Quality change and structural damage of polymer-bitumen binders during road construction

M. N. PARTL, M. HUGENER, CH. RAAB

EMPA Department Road Engineering/Sealing Components

1. INTRODUCTION

Polymer-bitumens are applied extensively in pavements, joint sealings and sealing membranes to improve quality characteristics and durability of bituminous binders. In particular, they are used to reduce the risk of embrittlement and cracking in winter, to improve fatigue resistance under repetitive heavy traffic loads, to prevent permanent deformations in summer, to improve adhesion, and to increase resistance to ageing and water damage as well. Special polymers, such as thermoplastic elastomers like styrene-butadiene copolymer (SBS), mainly expand the practical temperature range of a bitumen, the so-called plasticity range. Polymer-bitumens allow new technical approaches, such as thin-layer road surfacing and porous asphalt pavements, and are often used for maintenance and repair jobs.

The extended use of polymer-bitumen has increased not only the number of commercially available products but also the potential for damage due to the insufficient knowledge of many users about composition, quality and application. This calls for better instruction and quality control as well as more practice-oriented research.

At EMPA major efforts have been undertaken in this direction using high pressure gel permeation chromatography (HP-GPC), a promising modern method for analysing most of the polymers used in bituminous binders in Switzerland. HP-GPC is a special form of liquid chromatography. The separation of the molecules of the sample substance is carried out in a solvent, by simple classification of the molecular sizes in a column packed with gel, similar to a sedimentation process with solid particles.

2. EXAMPLE OF AN INVESTIGATION

Most bituminous road constructions are still built using a hot paving process (Fig. 1). Hence, in practice, polymer-bitumen may sometimes be overheated during application, and the polymer damaged. This leads to a displacement of the molecular weight distribution of the polymer chains towards smaller molecules. This condition is shown clearly when HP-GPC results for the same SBS polymer-bitumen from pavement cores and from laboratory aged samples are compared.

Fig. 2 shows a section of chromatograms from cores of a damaged and a better preserved part of the same pavement, and of a laboratory mix sample. As far as the

Fig. 1 Hot paving process (EMPA Photo 101414/7).

Fig. 2 HP-GPC signals of polymer-bitumen extracted from cores of the same pavement and from the corresponding laboratory mix.

sample from the damaged pavement is concerned, the polymer peaks have merged with the bitumen peak, indicating that the large polymer molecules were reduced by overheating. In Fig. 3, the chromatograms of the original SBS polymer-bitumen are compared with laboratory aged samples. The sample after a rolling thin film oven test (RTFOT) at 180°C shows a substantially lower fraction of large polymer molecules than the sample after an RTFOT at 163°C, indicating that the former has aged more intensively. This is a clear indication that this polymer-bitumen is heat sensitive. Note that the

Fig. 3 HP-GPC signals of the same polymer-bitumen in the original state and after RTFOT at 163°C and 180°C.

laboratory mix binder generates almost the same signals as the original binder (uppermost curves in Figs 2 and 3) and that the binder after an RTFOT at 163°C (Fig. 3) compares well with the binder from the better preserved road sections (core #5 in Fig. 2). In reality, however, stronger ageing effects may also occur, as shown by the

curve of the damaged pavement. These results show that the structural damage to polymer-bitumens during application may indeed be simulated by laboratory ageing.

3. CONCLUSIONS

The results have shown that HP-GPC methods are superior to conventional test methods in the following points. (i) The molecular size distribution of the polymer-bitumen can be determined and used not only for the quality assurance of original polymer-bitumen but also for the detection of quality change and structural damage to the polymer-bitumen during road construction due to premature ageing, phase separation or excessive overheating. (ii) In production, the quality of the polymer-bitumen may be controlled more effectively, and faulty treatment of materials during application may be detected. (iii) The time consumption for analysis is comparable with conventional test methods, but conventional tests give no information on the changes in molecular distribution in a polymer-bitumen. (iv) Only a small amount of material is required for the analysis, which makes it extremely valuable for 'in field' long term performance research on the ageing of polymer-bitumens.

Characterization of emissions of volatile organic compounds from building materials

ROBERT GEHRIG

EMPA Department Air Pollution/Environmental Technology

1. INTRODUCTION

During the last few years, increasing public interest has been directed at indoor air quality and, in particular, at the problem of the emission of volatile organic compounds (VOC) from indoor building materials. Today, the construction of almost airtight rooms (for reasons of energy conservation) and the use of a variety of chemicals in the production of building materials represent a risk of elevated concentrations of indoor air pollutants. The characterization of emissions from building materials in normal rooms is extremely difficult, because the environmental conditions cannot be controlled properly and the pollutants analysed cannot be attributed easily to a specific source. In order to obtain well defined and reproducible information about VOC emissions from a specific building material, evaluation in test chambers under precisely controlled conditions is necessary. Test facilities and methods have been developed and implemented at the EMPA, within the scope of a project sponsored by the Swiss Federal

Office for Energy. The aims of this project are to

generate compound-specific data on the emissions of various indoor building materials on the Swiss market, provide emission data for the development and verification of models which can be used to predict indoor concentrations, and determine the effect of environmental variables such as temperature, humidity and air velocity on emission rates.

2. TEST METHOD AND RESULTS

The two test chambers used in this project have volumes of 200 l and 1 m³. All parts coming into contact with the air to be measured are of stainless steel. Temperature, humidity and air change rate can be controlled exactly. Fig. 1 provides a schematic view of the design of the 1 m³ test chamber. With the internal air recirculation system a defined laminar air velocity can be maintained in the test chamber. For the analysis of the emitted VOC,