1**
Voids (%)	5.6	5.2	-
|E*| @ 15°C, 0.02s (MPa)	9,900	10,700	≥ 7,000

Regarding the results, the modulus value at 15 °C and 0.02 s of the two asphalt mixes reflect a difference less than 10 %. This gap remains lower than the reproducibility test (R = 2,740 MPa).

Through this method test, it is possible to establish the corresponding master curve. Comparing AC_1^{PMB} and $AC_1^{P.PMB}$, the rheological behaviors are the same overall frequency and temperature ranges.

Resistance to fatigue

Under wheel load, the pavement structure is damaged because of repeated deformation in traction, particularly in the base course. High traffic promotes micro-cracks after a few cycles and then the total deterioration of the structure.

The fatigue resistance of an asphalt mix reflects the capacity of the mixture to resist under cyclical tensile force. It is possible to define it thanks to the European standard EN 12697-24.

However, if the road pavement structure is adjusted rightly, tensile traction force rarely influences the surface layer. Then, it is exceptional to measure resistance to fatigue on an asphalt mix designed for the surface layer.

Nevertheless, using PMB with SBS improves substantially the elastic behavior of the asphalt mix and thus the fatigue resistance. This characteristic could be a good parameter to predict the resistance to fatigue of the asphalt mix.

Table 7

Fatigue resistance

Resistance to fatigue (EN 12697-24)	**$AC_1^{P.PMB}$**	**Surface course French requirement EN 13108-1**
Voids (%)	5.6	5 to 8
Slope	-0.179	n.r
ε_6 (µdef)	126	≥ 100

n.r: No Requirement

With pure bitumen, the fatigue resistance of the asphalt mix designed for a surface layer is around 100 µdef. Therefore, $AC_1^{P.PMB}$ presents much better fatigue resistance compared to asphalt with pure bitumen. The use of the PMB in pellets improves significantly the rheological behavior of the mixture as well as the PMB manufactured in the binder plant.

Binders Performance

Pellets of PMB are designed to be introduced directly and exclusively into the pug mill of the asphalt plant. In any case, the pellets must be incorporated into the bitumen. However, it is still possible to manufacture a PMB in the laboratory. This needs a specific procedure but thanks to this step, it is possible to evaluate PMB performance according to the usual laboratory tests methods.

The following results are obtained on PMB manufactured with the PMB in pellets mixed into the 70/100 penetration grade neat bitumen.

It should be noted that an increase in the PMB in pellets improves the PMB performance. The adjustment could also be economical and find the optimal content to be closer to the requirements.

PMB performance and requirements

Manufacturing PMB based on the dilution of concentrated PMB in pellets into neat bitumen is a common procedure for customers. Many tests are done with several origin and penetration grade neat bitumen.

Measuring this PMB performance allows adjusting the PMB in pellets content and doing the neat bitumen selection wisely.

As PMB in pellets is introduced directly into the pug mill in the asphalt plant, it is possible to increase drastically the modification level of the asphalt mix. Therefore, very high performance could be reached with no limit whereas PMB produced in the binder plant is limited to pumpability issues.

Table 8

PMB with RW Elast® performance

Test method		**PMB pellets**	**PMB requirement**
Test on original PMB			
Penetration EN 1426	25°C, 100 g, 5 s, 0.1 mm	46	45 – 80
Softening point EN 14267	Water °C	88.0	≥ 65
FRAASS EN 12593	°C	-15	≤ -12
Elastic recovery EN 13398	25°C %	96	≥ 85
Test on residue from Rolling Thin Film Oven Test (RTFOT) – EN 12607-1			
Retained Penetration EN 12607-1	25°C, 100 g, 5 s %	70	n.r
Softening point variation EN 12607-1	°C	-4.5	n.r
Mass variation EN 12607-1	%	0.02	n.r
Rheological test (DSR)			
High T°C of PG on unaged PMB AASHTO T315	$G^*/\sin\delta = 1$ kPa °C	82.0	n.r
High T°C of PG after RTFOT AASHTO T315	$G^*/\sin\delta = 2.2$ kPa °C	83.0	n.r

n.r: No Requirement

Elastic recovery

The binder's elastic behavior can be characterized according to the European standard EN 13398. It is a good indicator to define the PMB behavior and predict the asphalt mix performance.

It is well known that neat bitumen presents no elastic recovery. The SBS polymer is used to increase the elastic recovery of the PMB.

Pellets of PMB present the same elastic recovery performance as PMB manufactured in the asphalt plant.

Rheological test (DSR) and PG classification

In addition to European test standards, concentrated PMB in pellets is also evaluated according to the American standards more specifically the “Performance Grade” (PG) according to the AASHTO M320. Some results are presented in the

Table 8.

With concentrated PMB in pellets, it is possible to reach the highest PG classification. The content could be adjusted according to the required PG class.

Road construction

The concentrated PMB in pellets is a solution usually used to carry out many work sites in France and abroad. It could be used for the production of all types of asphalt mix.

The solution is suitable for different weather conditions and also extreme one. Examples of work sites could be mentioned in hot countries like the Middle East as well as countries with humid climates like South America or South East Asia. Some of them are also located in countries with low temperatures for example Central Asia or Quebec.

The concentrated PMB aimed to reach a very good mechanical performance of the asphalt mix. Therefore, it is a good solution for: highways; roundabouts; airport runways and taxiways; logistic platforms, car parks, and truck areas; industrial zone access; bus lanes.

Concerning the quality control of the concentrated PMB in pellets, test methods are developed to ensure the conformity of the asphalt mix composition. Moreover, the provider also guarantees the quality of its product through a quality control management.

Conclusion

The innovative solution of concentrated PMB in pellets is a good alternative to PMB manufactured in the binder plant. The SBS technology for modifying bitumen is available without no investment in any binder plant. The use of the PMB in pellets is easy and appropriate to various climates.

With this new solution, it is easy to adjust accurately the content according to the required performance. The laboratory tests could be realized according to any standards test and the asphalt mix, as well as the PMB, could be evaluated.

It offers a lot of flexibility as it overcomes constraints such as a minimum quantity, hot storage in an appropriate tank, or storage stability issues.