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

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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,

Fig. 1 Schematic design of test chamber.

Fig. 2 Test chamber concentrations of decane emitted from a paint.

air samples are taken from the exhaust air of the chamber on Tenax traps and analysed with combined gas chromatography and mass spectrometry. As a direct result of the test chamber measurements, concentrations of VOC as a function of time are obtained. Fig. 2 shows a typical example. From the concentrations emission factors ($\text{mg emission m}^{-2} \text{h}^{-1}$) for the VOC detected can be calculated. These emission factors can then be used by architects or planners to compare different building materials with respect to their emissions, or to calculate VOC exposures which can be expected in a room.

3. ASSESSMENT OF RESULTS

The international harmonization of measurement procedures for emissions from building materials is already quite advanced, thus making it possible to use and compare results from different laboratories. Many more difficulties arise, however, with the assessment of these data. The question of what level of emissions is tolerable is extremely difficult to answer, due to a lack of knowledge about toxicity in the concentration ranges in question. In contrast to the situation in ambient air

or the air quality at work places, no generally agreed limits or guideline values are yet available. For certain types of building material (e.g., particle boards, carpets, paints) producers have agreed on a voluntary basis on standards to limit the emissions of their products.

Currently, a working group of the European Commission is working to elaborate criteria for the assessment of emission data from building materials making use of results from ongoing activities in several member states.

One-dimensional water transport in covercrete – application of non-destructive methods

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1. INTRODUCTION

The durability of concrete, especially the corrosion of reinforcing steel due to carbonation or the presence of chlorides or other depassivating substances, is a growing problem and has led to a great deal of investigation during the last few years. Gas permeability, gas exchange and the transport of halogenides depend strongly on the humidity distribution or humidity changes, especially in the outer layers of concrete (covercrete) where weather conditions have a large influence. Therefore the investigation of humidity distribution during suction and evaporation tests on samples with one moulded surface are appropriate. Measurement of mass changes is a simple method for detecting the total amount of water exchanged, but without further assumptions no conclusions about the moisture distribution within concrete can be derived. Often other methods like γ -ray absorption [1], conductivity measurements or microwave absorption are applied to this problem [2, 3], but insufficient spatial and signal resolutions, as well as secondary parameters such as solubility of ions lead to unsatisfactory results, especially if concrete containing aggregates of 32 mm is being studied. Therefore non-destructive tomographic methods like magnetic resonance imaging (MRI) and x-ray tomography are used to detect humidity distributions within concrete samples during suction tests.

2. MASS MEASUREMENTS

2.1 Sample preparation

The samples for the suction and water loss test were taken from 4 different walls [4] approximately 4 or 5 years after their production, so they can be considered as fully hydrated. The mix design is shown in Table 1. Through variation of water and cement content the cementstone volume, viz. the quantity and grain size distribution of aggregates with maximum grain size 32 mm, was kept constant. In a central region (avoiding boundary zones and vibration points) 60 cores ($d = 50$ mm, $l = 200$ mm = wall thickness) were taken. These were cut into lengths of 25 mm, 50 mm and

Table 1 Mix design

	Mix 1	Mix 2	Mix 3	Mix 4
Sand 0/4 mm	627	622	633	627 kg m ⁻³
Gravel 4/32 mm	1332	1322	1332	1332 kg m ⁻³
Cement OPC	294	258	230	230 kg m ⁻³
Water	147	129	158	138 kg m ⁻³
Ratio w/c	0.5	0.5	0.6	0.6
Air pore content	2.6	5	2.1	5.2 vol %
Bulk density	2401	2331	2399	2328 kg m ⁻³

100 mm. All samples had one moulded surface at one end. Each series was composed of five samples which were equal with respect to position and distance to the vibration points.

After a short intermediate storage in a laboratory room, the samples were stored at 20 °C and 35%, 70% and 90% RH until the beginning of the suction test (half of the samples stored at 35% RH were dried for 4 days at 50 °C). The storage time was 300–400 days, so that a uniform humidity distribution could be expected within the samples.

2.2 Suction test

2.2.1 Description of test procedure

For the suction test all samples had previously been sealed with an aluminium adhesive tape on all surfaces except the moulded surface. The tape could be applied without humidity changes. The influence of the sealing of the cut surface on water uptake was low; the water uptake through the other surfaces without sealing was considerable. Sealing with this tape guarantees one-dimensional water uptake with sufficient accuracy. Then the samples were put into closed boxes with the non-sealed surface 3 mm deep in water (20 °C). Periodically the samples were weighed. The first measurement was carried out after 15 min. After the last measurement, 14 days later, the aluminium tape was removed and the samples were stored under water for another 3 days and then weighed again.