THE USE OF FLUORESCENT MICROSCOPIC TECHNIQUES IN THE ASSESSMENT OF DAMAGE TO SEALING SYSTEMS OF BUILDINGS

SCHADENSANALYSEN AN BAUWERKSABDICHTUNGSSYSTEMEN MITTELS FLUORESZENZMIKROSKOPIE

APPLICATION DE LA MICROSCOPIE DE FLUORESCENCE A L´ANALYSE DES DOMMAGES DE SYSTEMES D'ETANCHEITE

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SUMMARY

Bitumen and polymerbitumen sheets are used in various forms in sealing systems for buildings. The material properties of the components are standardized to a large extent. The element combination, dimensioning and element adhesion of sealing systems however are only verbally described. The fluorescent microscope allows an assessment of the compound properties of sealing systems and thus an analysis of damage in sealing systems.

ZUSAMMENFASSUNG

Bitumen- und Polymerbitumenbahnen haben in der Bauwerksabdichtung einen sehr großen Anteil in den verschiedensten Abdichtungssystemen. Sie sind materialprüfungstechnisch zum großen Teil genormt. Hinsichtlich ihrer Ausstattung, Elementkombination, gegenseitigem Verbund und Dimensionierung aber nur beschreibend niedergelegt. Die Anwendung der Fluoreszenzmikroskopie ermöglicht es, Produktionskombinationen von Bahnen hinsichtlich ihrer Compoundeigenschaften zu bewerten und daraus auch Schadensanalysen an Abdichtungssystemen zu erstellen.

RESUME

Les chapes de bitume et de bitume-polymère sont utilisées sous diverses formes dans des systèmes d'étanchéité les plus variés. Les propriétés de matériau des composants sont standardisées dans une grande mesure. La combinaisons d'éléments, le dimensionnement et l'adhésion des éléments ne sont donnés que de façon descriptive. Par application de la microscopie de fluorescence, il est possible d'évaiuer les combinaisons de produits de chape et d'établir des analyses de dommages des systèmes d'étanchéité.

KEYWORDS
Bitumen/polymerbitumen sheets in watertight systems of building, fluorescence microscopical analysis.

1 INTRODUCTION

Building seals are membrane systems out of one or more layers of industrially produced sheets or coatings applied to the building with additional reinforcement built in during the application. Such sealing systems are used on the outside of buildings against ground water, precipitation and dampness when rooms in underground stories are endangered. Such sealing systems are also used extensively in tunnels, flat roofs, road bridges and in road underpasses. These membrane sealing systems are always required when the construction is permanently under water and the construction itself is no in a position to prevent water penetration.

The main market of sheets for sealing systems consists of factory products on a bitumen basis. During the last 30 years a diversified development of elements has taken place. This development was initiated by the increasing demands in specific fields which has lead to special products for certain applications. As a result new standards had to be developed in order to describe the materials and check delivery conditions.

These standards refer to the individual products as delivered and do not allow an evaluation of the sealing system. The reason is that , whether a single or multi-layer system is used , they are either welded or glued and the original delivery conditions cannot be checked. Furthermore the function of the system cannot be tested in-situ. It is essential to be able to check the individual products after installation as well as the workmanship in order to judge the effectiveness of the sealing system. A suitable method used in the medical world, one using the fluorescent microscope, presented itself as a possible solution. The use of this method for determining the effectiveness of building sealing systems will be demonstrated in the following using several test cases.

2 THE USE OF THE FLUORESCENT MICROSCOPE FOR THE STRUCTURE ANALYSIS OF BITUMEN SHEETS

The fluorescent microscope allows the structural build up of a material with several components to be made visible using the fact that there are fluorescent and non-fluorescent components present Thus it is possible to ascertain the structure of the products used and record them on either photographic prints or as video-copy prints. During the last 20 years polymer modifications have been used extensively to change the properties of and stabilize bitumen. The materials used are macro molecular chains of monomers which have fluorescent properties as opposed to bitumen which appears black. (2),(3).In the relevant literature the fluorescent microscope is used along with other microscopic methods for the structure analysis of polymer modified bitumen in road construction. In industrial bitumen applications polymer modification has a much wider use and the fluorescent microscope is used in the development of polymer modified bitumen for sealing products both by manufacturers as well as testing institutes. In the FMPA the fluorescent microscope analysis is used both in the quality control as well as research into the causes of damage in building sealing systems using polymer bitumen products and synthetic sheets.

3 APPARATUS FOR FLUORESCENT MICROSCOPE ANALYSIS AVAILABLE AT THE FMPA

3.1 Sample preparation

Microtome	Reichert-Jung 2035 Biocut Rotation microtome
Sample	0-0.06mm plane frozen with CO2 gas

3.2 Fluorescent Microscope

apparatus	Jenalumar- research microscope with power supply SH50
exit wave length	410 and 450 nm
magnification	20/40/80/160/320
ocular	6.3
Photo attachment	Pentax camera

3.3 Picture recording

Video-camera	Kappa colour TV camera CF 15 MC for microscopes with MCU computer interface
Controller	Kappa MFK multi-function controller for colour, brightness, measuring time and cross hair
Monitor	Sony KX-14CP1
Video copier	Video colour picture processor Mitsubishi CP100E
Colour picture copies	11x11cm. picture size 10x7.5cm

4 SEALING SYSTEMS WITH BITUMEN AND/OR POLYMERBITUMEN SHEETS

Polymerbitumen sheets are mainly used of the sealing of flat roofs of industrial production sheds (1) and for the sealing of bridge surface systems or similar surfaces in parking buildings. Flat roof sealing systems are mainly composed of 2 layers of bitumen or polymerbitumen sheets which are heat welded together. They are normally laid on an insulation layer and have a protective layer on the top surface, especially slate particles(4). Heavy surface protection layers in the form of gravel etc. are generally not used for weight reasons. On bridges and in parking buildings the sheets are used either as one or two layers with a protective layer of asphalt concrete or poured asphalt. The above mentioned sealing systems each have different specifications regarding the type and dimensioning of the bitumen or polymerbitumen sheets. The fluorescent microscope equipment in the FMPA allows the sheet components to be identified and the quality of the work in the individual sealing systems to be assessed.

5 EXAMPLES OF THE FIELDS OF APPLICATION OF DIFFERENT TYPES OF SHEETS (see sect. 1 and 4)

5.1 Polymerbitumen sheets with fibre glass fabric inclusion

The picture of the cross-section with a magnification of 20x shows the sealing sheet which can be used as a two layer composite sealing system for flat roofs or bridges. The fluorescent microscope analysis allows the elements of the sheet to be identified as well as the determination of their position, dimensions and joining.

The analysis gave the following results (from top to bottom)

- Covering bedded in the top layer
- Top coating; intensive and regular distribution of polymer/bitumen matrix
- Glass fibre woven reinforcement; staple threads cut, bitumen saturated, chain threads running through, sheet and bitumen securely attached to upper and lower layer
- Bottom coating; intensive and regular distribution of polymer/bitumen matrix, as in top coating
- bottom side; cover foil as transport protection

Dimensions (from top to bottom)

top coating	1.83mm
glass fibre reinforcement	
bitumen saturated	0.47mm
bottom coating	1.82mm
total thickness	4.12mm

Specific evaluation of the sheet:

The sample has the correct construction and corresponds to the specifications with regard to the position of the elements, connection and dimensions for the sealing applications mentioned above.

5.2 Polymerbitumen sheet with a polyester fibre fleece reinforcement in the upper position

The cross-section picture (fig.2) with a similar magnification to that in fig 1 shows a specially produced sealing sheet with a reinforcement in top position. This sheet is for single layer use on bridges and in parking buildings where a protective layer of poured asphalt is applied on top.

The picture analysis showed the following results

-top protection; talcum (checked by touch)

-upper reinforcement; polyester fibre fleece, completely saturated with polymer bitumen

-bottom coating; (adhesive layer); zone dependent distribution of polymer/bitumen matrix more intense at the bottom

Dimensions (from top to bottom)

top coating	0.0mm
reinforcement	
polymerbitumen saturated	1.05mm
bottom coating	
(adhesive layer)	3.55mm
Total thickness	4.60mm

Specific evaluation of the sheet:

The sample has the right element distribution, dimensions as well as good joining between the elements. There is however a mistake in the overall construction in that a top element, a top coating of 0.5mm is missing. This element is required to provide a good connection with the poured asphalt. in the sealing system.

5.3 Bitumen sheet with glass fibre fabric reinforcement and metal laminate (fig.3)

The cross-section picture with a similar magnification to figs. 1 and 2 shows a specially constructed sealing sheet for one layered sealing systems in bridges and parking buildings. This system also includes a poured asphalt layer above the sheet.

Picture analysis: (top to bottom)

- -Aluminium laminate, waffled (checked by touch)
- -top coating; unmodified bitumen with filler
- -reinforcement in the middle glass fibre fabric saturated with bitumen, layer firmly connected to top and bottom coating
- -bottom coating (adhesive layer); unmodified bitumen with filler
- -cover foil as transport protection

Dimensions (top to bottom);

Aluminium laminate	0.11mm
top coating	≤2.30mm
g. f. reinf., saturated	0.23mm
bottom coating	1.95mm
Total thickness	≤4.59mm

Specific evaluation of the sheet:

The sample has the correct construction, element distribution, element adhesion and dimensions as required in the type specifications for this particular sealing system.

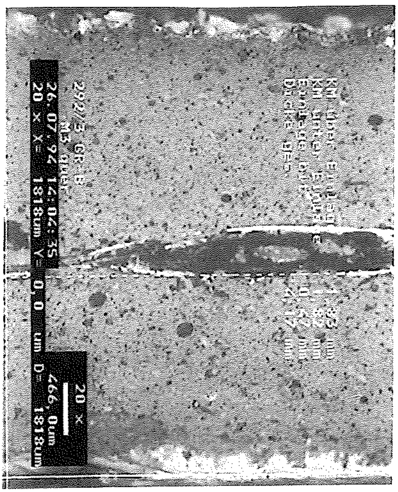

Fig. 1
Polymerbitumen sheet with reinforcement in the middle
(glass fibre fabric)

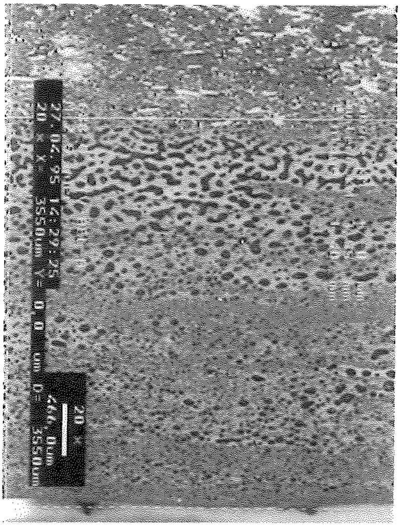

Fig.2
Polymerbitumen sheet with reinforcement
in top position
(polyester fibre fleece)

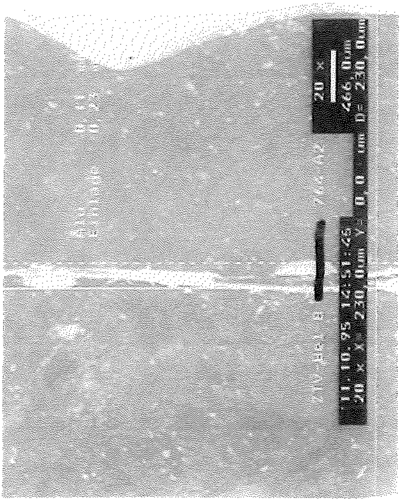

Fig. 3
Bitumen sheet unmodified with
reinforcement
in the middle and laminate on top surface
(fibre glass fabric)
(aluminium sheet)

6 EXAMPLES OF THE USE OF THE METHOD FOR DAMAGE ANALYSIS OF SEALING SYSTEMS

6.1 Polymerbitumen upper layer from a flat roof sealing system

In the considered case the top protective mineral layer in the form of slate particles on the outer skin of the sealing system had been most likely subject to shrinkage influences. The typical conditions for such damage to occur, such as an insufficient slope leading to encrustations and curling effect were not given. Viscosity test on samples from the top coating showed that the viscosity was relatively low. The damage caused was most likely of thermal origin. A fluorescent microscope investigation of a cross-section of the sheet in question (fig. 4) revealed the reasons why the top coating had relatively high flow properties.

- The upper polymerbitumen covering layer is relatively thin with a thickness of 0.3-0.6mm. The polymer/bitumen distribution is irregular and slate particles are embedded in this top coating. These facts are responsible for the high flow properties of this layer.

- The reinforcement underneath consists of unmodified bitumen and has a thickness of approx. 1.20mm. This relatively thick layer together with its low viscosity has a negative influence on the flow properties of the top coating.

- As a result of the low viscosity of the upper layer, climatic temperature drops due to for instance to cloud bursts cause shrinkage in this zone of the top coating and to the conglomeration of slate particles.

6.2 Bitumen upper layer from a flat roof sealing system (fig.5):

In this case the upper covering layer of the top sheet of a flat roof sealing system started to peel after a short time of about 2 years. Material tests showed that the upper layer consisted of a hard bitumen with filler. This fact explains the cracks in the upper layer but is not the reason for the peeling from the glass fibre fabric reinforcement. A fluorescent microscope analysis (fig. 5) showed that the glass fibre fabric was not saturated. Because of the low affinity of glass fibre to bitumen it is necessary to saturate the glass fibre reinforcement with bitumen during production. The fact that this was not given in this case is the cause of the damage.

6.3 Polymerbitumen sheet from a sealing system of a parking area (figs. 6-8):

In this case a poured asphalt protective layer was laid on the polymer bitumen sheet. During the laying , at temperatures of approx. 250°C, material from the top coating of the polymerbitumen sheet migrated upwards to the surface of the protective layer. In order to investigate the causes, reserve samples of the sheets were heated up to 220°C for 5 and 20 minutes. Fluorescent microscope analyses were carried out on cross-sections of these samples. The results are shown in figs. 6,7 and 8. It can be seen that as a result of the heating, the unmodified bitumen used for the saturation of the polyester fibre fleece penetrated (through) the 0.5 mm thick polymerbitumen top coating. The low viscous saturation mass in the fleece reinforcement becomes so liquid that it can penetrate into the poured asphalt protective layer.

The required resistance against penetration into the coating mass wasn't attained, due to an inappropriate choice of the saturation mass used in this type of sheet.

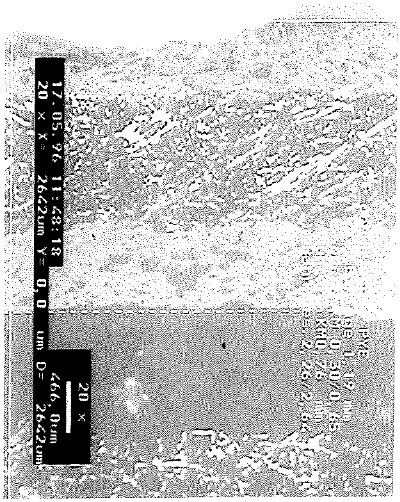

Fig.4
Polymerbitumen top layer sheet of a flat roof sealing system with irregular polymer bitumen distribution and low slate particle covering.

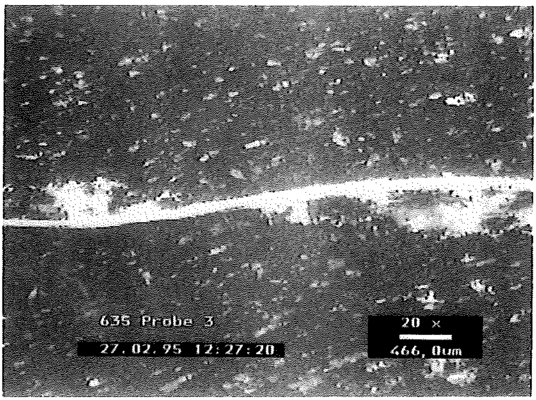

Fig.5
Bitumen top layer sheet of a flat roof sealing system with an unsaturated glass fibre fabric reinforcement.

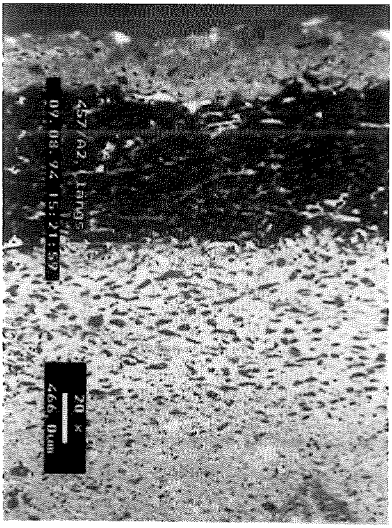

Fig.6
Polymerbitumen sheet,original state

Fig.7
Polymerbitumen sheet after heating for 5 mins. at 220°C

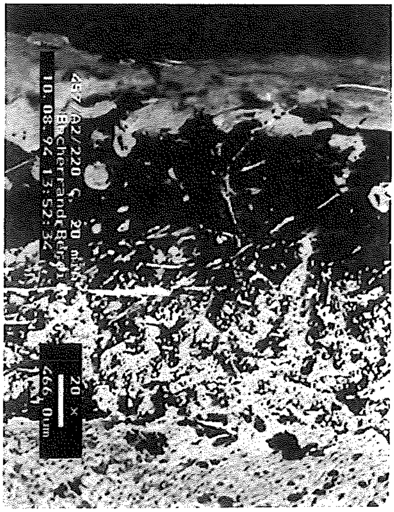

Fig.8
Polymerbitumen sheet after heating for 20 mins. at 220°C

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