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CONSTRUCTION OF THIN ASPHALT WEARING COURSES WITH MODIFIED BITUMEN IN THE ROAD NETWORK OF HUNGARY

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Abstract

The thin asphalt produced with the use of modified bitumens are economical for the reconstruction of our motor-way surfaces in spite of the higher price of the modified bitumens. From technological point of view, the thin asphalt wearing surfaces can be used with advantage in the following cases:

- for the preservation and renewal of the substance of aged wearing surfaces and road pavements,
- for the renewal of the smoothened surfaces of the wearing-surfaces not rough enough any longer with respect to traffic safety,
- on sections at a specified height between elevated edges,
- for building a rough wearing surface necessary to meet special requirements.

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 conditions during the endurance of the road with different methods taking the viscoelastic character of the asphalt into consideration.

Keywords: thin asphalt with modified bitumen, static and dynamic test, test methods.

Introduction

In the contemporary asphalt technology many new changes are encountered, and new developments of asphaltic materials as well as up-to-date asphalt techniques have been elaborated. Within the wide range of developments, the appearance of the polymer-modified bitumens can be considered as an important phenomenon, which is spreading to an ever increasing extent in road construction all over the world. These microphalts produced and built up with the use of up-to-date binders, the thin asphalt layers, the drain asphalt having, in addition, a noise-absorbing property, the modified mastics and mastic asphalts applied as the elements of sealing and floor paving systems with the bridges are considered today already as the elements of building and maintenance technologies. In addition, the modified bitumen technologies offer an excellent opportunity for giving solution to numerous problems of highway engineering (e.g. building special surface toppings, insertion of interlayers of stress-distributing property, construction of bond layers and base courses of great deformation resistance and high load-carrying capacity, the layout of elastic expansion joints in the asphalt layers, the different joint treatment procedures, etc.).

In Hungary, for preventing the deterioration process of road surfaces, first of all, renewal technologies for the *modified thin asphalt* layers are applied mainly to the reconstruction of pavements of the old motorway sections of deteriorated condition but still serviceable with respect to their load-carrying capacity. [1]

In this paper, the experiences gained in the field of building wearing-surfaces of modified bituminous thin asphalt in Hungary are described. With this in mind, the different substances and building technolgies, as well as certain asphalt-mechanical tests developed at the Department of Highway Engineering at the TUB (Technical University of Budapest) are shown here. These tests clearly demonstrate the advantageous and disadvantageous properties of the different kinds of asphalt, and render possible the evaluation of comparative character between the most different kinds of asphalt [2].

Construction of Modified thin Asphalt Layer on Concrete Pavement

In the Hungarian network of motorways, it is only motorway M7 on which a concrete main carriageway pavement has been applied. On the pavement – and first of all on the surface of the left-hand side carriageway built earlier – several kinds of damage could be observed, first of all, surface scale-offs and decompositions. A part of the deficiencies can be traced back to the conditions of the construction, the deficiencies in the technology applied 25 years ago, while another part of them, as a matter of fact, is due to the wear caused by traffic and every-day operation. When the reconstruction of the left-hand side carriage-way section between Budapest and Martonvásár took place ten years ago, after the breaking-up of the slabs as a preliminary work, a traditional multi-layer asphalt road structure was built in a thickness varying between 12–16 cm.

This classical reconstruction procedure consumes a considerable time expenditure because it requires the reinforcement of the stopping lane, as well as the rebuilding of the drainage system, i.e. other accessory work, too (elevation of railings, road signs, etc.). On other road sections where only surface scale-off could be detected characteristically, repair work requiring a synthetic resin technology was performed earlier. Though the repair by synthetic resin technology proved to be a success from technological point of view, however, the local repair had to be repeated cyclically (in every 3-5 years), so that in the case of repair of a greater volume, the effectiveness and the economy of this technology were rendered doubtful.

Due to the appearance of the bitumens with thermoelastomer additives, it was rendered possible to carry on a large-scale reconstruction work on the concrete pavement of our motorways by building modified thin asphalt layers on the basis of foreign recommendations and our initial experiences gathered already at that stage of building. Though according to the preliminary economic efficiency analyses and with respect to the increase in prices, the very high price of the modified bitumen played a decisive role in our calculations, however with respect to the total cost effects the building of the modified thin asphalt layer seemed to be an economical solution when a life of 6-8 years is assumed. (The reconstruction of the stopping lane and the drainage system can be omitted, accessory work, e.g. the elevation of railings is also omitted, and besides, the possibility of rapid realization has also several advantageous economical effects.)

However, the repaving of the concrete pavements represents a special building task, therefore in 1985 experimental sections of smaller length were built with the use of different technological solutions on this motorway on the basis of foreign recommendations, and with the application of foreign modified bitumens as described below.

a) With the use of the technology of SHELL COLAS (Austria) GmbH, modified asphalt AB 0/8 of small voids content containing crushed aggregate of 100% was applied in a thickness of 2.5–3.0 cm.The thin asphalt layer was cut through at the places over each expansion joint of the concrete pavement, and the joints were filled in with elastic joint sealing compound.
b) According to the recommendations of the German firm 'von der Wettern' (VDW firm), *asphalt of type AB 0/8* was produced with the use of modified bitumen VDW-pmB-A-140 in a nominal thickness of 3.5 cm. According to this technology, the cleared out joints of the concrete slab were filled in – not in the traditional way – with modified bitumen of a not too high softening point. The joint sealing compound exuded in a more or less measure in the course of building the pavement, and due to it, the thin asphalt layer over the joints was saturated with bitumen. It can be contributed to this fact that the thin asphalt over the expansion joints did not crack through in the winter-time in spite of the omission of throughcut.
c) *Thin asphalt paving system* according to technology BP - OLEXOBIT was used. With this procedure, a streak of geotextile fabrics was

sticked over the expansion joints of the concrete, then a system of thin aspahlt consisting of types AB 0/5 and AB 0/8 in two layers was built in a total thickness of 4.5 cm.

d) SAMI - FLÜSTERASPHALT system according to procedure of CT-ESSO. With this procedure, the pre-treatment of the concrete slabs prior to the building of the stress-absorbing membrane, as well as the preliminary clearing out and re-sealing of the expansion joints could be omitted.

e) *Splittmastixasphalt* for the stress-absorbing membrane according to the procedure of CT-ESSO. The rated voids content of the asphalt of type SMA 0/8 produced with the use of Spezialbitumen of the CT-ESSO was higher than that of the traditional one, i.e. 5.5 vol%. The throughcut of the thin asphalt layer built in a thickness of 4 cm was omitted on this section, too.

Large-scale Application of Thin Asphalt Layer

The Motorway Directorate envisaged the construction of the modified thin asphalt layer of the wearing course in a length of 10-15 km on Motorway M7 having originally a cement–concrete pavement. As a result of the joint analysis of the experiences gained in the course of building five experimental sections of different solution, as well as the aspects of operation, maintenance and economy, the party placing the order decided on choosing variation b).

According to this variation following the German, Austrian and Hungarian specifications, this is an asphaltic mix of mineral composition following the lower grading limit of the wearing course of type AB 0/8. The constituents of the mineral composition are: limestone-powder, crushed sand, as well as crushed aggregates of type NZ 2/5 and NZ 5/8, in other words, the mineral composition contains only crushed material exclusively.

Its binder is modified bitumen with thermoelastomer additives according to the specifications contained in *Table 1*.

The conditions of the pavement reconstruction of this concrete pavement motorway were fixed in a separate technical specification. Accordingly:

- a special preparatory technology was required in the cases when the pitching (rocking) of panels exceeded the value of 0.7 mm order, and if a height difference (rise) greater than 8 mm could be determined between the edges of two adjacent slabs;
- the former synthetic resin repairs on the surfaces of concrete slabs had to be milled off for the sake of a better adhesion of the thin asphalt

Table 1
Quality requirements of the bitumen modified by thermoelastomers

Parameters	Requirement
Penetration, at 25 °C, 0.1 mm	70-100
Softening point, °C	68–78
Breaking point, °C	15–20
Ductility, at 25 °C, cm	80-140
Ductility, at 4 °C, cm	30–60
Elastic recovery in ductilometer, at 25 °C, %	min. 70
Tendency to bifurcation (TUBENTEST)	no bifurcation possible
After application of thermal load:	
Relative change in mass, at 190 °C %	± 0.25
Reduction in penetration, %	max. 30
Reduction in elastic recovery	practically unchanged

layer, and the old, aged joint-sealing compound had to be removed out of the expansion joints;

- for the re-sealing of the joints, a special joint sealing compound of a great SBS content containing rubber powder, too, had to be applied;
- for the binding of the thin asphalt wearing course of 3 cm thick, the spraying of the modified bitumen used for the production of asphalt was prescribed at 190 °C in a specific volume of 1.0 kg/m^2.

The main regulations related to the quality requirement of the produced asphalt mix and the built-in layer are the following:

- the binder content of the asphaltic mix: min. 6.5 m% pmB
- the rated voids content: 2.5–4.0 vol%
- on the basis of the dynamic creep-test used for the characterization of the warm deformation resistance of asphalt,
- Cycle-number n_i: min. 25000
- deformation resistance n_i/ε_i: min. 1500
- density degree of the built-in layer: min. 97 %
- characterization of the layer adhesion by shear test: F_{ny}: 20 °C min. 10 kN.

The method of the dynamic creep-test used at the Department of Highway Engineering at the TUB for the characterization of the warm deformation resistance of asphalt, as well as the evaluation method of the test are illustrated in *Fig. 1.*

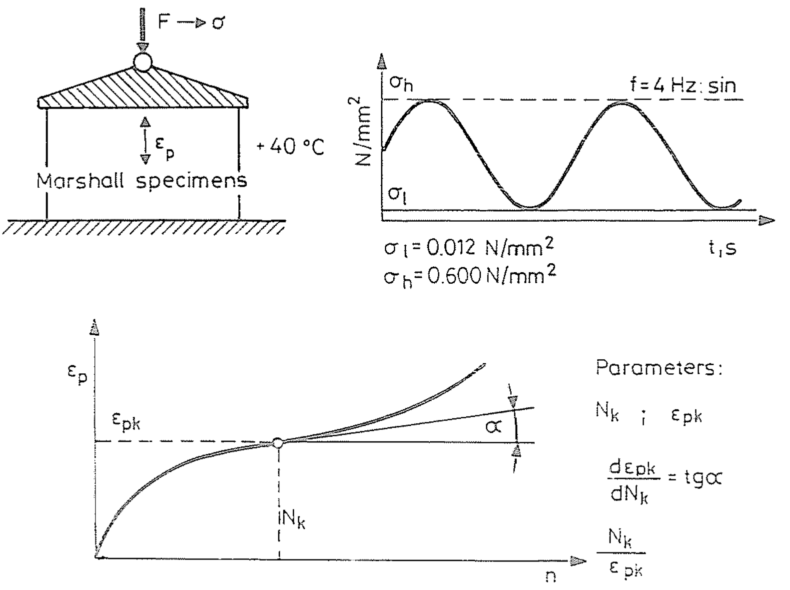

Fig. 1. Dynamic creep test at +40 °C on Marshall specimen

In *Fig. 2* the deviation of the fatigue curves determined by dynamic creep test for the type of asphalt AB 0/8 produced with modified bitumen, and the type of asphaltic concrete AB-12 produced with normal bitumen is shown clearly. The figure also shows the more disadvantageous warm deformation resistance of the traditional asphaltic concrete.

Experiences in Operation, Modification of Technology

With the use of the technology described in point 2.1, totally about 37 km of modified thin asphalt wearing course was built on the cement-paved layer of Motorway M7 over a three years time. As far as the surface properties are concerned (evenness, surface texture, skidding resistance, noise-inducing effect), this longer section revealed a correspondingly favourable quality on the basis of the measurements performed regularly. No rutting tracking has developed, or else no phenomena relating to any tendency to rutting have

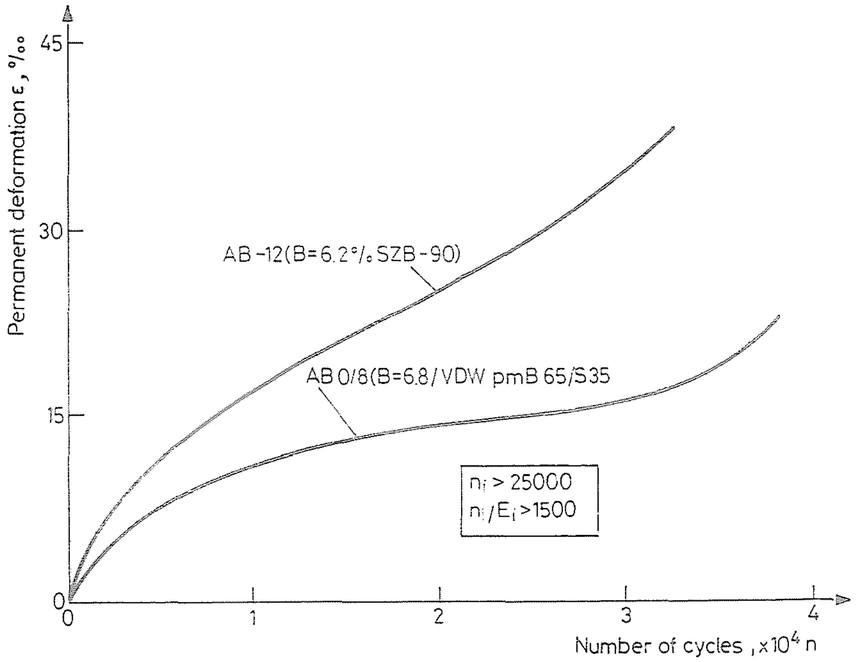

Fig. 2. Character of $\varepsilon - n$ curves determined by dynamic creep tests in the cases of asphaltic concrete produced with normal and modified bitumens

been experienced so far. With one or two winter periods elapsed, the thin asphalt layer has cracked through over the expansion joints of the concrete slabs in winter-time, however, the width of the cracks is only slight and will not increase even with some years elapsed. Along the cracking line, the modified asphalt of a finer granular structure will not be decomposed, the precipitation cannot penetrate into the expansion joints of the concrete slabs to the lower plane of them because they were re-sealed with a joint sealing compound of the best grade very carefully prior to applying the thin asphalt layer, and subsequently they were checked for quality. Otherwise, these narrow cracks will be closed in the milder seasons of spring and summer, and will again open up in winter-time. Consequently, the omission of the throughcut of the thin asphalt wearing course built with modified thin asphalt technology over the expansion joints caused no technical problems. This can be verified in our days, too, since the individual part-sections have survived already 4–5 winter seasons without any damage to the structure.

In the spring of 1989, the weather was more rainy than usual, and in early summer there was a considerable rise in the temperature.

In early summer in June, there occurred an unagreable phenomenon: blistering could be experienced on the sections of the thin asphalt layer of type VDW AB-0/8 built so far. On some sections, the measure of blister-forming was very intensive, while on other ones it could be observed only sporadically.

This phenomenon required a thorough investigation into the causes, on the basis of which the following statements could be made:

- the phenomenon of blistering is brought about by the occurrence of water vapour pressure greater than the bonding strength between the asphalt and concrete,
- when the modified thin asphalt was built in, a fraction of the binder representing a volume of 1.0 kg/m^2 exuded, and as a consequence, the lower plane of the otherwise, too, closed thin asphalt of voids content of 3.5 vol% became practically vapour-blocking.
- in more wet seasons, the concrete pavement of inhomogeneous structure absorbs and holds a higher volume of water.

By the effect of a more rapid and considerable rise in temperature following the set-in of the rainy weather, when both the asphalt and the bonding layers are rendered plastic, the developed water-vapour pressure exceeds the adhesion strength of the bond layer. In such cases, blisters develop in a greater number especially on the sections where the moisture content of the concrete is of a higher value. In the case of a slow, gradual increase in temperature, such a pressure-compensating mechanism takes place by whose effect no blistering will develop, or – if it is – only in a small measure on the thin asphalt.

Owing to the danger of blistering in the process of further building work, either emulsion gluing (binding), or SAMI layer (=Stress Absorbing Membrane Interlayer) could be chosen for binding the thin asphalt layer.

The change of the parameters of asphalt composition and asphalt technology was also considered indispensable. Due also to the porosity structure of the concrete pavement, it is more correct to prescribe a higher value of 3.5–4.0 vol. % for the rated voids content.

However, the emulsion binding method involves also certain disadvantages, particularly:

- it demands the very careful, precise pre-treatment of the surface (full removal of the synthetic resin repairs, repair of the edges of slabs etc.). These operations involve considerable cost-effects;
- the accurate previous treatment of the surface is more time-consuming at the same time which involves hindering the possibility of the rapid realization of the pavement reconstruction operations;
- in the case of emulsion binding with the use of a mix of smaller mortar content and greater voids content, the throughcut of the thin asphalt

layer over the expansion joints, or the sealing of them can no more be omitted.

On the basis of the arguments sketched above, *the building of SAMI layer* seems to be a more *advantageous* variation in technology. With the use of it, an additional accessory advantage will be provided by the possibility that the stopping lane can be protected in a conscious way, too, by using the SAMI layer. In this case, SAMI is functioning as a hot surface dressing (SAM) on the stopping lane.

When SAMI is used, the pre-treatment of the concrete surface involves only a few, more important operations which can be performed quickly.

There are two types of asphalt which can be considered corresponding with respect to building SAMI with the exclusion of the possibility of blistering, particularly: the *application of the drain-asphalt*, on the one hand, and the building of *Splittmastixasphalt*-system, on the other hand. For both variants, the type $D_{max} = 12$ mm can be recommended with a built-in thickness of 3.5–4.0 cm. Since here the concrete pavement serves as the actual base course, it is advisable to use modified bitumen of elastomer content for the production of the asphalt of the Splittmastix system, too.

With respect to the continuation of building, the building of the *SAMI-Splittmastixasphalt-system* seemed to be the *most advantageous* and *safest* time. The Splittmastixasphalt requires the use of the maintenance-operation technology elaborated for the traditional asphalts applied in winter-time, so it can be built on shorter sections where the special demand and financial possibilities can be taken into consideration better than with building drain-asphalt. But it is a more important aspect that SMA is a more durable kind of the thin asphalt layer than the drain asphalt, and besides, it displays very good surface properties, too. If it is applied onto the SAMI built on the concrete pavement, it seemed to be indispensable to specify *the rated voids content of it between 4.5–5.0 vol%* so that its *binder content of min. 6.2 vol %* should be required at the same time.

With this modification in technology, a newer thin-asphalt wearing-course of 26 km long was built over the former concrete pavement of Motorway M7 in 1989 and 1990 resulting in a favourable quality according to our experiences gained so far.

Building of Modified thin Ashpalt Wearing Course on the Concrete Pavement of our Motorways

On the asphalt-paved motorways of Hungary, the pavements built with a roughened sand-asphalt modified Hot Rolled Asphalt wearing course proved to be a success. On this wearing course, ruts of about 10–15 mm depth developed only after 10-12 years of operation. However, the renewal of the agened wearing course of the sections built long ago has become an urgent task for today. On the sections where the aging process is not yet in an advanced stage, the building of a modified thin asphalt layer bonded by modified bitumen is considered to be a satisfactory and economical technique.

However, certain sections are in a more deteriorated condition where – in addition to the cracks of fatigue character in the asphalt layer, even reflection cracks of larger or smaller crack width have developed starting from the too rigid hydraulically bound base course. With the aim of selecting the most effective technology, or examining its future applicability, in 1988 experimental building was carried out on a section of Motorway M1 already badly deteriorated and cracked today, with the insertion of stress-absorbing membranes of different kinds. (On those different stress-absorbing membranes, everywhere modified asphalt of type SMA 0/8 was built in a thickness of 3 cm).

In the capacity of stress-absorbing membrane, the following variants were built in a length of 500 m each:

a) modified mastic of 5 mm thick with binder content of 35 vol% according to the technological recommendations of the firm VDW. A high-tensile strength geotextile fabrics of type TYPAR was applied on the hot mastic.
b) Geotextile fabrics of type TYPAR bonded by means of modified bitumen.
c) Modified mastic with crushed aggregate (modified mastic of 5 mm nominal thickness +15–18 kg/m^2 aggregate).
d) SAMI in one layer (3 kg/^{2} of modified bitumen +16–20 kg/^{2} of washed crushed aggregate of 8/12 mm)
e) SAMI in two layers
   - first layer: 2.5 kg/m^2 of modified bitumen +14 kg/m^2 of washed crushed aggregate of 8/12 mm,
   - second layer: 2.0 kg/m^2 of modified bitumen +10 kg/m^2 of washed crushed aggregate of 8/12 mm.

For both the production of the asphalt-type SMA 0/8, and the building of the stress-absorbing membranes, modified bitumens of VDW-pmB, or as an alternative solution, the home-produced ZALAPLAST-8 displaying similarly excellent cold-elongation and elastic recovery capacity was applied.

It should be noted here that on a further section, a pavement consisting of a bond-layer of 2.5 cm thick and a wearing course of type SMA 0/8 of 3 cm thick serving also for reinforcement purposes was also built subsequent to the sealing of the treatable joints with modified bitumen used for the production of the asphalt in both layers.

'Wheel Tracking Tests' were performed on the samples taken from each experimental section furnished with a different stress-absorbing membrane – with a total thickness of 8 cm including also the old pavement – in the Laboratory of the Department of Highway Engineering at the TUB. The principle of the examination is shown in *Fig. 3*.

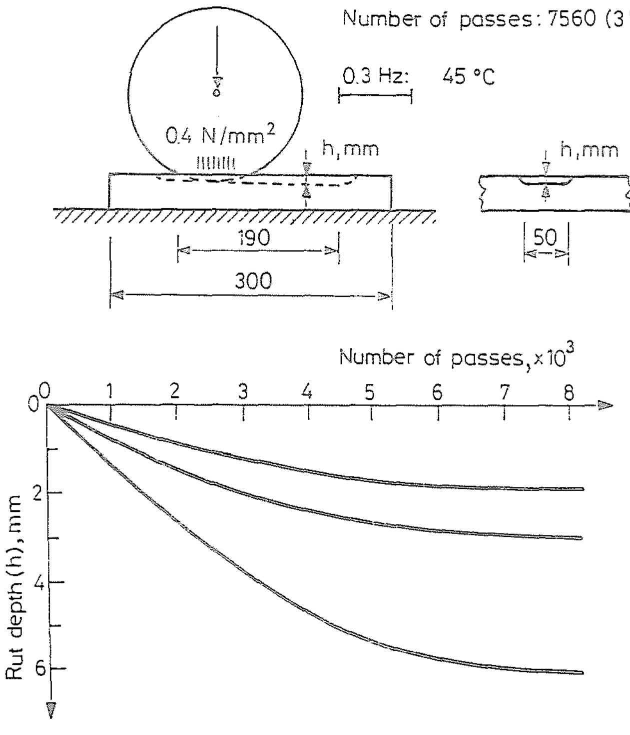

Fig. 3. Test of dynamic track formation at +45 °C on asphalt sample

On the basis of the characteristic parameters of '*the average rut depth*' obtained as a result of the examinations performed with 7560 passes under a load of 0.4 N/mm^2 and at a test temperature of 45 °C, it can be stated that according to expectations – the systems built with SAMI-type in one and two layers are more favourable with respect to the tendency to tracking as compared to the mastic variant *(Table 2)*.

Within the framework of pavement reconstruction, thin asphalt wearing course was built in a total length of about 50 km with the use of

Table 2
Results of the tracking test for the modified thin asphalt of type SMA 0/8 of 3 cm thickness built with the use of different stress-absorbing membranes (Motorway M1, 1988)

Type of stress-absorbing membrane built under the modified asphalt	Average depth of rut in mm, ($T = 45°$ C,) $P = 0.4$ N/mm^2; number of passes: 7560
modified mastic + TYPAR geotextile fabrics	3.67
geotextiles-fabrics TYPAR bonded with modified bitumen	0,99
crushed modified mastic	2.11
SAMI in one layer	1.00
SAMI in two layers	0.96

combination of SAMI in one layer on various asphalt pavement sections of motorways M1 and M3, thus prolonging the maintenance interval, as well as providing sufficient traffic safety and riding comfort.

The New Regulations for Asphalt Wearing Courses to be Built in this Layer

In this paper, so far the main characteristics of the thin asphalt layer technology used in the pavement reconstruction carried out on the motorways of Hungary have been described.

This year, an effective general regulation – Technical Specifications – have already been used related to the entire Hungarian highway network with the title: 'Asphalt wearing course to be built in thin layer thickness' [3]. According to this regulation, within the categories of 'heavy traffic' and 'very heavy traffic', two types of the modified asphalt – m-VRA-8 and m-VRA-12 – can be built in a thickness of 1.5–2.5 cm, or 2.0–3.5 cm, respectively.

To build up the mineral composition of the mixtures, in the capacity of mineral additives the following materials can be used: limestone-powder as mineral filler, crushed sand, as well as crushed aggregates of types: UKZ 2/5, UKZ 5/8 and UKZ 8/12 having first-grade mineral-physical parameters according to the Hungarian Standard. The grading limits of the two types of asphalt are shown in *Fig. 4*.

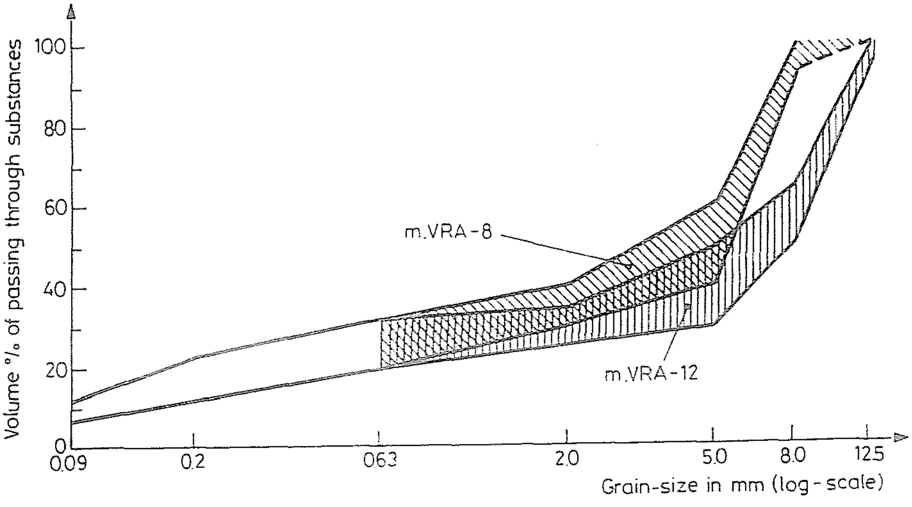

Fig. 4. Grading limits of the types of modified thin asphalt wearing surfaces on the basis of Hungarian specifications

For the production of asphalt-mix of type m-VRA-8 and m-VRA-12, bitumens modified with elastomer additives of types pmB-A and pmB-B can be used as specified in the Hungarian Standard [4]. (Difference between the modified bituminous products of type pmB-A and pmB-B consists practically in the required value of the low-temperature ductility and in the measure of the elastic recovery capacity).

Depending on the condition of the reception surface (depending, first of all, on aging process and not on the cracked character due to the inadequate load-carrying capacity), the thin asphalt wearing course can be built either by the insertion of a stress-distributing interlayer *(Fig. 5a)*, or – in case the reception-surface is not cracked – it can be bonded by spray-application of modified bituminous emulsion (*Fig. 5b).* In case a), to divert the danger of exudation, the rated voids content of the asphalt mix should be chosen for a higher value between 4.0-5.5 vol.%, while in the case of emulsion bonding (case b), the rated voids content should be determined between 2.0-4.0 vol.%. The voids content of the built-in layer should not exceed a threshold value of 7.0 vol.%.

According to this technical specification, the laboratory attitude test should cover the examination of the individual asphalt-mechanical parameters – warm deformation resistance and cold behaviour properties, too – on the basis of the examination method developed at the Department of

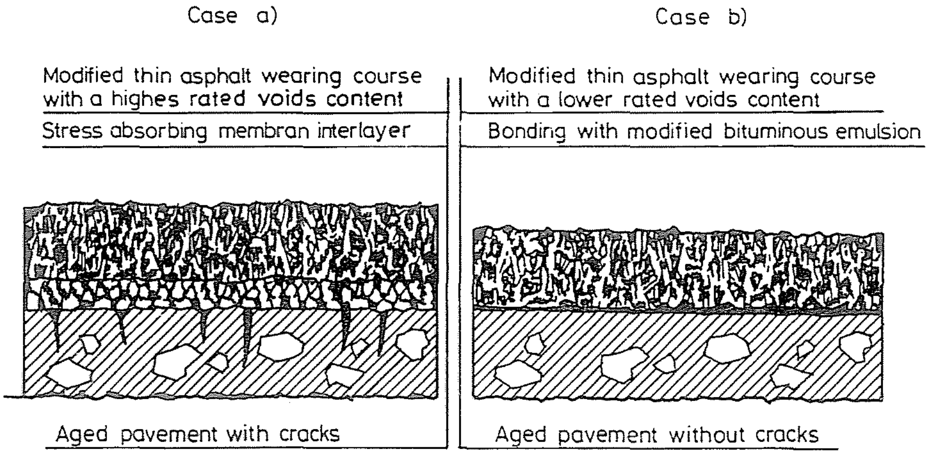

Fig. 5. Two methods for building modified thin asphalt wearing courses

Highway Engineering at the TUB [5]. The examination methods associated with the determination of warm deformation resistance were already described schematically in the foregoing.

The examination of the life of asphalt pavements shows that the shortest period is the so-called 'cold' temperature range, however, in most cases, the deterioration of pavements resulted from this range. In winter-time, the relaxation capacity of asphalt slows down, its crack sensitivity increases. The stresses arising thermally act against the tensile strength of asphalt, and as a consequence, it can bear the tensile load resulting from traffic only with a reduced capacity.

The examination method developed at our Department – and presently, too, being under development - provides information on the expectable winter-time behaviour of different kinds of asphalt with a comparative character. As a matter of fact, two kinds of examination are performed in the temperature range of +5 °C and −20 °C, on the basis of which conclusions are inferred on the crack sensitivity of asphalt.

a) Static splitting-tests

With the help of this test, the splitting tensile strength of asphalt (parameter δ_{Hh}: N(mm^2) and its modulus of splitting rigidity (parameter E_{Hh}: N(mm^2) are determined at three different temperatures: +5°C, −5°C and −20 °C. A polynomial regression of the second order is adapted on the pair of values associated with these three temperatures of parameters δ_{Hh}, and in this way, the temperature function of these two parameters are available. On the basis of a great number of test data, the result of which is illustrated in *Fig. 6* showing that the values of the temperature-dependent tensile strength and modulus of rigidity display deviating characteristics for the cases of normal and modified asphalts [6]. In the figure, it can be seen, on the eone hand that the modified asphalts of lower temperature have a greater tensile strength, while on the other hand, it is very favourable feature that at deeper temperatures their modulus of rigidity is essentially smaller in comparison to that of the normal asphalts. This latter observation holds mainly for the elastomer content. In *Fig. 7*, the temperature–dependence of the values of break–strain ε_{sz} calculated as the quotient of parameters δ/E is shown in the cases of asphalts of different type and composition – produced with normal and modified bitumens. In the figure, it can be seen that the break–strain of the modified asphalts has a favourable value greater by 2.5, 3.0 times below a temperature of -10 °C. The figure also shows that the ε_{sz} values of the asphalts of a very different composition and differing type produced with the use of traditional normal bitumens deviate from each other only to a slight extent at a temperature of -20°C. At the same time, it also can be seen that the break–strain of the asphalts produced with the use off modified bitumens can be influenced well also by the selection of their technological composition at low temperatures. The new Technical Specifications of modified thin asphalts require that the parameter ε_{sz} should have a greater value than 20 at a test–temperatur of 20 °C.

b) Measurement of the linear thermal expansion coefficient of asphalt:

To determine the crack sensitivity of asphalt, the knowledge of the values of thermal shrinkage coefficient α within the temperature range of $+5$ and -20°C is required. With this in mind, prism-shaped specimens of a size $40\times40 \times 320$ mm are formed of the asphalt to be examined by vibration so that their bulk density be identical with that of the Marshall specimen.

On both end planes of the prism a glass plate is sticked, and thereby a homogeneous flat surface will be formed for the contact points of the measuring devices. Within the test chamber, the temperature is (-30 and ±1)°C. On one of the dilatometers located here, the specimen will be positioned which supplies the continuous determination of temperature-fall through a proper transducer. The other specimen (to be measured) will the help of it, the change in length (shrinkage) of the specimen is measured by an electronic displacement-transducer *(Fig.8)*. Then a regression polynomial is adapted on the curve yielded from the pair of values of tem-

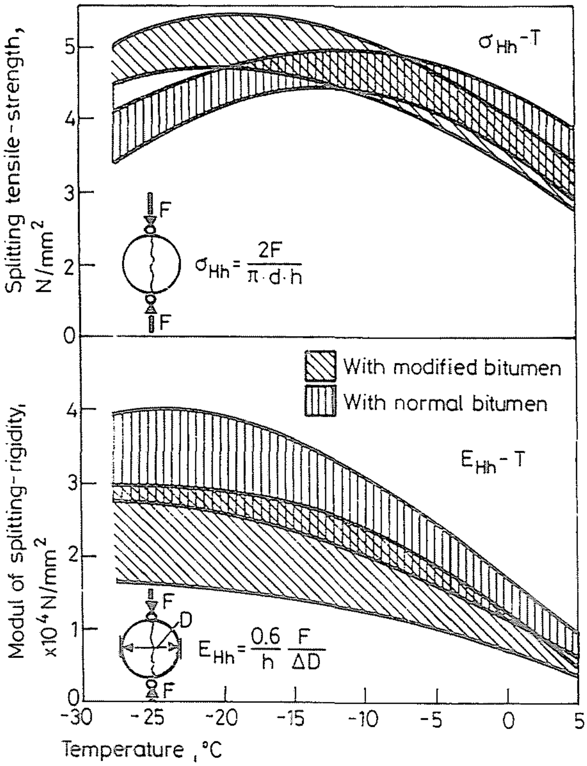

Fig. 6. Temperature - dependence of the splitting tensile strength and the modulus of splitting-rigidly in the case of normal and modified asphalts

perature differences $\Delta t°$C and shrinkages 1 mm, and then its constants will be determined. From this, the value-set of linear thermal shrinkage-coefficients $d = \Delta 1/1.\Delta t$ is yielded as a function of temperature within the temperature range between –5 and –20 °C.

The interpretation of the so-called fictitious cracking temperature $Rh°$C and the principle of its calculation method are shown in *Fig. 9.* It is assumed that the relaxation of asphalt is 100 % over –5 °C, while below it, it is 0 %, i.e. in the cold range the thermal stresses are accumulated in a measure of 100 %. On the basis of the examination described in the foregoing, temperature-dependent values of δ_{Hh}, E_{Hh} and α are known in the cold range. For each measured relation, one polynomial regression is calculated individually. Similarly, on the basis of the foregoing, the values of thermal tensile stresses δ_T are calculated as a function of temperature T. Then, the intersection point of curves δ_T and δ_{Hh} will be determined by the computer using iterative method of calculation. Since in this case,

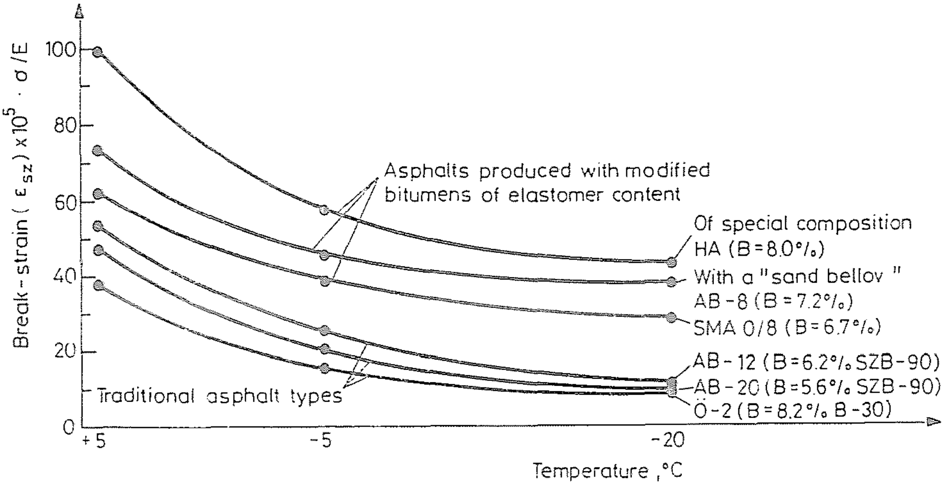

Fig. 7. Temperature - dependence of the break - strain in the case of different types of asphalt produced with normal and modified bitumens

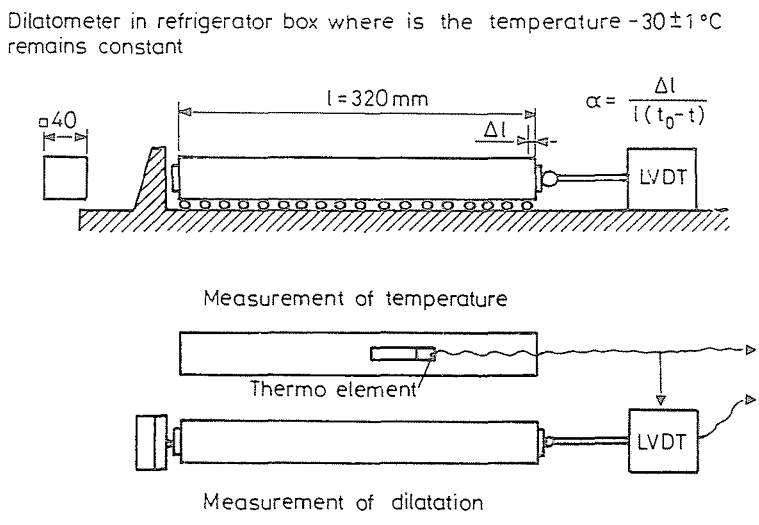

Fig. 8. Determination of the linear expansion coefficient of asphalt prism specimen

the magnitude of thermal tensile stresses measured in winter-time reaches, then exceeds that of the tensile-strength of asphalt valid only for that temperature; consequently, this is the value of 'fictitious cracking temperature Rh °C'.

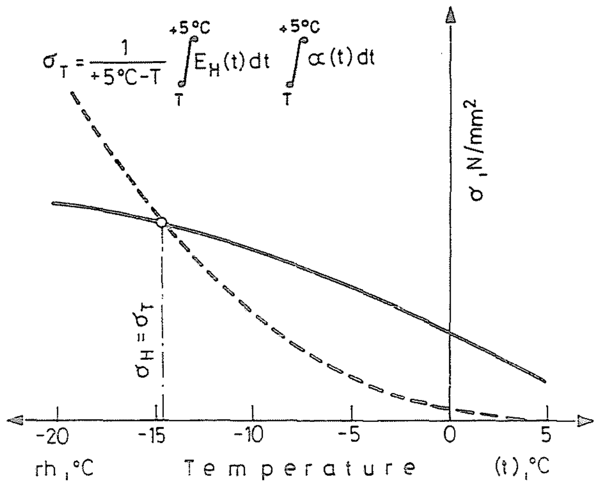

Fig. 9. Determination principle of fictitious cracking temperature Rh °C at asphalt.

With respect to road building and maintenance, it is more favourable if the value of the fictitious cracking temperature is as low as possible. On the basis of our experiences gained from the tests, our asphalts produced with the use of normal bitumens can be characterized by fictitious cracking values valid between –7 and $-12°$ C, while the modified asphalts are characterized by values valid between -10 and -18 °C. In the new technical specifications, values under $-12°$C are required for this parameter. In addition, it should be noted that recently the parameters determined by dynamic bending-test for fatigue performed at a low temperature are also evaluated with respect to cold behaviour properties. However, the description of the test procedure and the evaluation methods developed at our Department with respect to the fatigue properties of asphalts is beyond the reach of this paper.

Summary

According to the analyses, the thin asphalt techniques produced with the use of modified bitumens are economical for the reconstruction of our wear-

ing courses – in spite of the higher price of the modified bitumens. The more advantageous cost effect is due, first of all, to the omission of re-building the stopping lane and the drainage-system.

From the technological point of view, the thin-asphalt wearing courses can be used advantage in the following cases:

- for the preservation and renewal of the substance of aged wearing courses and road pavements,
- for the renewal of the smoothened surfaces of the wearing courses not rough enough any longer with respect to traffic safety,
- on sections at a specified height between elevated edges,
- for building a rough wearing course necessary to meet special requirements.

The mechanical test methods are able to disclose the advantageous-disadvantageous properties of asphalts, and provide possibility of drawing a comparison between the most different types of asphalt. The Department of Highway Engineering has contributed and continues to contribute to the new trend of qualitative development of asphalt technology by its asphalt-mechanical tests elaborated for the domestic application of modified bitumen techniques.

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