PERIODICA POLYTECHNICA SER. CIVIL ENG. VOL. 40, NO. 2, PP. 103–113 (1996)

ASPHALT-PLANNING EXPERIENCES AND TRENDS BY USING MODIFIED BITUMENS IN HUNGARY

Imre PALLÓS

Department of Highway and Traffic Engineering
Technical University of Budapest
H–1521 Budapest, Hungary

Received: Sept. 29, 1995

Abstract

The thin asphalt produced with the use of modified bitumens is economical for the rehabilitation of our motorway pavement surfaces in spite of the higher price of the modified bitumens. The conditions of applying a series of asphalt mechanical investigations have been established in the Laboratory of the Department of Road Engineering, Technical University of Budapest. The basic idea of the investigation system is the investigation of the asphalt in three important temperature ranges in accordance with real climatic character of the asphalt.

Keywords: asphalt-planning, quality of modified bitumeens, modified thin-asphalts, mechanical tests of asphalts.

Introduction

Exactly ten years have elapsed since slowing down the public roads' deterioration process in Hungary we have started to apply the modified thin asphalt technologies promising effectiveness at road surface rehabilitation works of our motorways and at renewal of main highway pavement surfaces otherwise suitable regarding bearing capacity. At the first experimental works in 1985 and 1986, we were forced to use imported modified bitumens for the mixtures. Not only the road builders but the bitumen producers also felt that applying modified bitumens, asphalts of better efficiency and higher use value can be made, meeting better the increased loads. It was unambiguous that the more expensive modified bitumen asphalt technologies cannot replace on account of economical reasons the traditional technologies applied in big volumens. Estimations and forecasts at that time placed the domestic utilization rate of modified bitumens only around 1 – 2% of the whole quantity of road bitumens, and even in Western European countries of solid capital then at best a 5% utilization ratio was regarded as real. Therefore I think the domestic bitumen producers were not governed by the possibility of a 'big business', but the internal demand of keeping profession in step when they started the research-product development program in 1985 resulting in shipping diverse — primarily elastomer containing — products for the Hungarian road building industry in 1987. The produced modified bitumens based on domestic development and on foreign licence, both containing SBS, have been likewise successfully applied at various surface renewal works.

The Hungarian road building industry could order from the domestic producer modified bitumen not only of elastomer but also of plastomer character in good quality as a result of the development works of the greatest Hungarian petroleum refining industry already in the early 90's. For producing these a plastomer type copolymer has been used being able to be mixed with bitumen in the form of finely-dispersed drops. Due to this additive the plastic temperature range of the binder increases and beside the good cohesion qualities, its heat sensitivity favourably decreases as well. Simply said, to satisfy the road building functional aim, using such additives a binder of more favourable properties can be formed than with adding pure polyethylene or polypropylene.

Our manufacturers have producedcation-active bitumen emulsions suitable for manufacturing properly emulsifiable modified bitumens in order to conform to the road building professional field from the 1990's.

Estimation of Modified Bitumens Quality with a Special Application-Technical Testing-Evaluating Method

Principal technical requirements for modified bitumens applied in asphalt can shortly be drafted as follows:

- high resistance against plastic deformation
- high ductility at low temperatures
- better elastic behaviour
- moderate temperature sensitivity
- more favourable cohesion and adhesion properties

These requirements (in this or similar form) were not recently raised and cannot be connected to the appearance and spread of modified bitumens. These wishes have already been expressed towards normal bitumens as well; it is another question that those can only partly meet such a requirement system. Road builders also have always missed the introduction — with regular or casual application— of a testing-requirement system demonstrating better the qualities of road building bitumens than the traditional product characteristics and estimating more actually the bitumens' functional behaviour and utility value. This becomes especially important if some change occurs in bitumen production (e.g. in crude oil, the base of manufacturing) and also when a new material with improved properties, in many aspects different from the earlier — like modified bitumen — appears and its utility value is the question. (This so-called 'performance' principle is also based on the recently elaborated American SHRP program regulating at what highest and lowest asphalt pavement temperatures certain bitumen types can be used in asphalt production, and raising also requirements for the rheological tests on certain parameter values of visco-elastic properties.)

In the period preceding directly the domestic development of modified bitumens, during the research work initiated by the Ministry of Transport and Posts and affecting several research laboratories, the Department of Highway and Traffic Engineering has developed the so-called BVA testing-evaluating system in order to get a better valuing for the utility value of the various road building bitumens. The developers dealing with modified bitumens in the producing enterprises recognised that the new BVA testing-evaluating system would be suitable to give a good feedback possibility to their experimental-developing work, and enable them to qualify succeeded experimental compositions regarding practical parameters of the road building industry.

The method's basic idea is that at tests performed with asphalt mixes with constant composition (standard asphalt mix), where bitumen quality is the single independent variable, the road building utility value of the bitumen is qualified with five parameters (see *Table 1*).

Table 1
The bitumen quality estimating parameters in the BVA-type testing-evaluating system

I. Modified Marshall stability (for characterising the bitumen's hot behaviour)
II. $n(S_0/2)$ failure repetition number defined by dynamic bending test (for characterising the bitumen's fatigue qualities at 5 °C temperature)
III. D_7/MH swelling/free void ratio (for characterising the bitumen's cohesion-adhesion qualities)
IV. ε_H measuring number of cold-stretchability of the standard asphalt based on splitting tests carried out at temperatures of +5°C and −20°C (this is one characteristic of bitumen's cold-behaviour)
V. Fraass breaking point (this is another characteristic of bitumen's cold behaviour)

Four from these five parameters can be obtained by the test of the standard asphalt and Fraass breaking point of the bitumen is also drawn in the evaluation.

An individual characteristic feature can be evaluated with points of 1–2–3–4–5, so based on the five characteristic evaluations the total evaluating point number can be calculated. If total evaluating points are above $P = 16$, then the bitumen is of high utility value and it is considered a good quality binder. The various Hungarian modified bitumens produced as results of development works have passed the examinations well in this special testing-evaluating system, particularly those with phantasy-names ZALAPLAST-8 and POLIROAD PmB-65/S belonging to product group PmB-45 and PmB-65, mixed with SBS additive. It is worth of attention that the DMB-80 and DMB-110 products with a plastomer additive can be characterised with penetration range between 60 – 100 and a softening point around 60 °C; their evaluating total points are between 16 – 18. The effectiveness of modification can be demonstrated by the following: normal bitumens with a nominal penetration of 80 can generally be qualified with 9 – 12 points, the domestic and occasionally tested foreign products B-65 and B-45 bitumens with 10 – 13 points, see *Table 2*.

Table 2
Evaluating total points of various road building bitumens with BVA-type tests

Bitumen's nomination	Evaluating total points
ZALAPLAST-8 POLIROAD PmB-65	18 – 20
DMB-80 DMB-110	16 – 18
SZB-90, B-80 (domestic, foreign)	9 – 12
B-65, SZB-50, B-45 (domestic, foreign)	10 – 13

Technologies Applied at the Domestic Construction of Modified Thin Asphalts

At the beginning of the domestic application of modified bitumens to slow down more effectively the roads' degradation process exclusively the modified thin asphalt renewal technologies were applied. Our enterprises constructed mixtures with relatively large aggregate skeleton: AB types containing only crushed sand were applied during the pavement rehabilitation works. From 1989 on the building of 'Splittmastixasphalt' type thin wearing course has almost become exclusive with maximum grain size of $D_{\max} = 8\,\text{mm}$ or $12\,\text{mm}$, using modified bitumen. It is worth mentioning that 'asphalt carpets' with a design thickness of 2.5 – 4 cm were always built on the considerably deteriorated motorway sections with inserting a SAMI layer.

The *asphalt mechanical tests* carried out at our Department – similarly to the BVA application-technical tests described in point 2 – fairly showed the great use and specific properties of asphalts manufactured with modified bitumens. At a major rehabilitation work dynamic creep tests have been carried out on modified asphalt type mAB-12 with modified bitumen corresponding in mineral composition and binder, but on one section containing SBS, and on the joining road section with modified bitumen of identical softening point, containing plastomer; results are compared in *Fig. 1.* According to the test method of the Department of Highway and Traffic Engineering the test was carried out at +40 °C, with 4 Hz sinusoidal load repetition, compressive load $0.6\,\text{N/mm}^2$. In *Fig. 2* characteristic values of the so-called fictive crack temperature indicating the crack sensitivity of the asphalt in winter based on the method of our Department are shown. The nature of modification (elastomer-plastomer type) clearly appears, as the plastomer type considerably helps to increase resistance to thermodeformation, besides the elastomer binder significantly improves dilatability in winter, positively effecting the asphalt's crack sensitivity. These two figures are in a good accordance with the characteristic curves in the publications of the big oil companies (SHELL, ESSO, BP) showing the modified binders' viscous-stiff properties between +60 °C and −20 °C in the whole operational temperature range compared with normal bitumens (*Fig. 3*).

Some Questions Relating to the Suitability of Quality Requirements Specified for Modified Bitumen Products

The question is often raised to what extent the polymer-bitumen's quality determining parameters, given as characteristics in the product catalogues, in the technical specifications of road authorities, or just in state standards, meets the higher quality requirements for the more expensive modified bitumens.

Reviewing the requirement system of certain European countries or big bitumen producers it can be seen that beside traditional product characteristics concerning normal bitumens (as penetration, ring-and-ball softening point, Fraass breaking point, ductility on 25 °C temperature, the

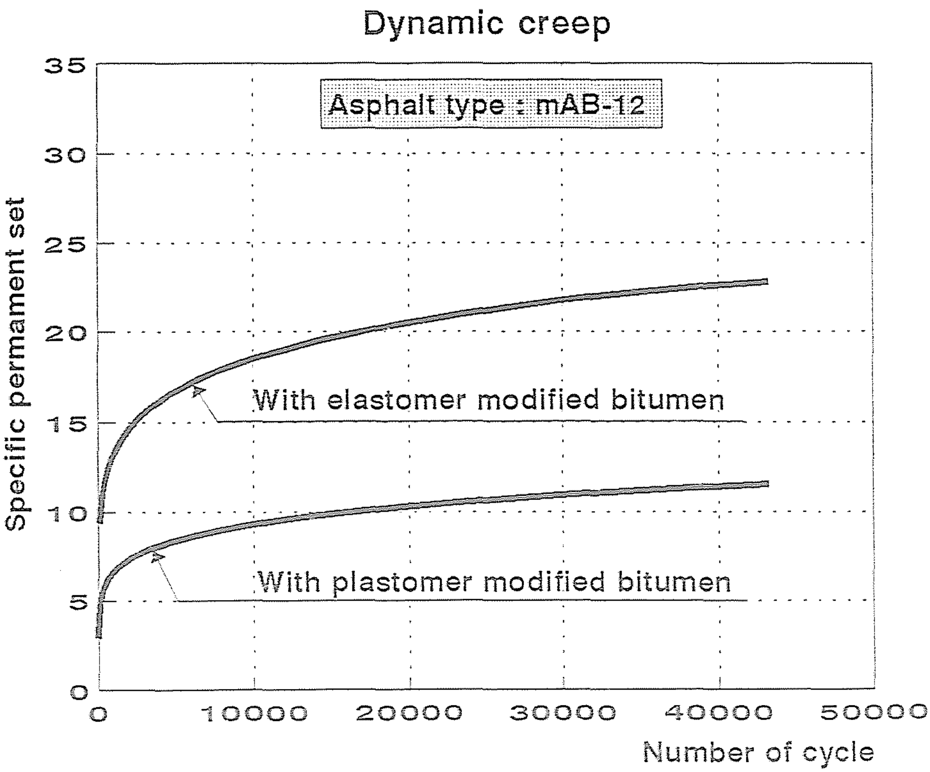

Fig. 1. $\varepsilon - n$ curves defined with dynamic creep test of asphalts manufactured with modified bitumens containing elastomers and plastomers

recently here ranked absolute viscosity values ordered to one or more temperatures and the characterization of adhesion) altogether two 'new' parameters distinguish the modified bitumens from the normal ones. One is the ductility measured also at a temperature lower than 25 °C, the other the testing of elastic recovery ability at 25 °C and/or at a lower temperature. The previous parameter characterizes the low temperature stretchability connected with cohesion, and provides certain information for the applied polymer type as well. The other one demonstrates the modified bitumen's elasticity in a relatively narrow (4, 5 or 7 to 25 °C) temperature range. Here has to be mentioned that flash point or for the tube-test specified requirements are rather secondary ones not relating to functional suitability.

The knowledge of traditional characteristics is naturally important with modified bitumens because the user's practice can primarily decide what kind of products can be applied to a given technology. From the

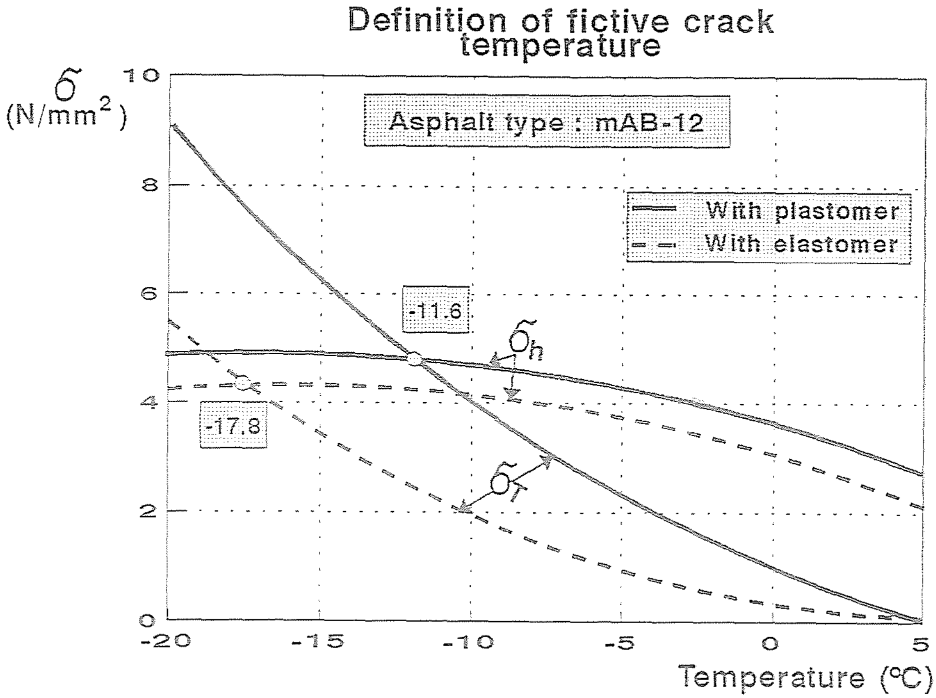

Fig. 2. Crack temperatures of asphalt manufactured with modified bitumens containing plastomers or elastomers

softening point and breaking point values the road builder can see e.g. the plastic thermal distance range, its size, or already feels from the softening point's values at what temperature to work during building. Plastic deformation inclination can also be estimated to a certain extent. The low temperature ductility or the values of elastic recovery are important characteristics indicating the polymer's presence, higher cohesion power, the binders stretching ability tending towards lower temperatures, and its elastic properties. Nevertheless it is considerably better manageable information for the road building engineer to know the produced and built-in asphalt's rutting resistance, to see numerically that with one or another recipe or just with the application of the various modified bitumens how the asphalt's better winter behaviour can be ensured, how stiff or elastic the planned mix would be. Today — with the appearance and spread of the modified bitumens — the demand for asphalt-mechanical tests becomes more accented.

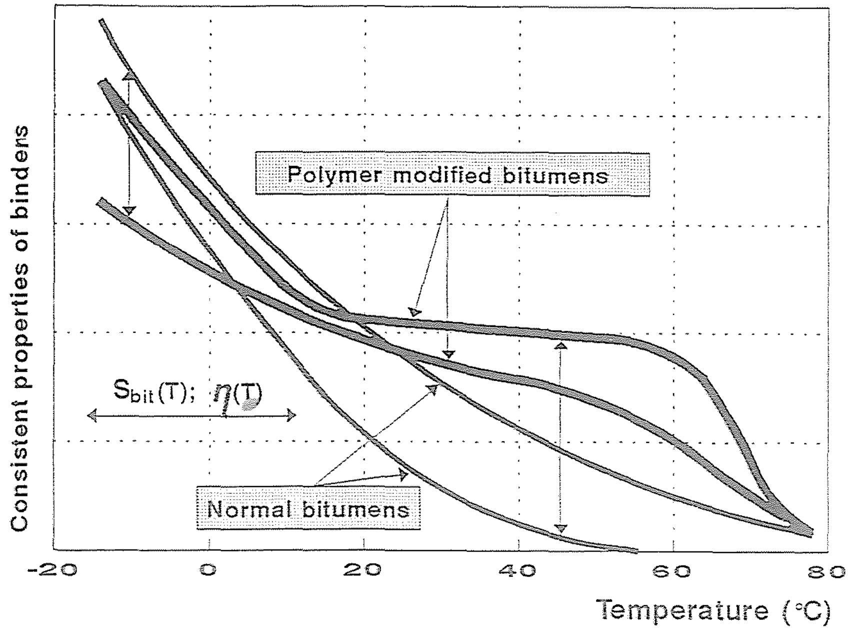

Fig. 3. Bitumens' viscous-stiff qualities as a function of temperature

Advantageous Possibilities for the Application of Modified Bitumens

In European countries modified bitumens were primarily used to hot process thin asphalts and to various *asphaltconcrete and splittmastix* asphalts. In the past ten years asphalt technology in Hungary has followed these technologies, and experience, observations, and condition evaluations show good results. Recently possibilities of applying modified bitumens advantageously have extended in the field of road building (see *Table 3*). In European practice modified bitumens are widely used not only to produce the wearing courses but to *'high stability' binder and base layers* of new pavement structures. The extension of another technology seems to be proven by that in countries where mastic asphalt was rarely used earlier, now *modified bitumen containing mastic asphalt* is widely applied as protective asphalt layers for bridge water proofing. *Noise-reducing drain-asphalts* and the binders of *thin or very thin open-graded wearing courses* having a void content of 10 – 15 volume % and a good skid resistance are at present exclusively modified bitumens on the European roads. The advantages of hot spraying of modified bitumen as well as of building surface layers with modified bitumen emulsions are indisputable. The so-called *'microseal'* and *'macroseal'* dressings with bitumen emulsion binder developed by the improvement of the Slurry Seal technology are built in with continually bigger volumens and also applied in Hungary today. For preparing these cold-process technology dressings several Western European enterprises use emulsions containing more polymers.

Table 3
Application possibilities of modified bitumens

I. *At road building jobs:*
- to the manufacturing of *AB* and *SMA* type asphalts built in heavily trafficked road sections
- at new pavement structure building to the asphalts of the so-called *'high stability'* or *'high modulus'* base courses or *binder courses*
- to the manufacture of *mastixes* and *mastic asphalts* (bridge pavements)
- to the manufacture of *drain-asphalts*
- to the manufacture of asphalts for pavements with *extreme loading* (road junctions with traffic lights, vehicle classifiers, space covers of industrial plants, take-off and landing zones of airports, etc.)
- stress distributing intermediate layers between pavement structure layers

II. *At road maintenance and improvement works:*
to the manufacturing of *SMA-type thin asphalts*
to the manufacture of hot-process *open-graded asphalts*
at producing the mixed, cold-process *'micro-seal'*, *'macro-seal'* dressings
to the manufacturing of *surface dressings* with spraying-spreading technology (hot- and cold-process alternatives)

III. *Special applications:*
joint-filling materials, elastic pavement dilatations, etc.

Modified bitumen products traded presently in Hungary are very suitable to several technologies. International practice shows that certain new asphalt technological processes would also demand the development of other products. We indicate here that for binder of SAMI course to be built under the thin wearing courses and to the production of mastic asphalts and mastics in several countries a bitumen of higher polymer content, higher softening point and modified with thermoplast is applied. We may also have tasks demanding modified bitumen of higher polymer content as well. (At the building of climbing lanes of motorways with heavy traffic, or for cases of slow canalized traffic conditions, and also for asphalts serving as bridges' wearing courses it is recommended to use modified bitumens with higher polymer content.) We may also mention that for producing the asphalts of open-graded wearing course a modified bitumen grade with softening point between 70 – 80 °C, breaking point of at least −15 °C, and stretchability of 60 cm on 13 °C testing temperature is recommended. In Hungary there are plenty of bridges with extremely heavy traffic, and on some smaller sections of our motorways and of the main road network extreme load stresses can be observed accompanied by continually warmer summer periods.

I think building of binder and base courses with high stability will start soon in our country. The most satisfactory modified bitumens have to be developed for these. The production of emulsifiable modified bitumens for this purpose seems to be solved, but modified emulsions most advantageously usable to the mixed, cold-process dressings have to be further developed intensively.

Closing Remarks

We have plenty of development works, first, to define more precisely the tasks, the road building purposes. This work has to be accomplished jointly with the bitumen producers; only this way can lead to a suitable, advantageously applicable product range for the modified bitumens being indispensable in the modern road building and road maintenance.

References

1. Department of Road Engineering: Asphalt Technological Tests of Commercial, Experimental and Modified Road Building Bitumens. (in Hungarian) – Research final report for the Highway Department of the Ministry of Transportation, Budapest, 1986.
2. PALLÓS, I.: Technical and Economical Questions of the Application of Modified Bitumens. (in Hungarian). *Review of Civil Engineering (Mélyépítéstudományi Szemle)*, Vol. XXXVII (1987) No. 11.
3. NEMESDY, E. – PALLÓS, I. – TÖRÖK, E.: Estimation of Bitumens for Road Building Purposes with Complex Mechanical Asphalt Testing Method at the TUB Department of Highway and Traffic Engineering. (in Hungarian). *Scientific Review of Civil Engineering (Közlekedés-építés- és Mélyépítéstudományi Szemle)*, Vol. XXXVIII, No. 10, October 1988.
4. REINISCH, E. – PALLÓS, I.: Application of Modified Bitumen Technologies in the Hungarian Motorway Network. (in Hungarian)*Scientific Review of Civil Engineering (Közlekedésépítés- és Mélyépítés-tudományi Szemle)*, Vol. XXXIX, April 1989.
5. NEMESDY, E. – PALLÓS, I. – TÖRÖK, E.: Special Standard Asphalt Test to Classify Road Building Qualities of Normal and Modified Bitumina. Issue of the Eurobitumen Symposium, Madrid, October 1988.

6. PALLÓS, I.: Construction of Thin Asphalt Wearing-Courses with Modified Bitumen in the Road Network of Hungary. *Periodica Polytechnica Civil Engineering.* Technical University of Budapest, Vol. 36, No. 1. 1992.
7. PALLÓS, I.: Experiences of Testing of Thin Asphalts Built with the Use of Zalaplast-8 Modified Bitumen in 1993. (in Hungarian) *Scientific Review of Civil Engineering (Közlekedésépítés- és Mélyépítés-tudományi Szemle),* Vol. XLIV, June 1994.
8. NEMESDY, E.: The American 'SHRP' Program and its Expectable Effects on European and Hungarian Road Building. (in Hungarian). *Scientific Review of Civil Engineering (Közlekedésépítés- és Mélyépítéstudományi Szemle),* Vol. XLIV, June 1994.
9. PALLÓS, I.: Characteristic Features of Modified Bitumens, Economical and Rational Possibilities of Use. (in Hungarian) *Scientific Review of Civil Engineering (Közlekedésépítés- és Mélyépítéstudományi Szemle),* Vol. XLV, January 1995.
10. PALLÓS, I.: Asphalt Designing Trends and Experiences with MOL Modified Bitumens. (in Hungarian) *Scientific Review of Civil Engineering (Közlekedésépítés- és Mélyépítéstudományi Szemle),* Vol. XLV, March 1995.