BRIDGE DECK WATERPROOFING WITH BITUMEN SHEETS

Developments, Practical Efficiency, and European Standardization

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SUMMARY

A partnership comprising of the Technical University of Graz, the Spittal Technical College, the Department of Bridge Maintenance of the provincial government of Carinthia (Austria) and the company VILLAS Austria GmbH, are undertaking a project to examine the long-term behaviour and performance of bridge deck waterproofing systems.

The development of bridge deck waterproofing systems is outlined in relation to the German and, in particular, the Austrian market.

During rehabilitation of bridge decks, samples of the waterproofing systems were taken and examined for their characteristics. For investigation of waterproofing systems based on polymer bitumen sheets, samples had to be taken from bridge decks being in normal use. No bridge under rehabilitation was available for sampling of those products.

Test results demonstrate the improvements in quality of the waterproofing systems gained by the introduction of polymer bitumen sheets and by the use of epoxy resin for priming and sealing the concrete substructure.

One part of the project deals with European standardization of waterproofing materials for concrete bridge decks. Waterproofing systems are assessed with appropriately adapted test apparatus in accordance with draft European standards.

RÉSUMÉ

Avec les partenaires coopératifs (associés): l'Univesité Technique de Granz, L'école technique de Spittal, la section conservation de ponts du gouvernment régional et de VILLAS-Austria GmbH une épreuve á long térme des calfeutrage de ponts (systémes) a été effectué dans le cadre d'un project.

Le dévelopement des systémes de calfeutrage, en tenant compte du marché allemand et sourtout du marché autrichien est décrit.

Dans le cadre de l'assainissément des constructions de ponts (résistance á la charge) des échantillons ont été pris et les qualités ont été examinées.
Pour l'examen de l'état des systémes de calfeutrage avec voies(routes) de bitume polymére il était nécessaire de prendre les échantillons de ponts avec circulationet sans assainissement.

La qualité des systémes de calfeutrage a été amélioré avec les routes (voies) de bitume et avec le traitement de la couche de béton avec de la résine (Epoxid).
Dans un project futur à part, la norme européenne pour les calfeutrage de ponts en béton va être traitée.
Les systémes de calfeutrage ont été examinés selon les normes européennes avec des engins nécessaires et adaptés.

ZUSAMMENFASSUNG

Mit den Kooperationspartnern Technische Universität Graz, Fachhochschule Spittal, der Abteilung "Brückenerhaltung" der Kärntner Landesregierung und der Firma VILLAS Austria GmbH wurde im Rahmen eines Projektes die Langzeitbewährung von Brückenabdichtungssystemen untersucht.

Die Entwicklung von Brückenabdichtungen unter

Berücksichtigung des deutschen und insbesondere des österreichischen Marktes wird beschrieben.

Im Rahmen von Sanierungen von Brückentragwerken wurden Ausbauproben entnommen und auf Ihre Eigenschaften untersucht. Zur Untersuchung des Zustandes von Abdichtungssystemen mit Polymerbitumenbahnen mußten Proben von Brückentragwerken entnommen werden, die unter Verkehr standen und nicht einer Sanierung unterworfen waren.

Die Verbesserungen der Qualität der Abdichtungssysteme für Brückentragwerke durch die Einführung von Polymerbitumenbahnen sowie durch die Behandlung des Betonuntergrundes mit Epoxidharzen konnten nachgewiesen werden.

In einem Teilprojekt wird die Europäische Normung für die Abdichtung von Betonbrücken behandelt. Brückenabdichtungssysteme wurden nach europäischen Normenentwürfen mit den dafür erforderlichen, adaptierten Prüfgeräten untersucht.

SOMMARIO

L'Università Tecnica di Graz, la Scuola di Ingegneria di Spittal/Carinzia, la sezione di manutenzione di ponti del governo provinciale della Carinzia e l'impresa VILLAS Austria hanno eseguito in cooperazione un progetto di ricerca sulla preservazione di lunga durata di sistemi di impermeabilizzazione di ponti. La contribuzion descrive lo sviluppo di sistemi di impermeabilizzazione di ponti avendo riguardo del mercato della Germania e specialmente di quello dell'Austria.

Si sono prese delle prove sull'impermeabilizzazione di ponti che stavano in riparazione ed erano esaminate sulla qualità. Per esaminare lo stato di impermeabilizzazione usando guaine con bitume modificato con polimeri si è dovuto prendere le prove di ponti che erano trafficati e che non erano ancora in manutenzione. Si poteva verificare il miglioramento della qualità dei sistemi d'impermeabilizzazione di ponti con l'introduzione di guaine con bitume modificato ed in più con il trattamento della superficie del calcestruzzo con resine epossidiche.

Una parte speciale del progetto tratta della futura normalizzazione Europea e dell'influsso di questa sul campo dell'impermeabilizzazione di ponti di calcestruzzo. Diversi sistemi erano esaminati secondo quelle nuove norme Europee ed i risultati erano comparati con quelle usando le norme Austriache.

1. Why waterproof bridge decks ?

Water and de-icing salts damage the concrete structure. Rain water penetrates and leaches out calciumhydroxide and salts formed by chemical reaction of the calcium compounds of the cement paste. Porosity increases and the structure of the concrete is damaged.

Low compaction of the concrete and high water/cement ratio leads to permeable concrete. Water penetrates the concrete and repeated freezing and thawing causes the concrete structure to deteriorate. The presence of salt promotes moisture migration and delays drying out of the concrete.

Corrosion of steel reinforcements is caused by carbonation, chlorides and cracks. Carbonation lowers the pH-value which protects the steel against corrosion. Chloride attacks the steel especially at low thickness of the covering layer and presence of oxygen [1,2].

As a result there is a need to waterproof new bridges and bridge decks undergoing refurbishment.

2. Development of waterproofing systems

Austrian topography requires a large number of bridges necessary. The importance of waterproofing bridge decks has been well known since decades.

It is reported that before World War II natural asphalt was used in conjunction with lead foil to waterproof bridge decks. The protection layer was formed by 2 cm of cement concrete. The use of bitumen sheets started in the 50s. A double layer system was applied. The first layer was bonded by the "roll and pour method". Subsequently the second layer was applied by torching . The water-proofing system was protected by 4 cm of cement concete. This type of protection layer proved not to be resistant against de-icing salts. In the 60s cement concrete was replaced by asphalt protection layers [1].

2.1 Waterproofing systems with oxidized bitumen sheets

The systems may be classified by the type of asphalt protection layer.

2.1.1 System with asphalt concrete protection layer

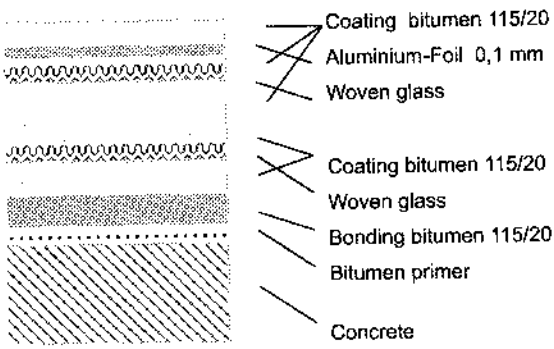


Figure 1: 2-layer system -oxidized bitumen sheets (asphalt concrete)

An aluminium foil, incorporated in the top layer, acts as a mechanical protection shield for the waterproofing system during installation of the sheets and during the application of the first asphalt layer. Both bitumen sheets are reinforced by woven glass carriers.

This waterproofing system formed the basis for specifications and technical guidelines of Austrian RVS 15.361 and German ZTV-BEL-B part 2 [3,4].

2.1.2 System with coarse aggregate mastic asphalt protection layer

Due to low void content coarse gravel mastic asphalt (gussasphalt) is considered to be waterproof. The waterproofing system consists of one layer of bitumen sheet and the gussasphalt.

Laying temperatures of the coarse aggregate mastic asphalt are in the range up to 250 °C.

The migration of coating bitumen from the sheet to the asphalt must be controlled by the application of self-adhering aluminium strips on-top of the overlaps at head and side of the individual sheets.

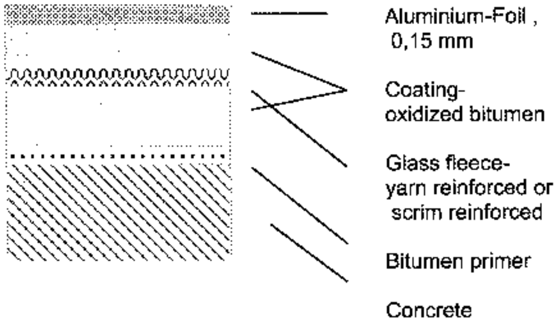


Figure 2: Single layer system - oxidized bitumen sheet (coarse gravel mastic asphalt)

2.2 Waterproofing systems with polymer bitumen sheets

2.2.1 Systems with asphalt concrete protection layer

In Austria polymer bitumen sheets were first installed on bridges in the beginning of the 80s.

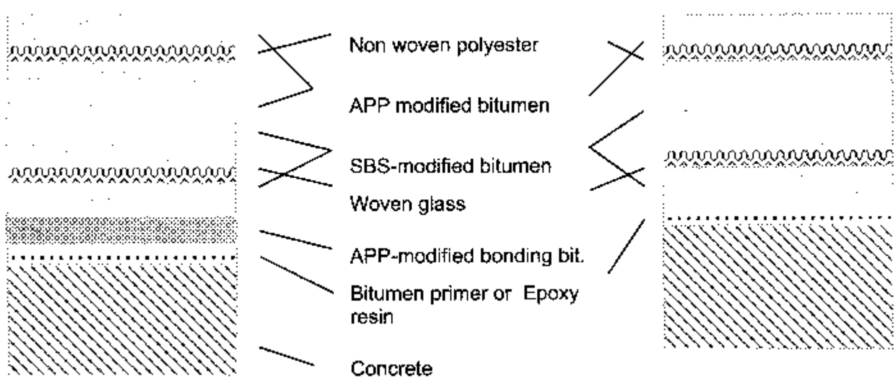


Figure 3: 2-layer system (asphalt concrete) polymer bitumen sheets
1st layer roll and pour method
2nd layer torching method

Figure 4: 2-layer waterproofing system (asphalt concrete) , polymer bitumen sheets, 1st and 2nd layer torched

The combination of an elastomeric bitumen sheet as bottom layer with a plastomeric bitumen sheet as top layer provides as main characteristics high crack bridging capability and high temperature resistance during the application of the asphalt protection layer. The waterproofing system is protected against mechanical damage by the polyester fleece positioned near the top of the upper layer.

2.2.2 System with coarse aggregate mastic asphalt protection layer

The system presented in figure 2 was developed into a system based on polymer bitumen sheets with APP- or SBS-modified coatings.The reinforcement is placed near the top of the cross section of the sheet [5].

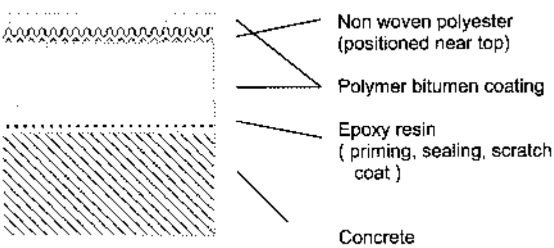


Figure 5: Single layer system (coarse aggregate mastic asphalt) polymer bitumen sheets

The ascending of polymer modified bitumen into the asphalt and to the surface of the asphalt is prevented by high viscosity of the coating and the asymmetric position of the non woven polyester near the top of the sheet.

2.3 Treatment of concrete surface with epoxy resin

The replacement of bitumen primer by epoxy resin led to a remarkable improvement of the waterproofing system [6]. Epoxy resins are used in single layer (priming) or in 2-layer application (priming and sealing). If concrete roughness exceeds 1.5 mm, a scratch coat consisting of an admixture of epoxy resin and quartz mineral is applied. For local depressions up to a maximum of 2 cm, a mortar of epoxy resin and quartz mineral , containing high content of quartz, is to be used [5].

Advantages of epoxy resin :

- reduction of water vapour transmission rate

- increase of bond strength between concrete and waterproofing system
- long term preservation of bond strength

The vapour barrier characteristic of epoxy resin avoids the formation of blisters and larger voids between concrete and waterproofing system. Blisters and voids are enlarged by solar radiation in summertime and at temperatures which prevail during the laying of the asphalt.

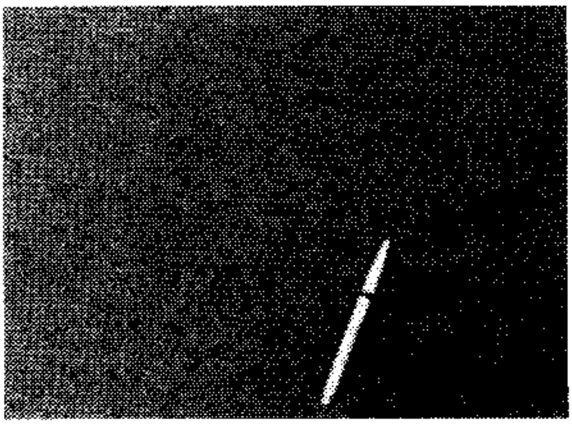


Figure 6: Pores in epoxy resin

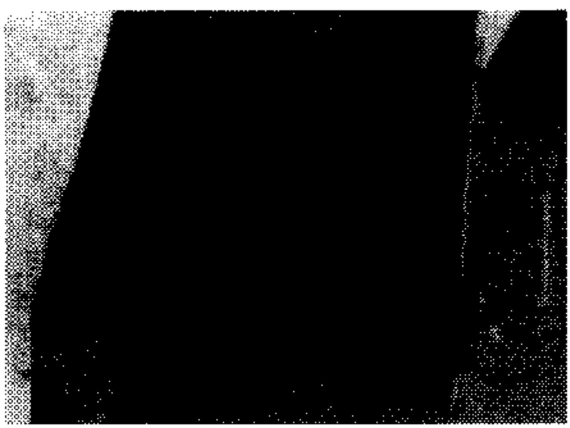


Figure 7: Blisters between sheet and resin treated concrete

When the concrete has a high moisture content, pores in the epoxy resin may be formed during the curing process of the resin. These pores may even penetrate priming coat and sealing coat at the same position. Under such conditions the application of resin when object temperatures are falling could help to avoid this phenomenon.

Some laboratory trials have been performed to investigate the influence of water to the bonding strenght of the waterproofing system. Figure 8 shows the influence of the type of primer for waterproofing systems with oxidized bitumen sheets applied either by roll and pour method, or by torching.

Concrete slabs with applied waterproofing system are dipped into a waterbath at 40 °C in such a way, that water wets the lower part of the concrete slab. The influence on bond strength of the waterproofing system is investigated. No reduction of bonding strength can be observed in the case of epoxy resin treatment of the concrete.

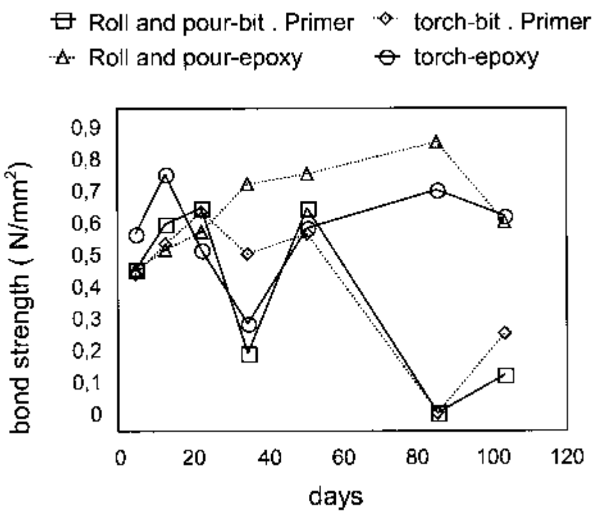


Figure 8: Bond stength after moisture loading from beneath

2.4 Application technology

The development of material quality was accompanied by the introduction of machine technology for the application of epoxy resin and bitumen sheets. Priming, sealing and scratch coating can be done by means of sophisticated laying equipment. Bitumen sheets are supplied in jumbo rolls and torched down by means of a special torching vehicle.

3. Asphalts

On bridge decks different types and combinations of asphalt layers are in use. Increasing traffic and axle loads along with climatic conditions and dynamic stresses require bitumen

Figure 9: Machine application of epoxy resin

Figure 10: Machine application of quartz sand

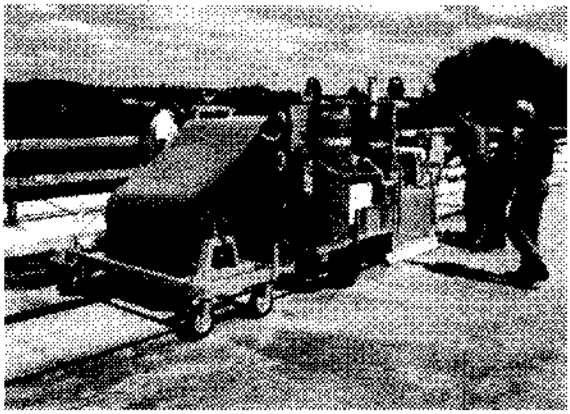


Figure 11: Torching vehicle for laying of jumbo rolls

binders with improved properties in respect of rutting, cracking, wear resistance and fatigue .These requirements can be fulfilled with polymer modified binders. For better deformation resistance, coarser mineral aggregate should be taken into account [7,8].

Protection layers:

The earliest waterproofing sheets had been protected by 2 cm of sand asphalt AB-4. Consequently this layer had functionally been replaced by an aluminium foil which was incorporated in the upper bitumen sheet. Highly temperature resistant sheets are required if coarse gravel mastic asphalt is used as a protection layer. These sheets should show no tendency of the coating to migrate into the asphalt and to the surface of the asphalt even at 250 °C. Figure 12 and 13 demonstrate the temperature between sheet and concrete and between sheet and asphalt, depending on time and asphalt type. With coarse aggregate mastic asphalt the temperature at the interphase of concrete and sheet rises to values beyond softening point of the bitumen coating. To avoid migration of coating into the asphalt a highly viscous polymer modified bitumen is required.

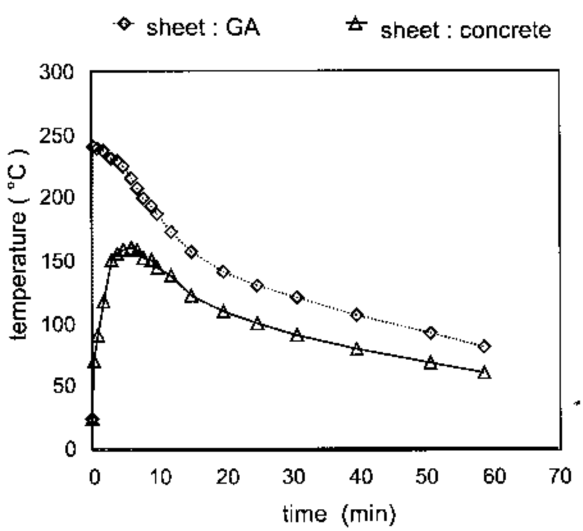


Figure 12: Temperature at interphase single layer system coarse aggregate mastic asphalt 250 °C

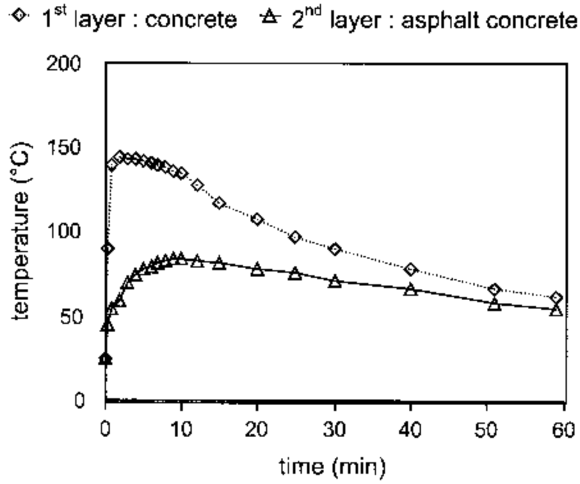


Figure 13: Temperature at interphase 2-layer system asphalt concrete 150 °C

Asphalt concrete is the prevailing type used for protection layer. Another option is the use of stone mastic asphalt, preferably produced with polymer modified binder and cellulose fiber. There are new concepts about the use of porous asphalt. If there is any water to be drained in the layer above the waterproofing membrane, porous asphalt could perform this task perfectly. Another concept considers the use of coarse graded asphalt base course material for protection layers. This leads to optimized deformation resistance of the asphalt construction [8].

Asphalt wearing courses:

All types of asphalts such as asphalt concrete, stone mastic asphalt, coarse aggregate mastic asphalt or porous asphalt are used for this purpose. The type selected depends on a variety of aspects. As for protection layers, polymer modified binders are to be specified for wearing courses equally. The required main characteristics are deformation resistance, resistance against cracking, and noise reduction.

On road bridges with heavy traffic, the minimum thickness of the asphalt construction is 12 cm.

Advantages of sufficient asphalt thickness:

- Deformation resistance
- Less static and dynamic loads in the area of the waterproofing sheets
- Less maximum temperature at interphase waterproofing / concrete
- Profiling in asphalt layers possible without reducing asphalt to non-acceptable thickness

Drainage:

Rain water must be drained at the surface of the asphalt and in the level of the waterproofing sheets . Drains must be integrated in such a way, that water can flow freely into the drain. The waterproofing system must be bonded to the drains with special care. The required minimum slope should be achieved during the construction of the concrete deck. This is to be prefered to profiling works within the asphalt layers. No gradient leads to ponding of rain water and the formation of ice in wintertime. As a consequence the asphalt construction is damaged (see figure 19, 21).

4. Long term performance

A partnership comprising of VILLAS Austria GmbH, the Technical University of Graz, the Spittal Technical College, the Department of Bridge Maintenance and the Asphalt Laboratory of the provincial government of Carinthia (Austria) are undertaking a project to examine the long-term efficiency and performance of bridge deck waterproofing systems.

A series of bridges were examined to assess the waterproofing systems. Bridges undergoing rehabilitation had been waterproofed with oxidized bitumen sheets according to figure 1. For the assessment of systems based on polymer bitumen sheets (see figure 3), no bridge under repair was available. Samples were taken from bridges in normal use..

4.1 Waterproofing system with oxidized bitumen sheets

As shown in table 1, the programme comprised 4 bridges with a waterproofing system according to RVS 15.361 (note: the new edition of RVS 15.361 will deal with epoxy resin for bridge decks).

Table 1: Bridge Data (oxidized bitumen sheets)

Road number		B 100	A 2	A 2	A 10
Bridge		Rennsteiner-brücke	Talbrücke Töschling	Hangbrücke Saag	Gasthofalmbrücke
Bridge number		1805	V 1	V 5	E 37
Year of construction		1966	1969	1970	1975
Traffic volume	JDTV	11 000	27 700	27 700	15 000
	JDTLV	700	2 500	2 500	1 200
Free span [m]		186.70	393.20	1581.60	436.00
Overall width [m]		11.00	13.85	13.85	16.00

This report concentrates on the description of the results for Hangbrücke Saag and Rennsteiner Brücke.

4.1.1 Hangbrücke Saag

Table 2: Construction layers on Hangbrücke Saag

old built up, constructed 1970			new built up, constructed 1998		
	thickness [cm]	material		thickness [cm]	material
wearing course	18.0	concrete	wearing course	20.0	concrete
protective course	3.0	AB 11	protective course	4.0	AB 11
waterproofing	1.0	RVS 15.361	waterproofing	1.0	RVS 15.362

After removal of the protective layer large areas of the waterproofing system had been available for sampling. The test results are reported in Table 4.

The waterproofing shows generally good adhesion properties to the concrete deck. In some adjacent areas good and poor adhesion was observable nearly at the same location. This seems to be due to cement laitance on the surface of the concrete and the effect of moisture content of the concrete at the time of application of the sheets (see figure 16,17).

Figure 14: Removal of concrete pavement

Figure 15: Removal of old waterproofing

Figure 16: Cement laitance on bottom side of waterproofing system

Figure 17: Blisters formed at the time of hot application of the waterproofing materials

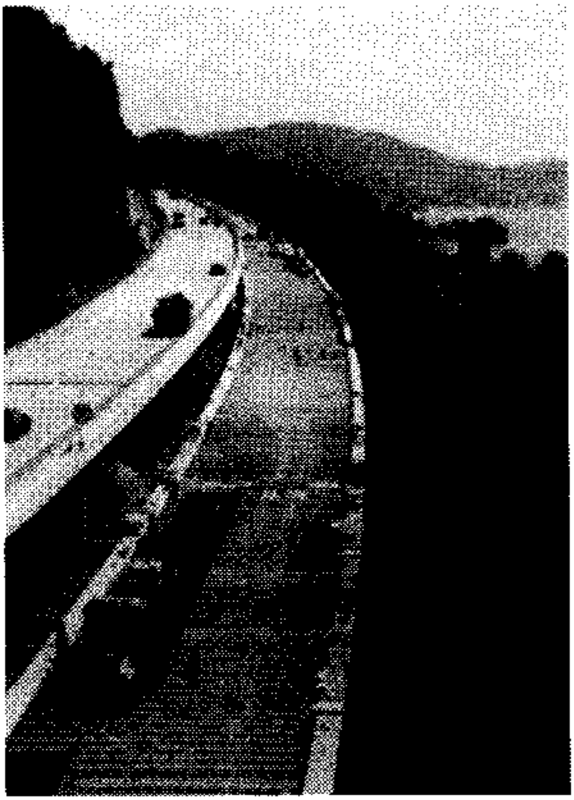


Figure 18: Application of asphalt concrete protection layer on waterproofing

The concrete of the bridge deck was repaired. After priming and sealing with epoxy resin, a new waterproofing system according to RVS 15.362 was installed. The 1st layer was bonded with polymer modified bitumen, the 2nd layer was applied by torching. The waterproofing was protected by 4 cm of asphalt concrete. Finally a concrete pavement was applied by means of finishers.

4.1.2 Rennsteiner Bridge

Table 3: Construction layers on Rennsteiner Bridge

old built up, constructed 1966			new built up, constructed 1998		
	thickness [cm]	material		thickness [cm]	material
wearing course	3.0	AB 11	wearing course	4.0	pm AB 11
protective course	3.0+3.0	AB 11	protective course	3.5+3.5	pm AB 11
waterproofing	1.0	RVS 15.361	waterproofing	1.0	RVS15.362

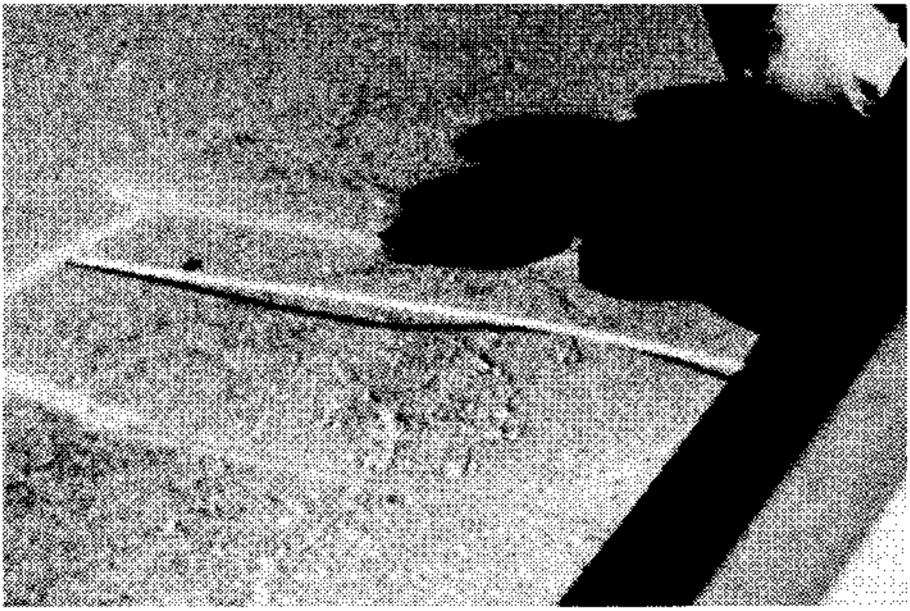


Figure 19: Cracking and rutting in asphalt

Figure 20: Cracking in asphalt layers at subsurface joint area

Figure 21: Accumulation of fine material matter below waterproofing

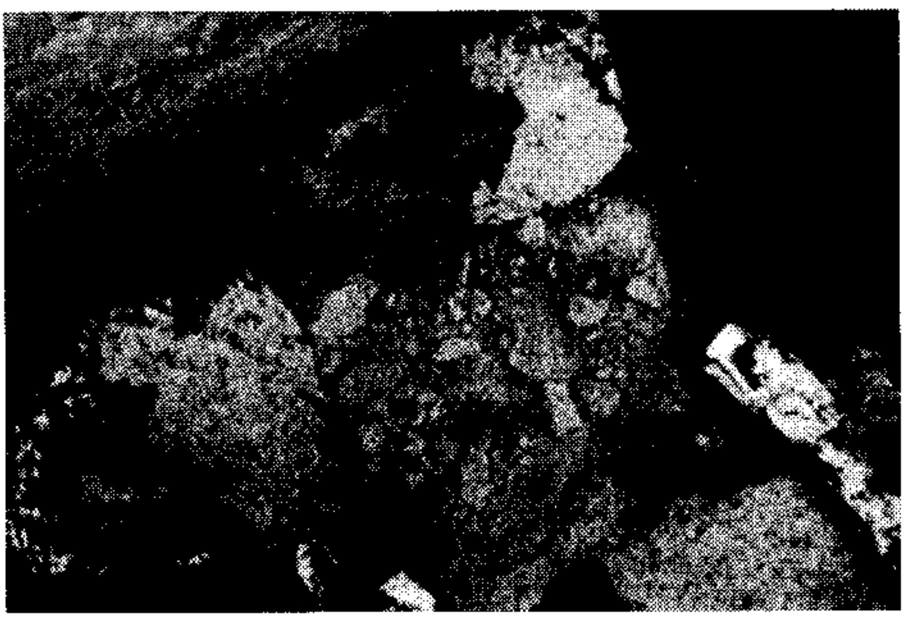


Figure 22: Disintergrated mortar below waterproofing

Table 4: Test results of waterproofing system with oxidized bitumen sheets

		requirements RVS 15.361	Hangbrücke Saag	Rennsteiner Brücke
Tensile test	Tensile strength, l/q N/5 cm	min 800/800	667/335	452/333
	Elongation, l/q %	min 2.0 / 2.0	4.8 / 2.4	3.0/2.5
Bonding bitumen	Softening point °C	min 100	117	137
	Fraass breaking point °C		0	5
	Penetration, 25°C mm/10		18	10
Coating of 1st layer	Softening point °C	min 100	124	114
	Fraass breaking point °C		-20	-11
	Penetration, 25°C mm/10		19	21
Coating 2nd layer	Softening point °C	min 100	127	122
	Fraass breaking point °C		-6	-6
	Penetration, 25°C mm/10		20	25

4.2 Waterproofing systems with polymer bitumen sheets

No bridge with polymer bitumen sheet based waterproofing was available. Smaller bridges, being in normal use, were selected for sampling.

Table 5: Bridge data (polymer bitumen sheets)

Road number/Bridge		B 98 Seebachbrücke	B 100 Lieserbrücke-	B 100 Weissenbachbrücke
Year of construction Year of rehabitation		1960/1984	1954/1988	1964/1990-91
Traffic volume	JDTV	11 000	27 700	15 000
	JDTLV	700	2 500	2 500
Free span [m]		43.0	41.2	6.8
Overall width [m]		9.9	10.4	9.7
Primer		Bitumen solution	Bitumen solution	Epoxy resin
Bonding bitumen (hot applied)		Oxidized bitumen 115/20	APP-Bitumen	APP-Bitumen
Waterproofing		RVS 15.362	RVS 15.362	RVS 15.362

4.2.1 Seebachbrücke

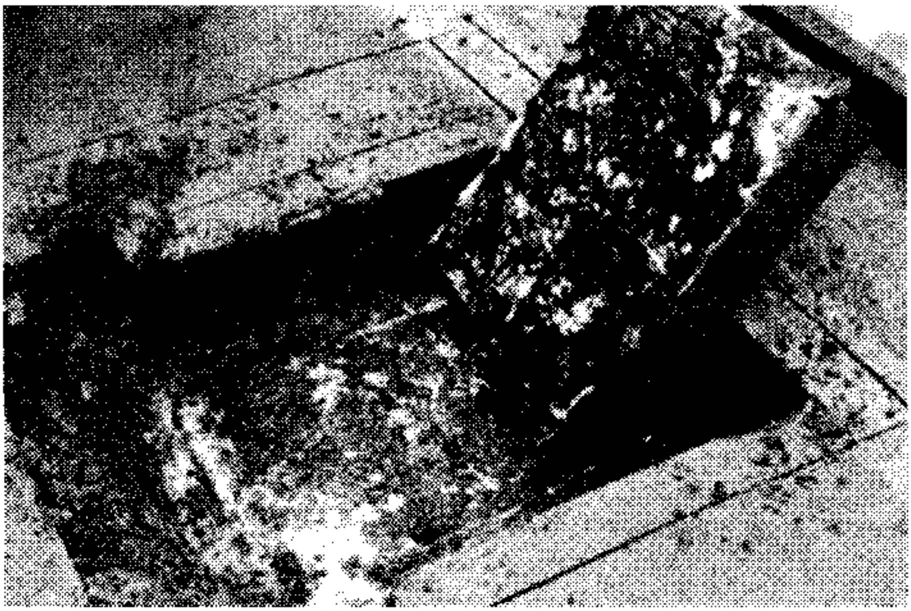


Figure 23 Seebachbrücke - Sample with adhereing concrete parts

At the time of introduction of polymer bitumen sheets on bridges bituminous primers had been used for treatment of the concrete substrate. The 1st layer was bonded by oxidized bitumen. This type of bitumen is sensitive to shock.

Figure 23 shows that the built up layers separated in the bonding bitumen area during sampling . It can be observed that parts of the concrete are adhering to the bottom side of the sample. Due to the separationwhich occured in the bonding bitumen layer there was no possibility to perform a tensile bond test.

4.2.2 Lieserbrücke Spittal

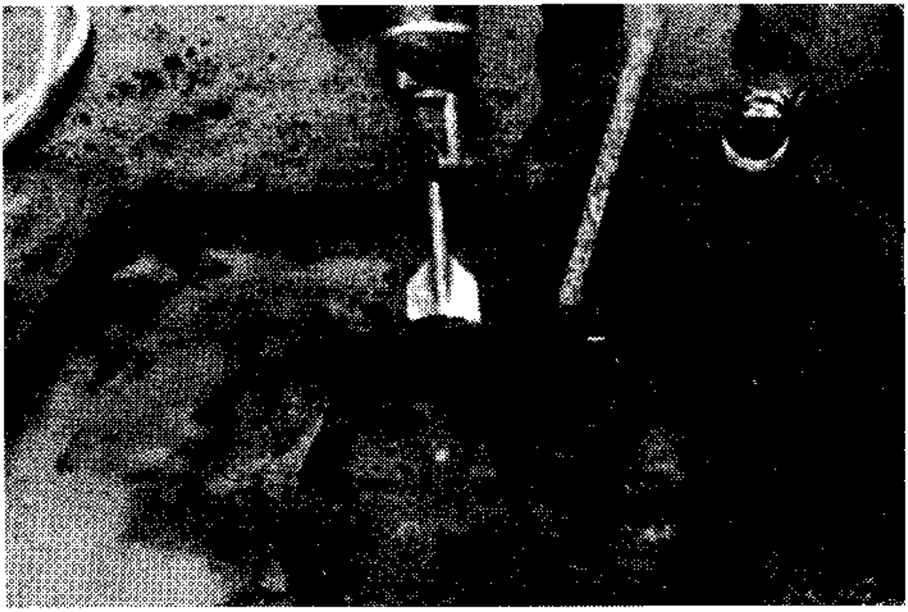


Figure: 24: Removal of waterproofing by means of a pick

Figure 25: testing of tensile bond after cooling to 0°C

The polymer modified hot bonding bitumen leads to a remarkably strong bond of the waterproofing to the concrete. The waterproofing could only be removed from the concrete by means of a pick (see figure 24). Tensile bond acc. to RVS 15.362 was 0.6 N/mm².

4.2.3 Weissenbach-Brücke:

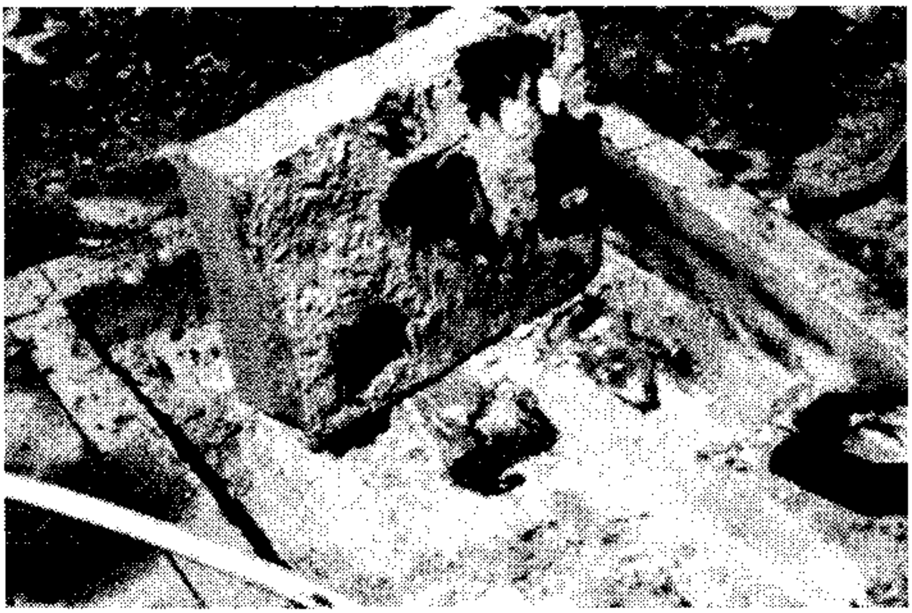


Figure 26: Weissenbachbrücke

The introduction of epoxy resin results in such a bond that at sampling action the separation took place deeply within the concrete. Figure 26 shows massive concrete parts on bottom side of the water-proofing.

Table 6 Test results- waterproofing system with polymer bitumen sheets

		B 98 Seebachbrücke	B 100 Lieserbrücke	B 100 Weißenbachbrücke
Bonding compound				
Type		oxidized bitumen	APP	APP
Softening point	°C	103	135	151,5
Penetration, 25 °C	mm/10	20	25	31
Fraass breaking point	°C	-10	-22	-20
Fluorescence micr.				
1st layer				
Reinforcement-type		woven glass	woven glass	woven glass
Mass per unit area	g/m2	211	214	221
Coating				
Type		SBS	SBS	SBS
Softening point	°C	126.5	109	123.5
Penetration, 25 °C	mm/10	20	23	15
Fraass breaking point	°C	< -30	<-30	< -30
Fluorescence micr.				
2nd layer				
Reinforcement-type		non woven polyester	non woven polyester	non woven polyester
Mass per unit area	g/m2	318	305	316
Coating				
Type		APP	APP	APP
Softening point	°C	150	150	152
Penetration, 25 °C	mm/10	30	35	29
Fraass breaking point	°C	-21	<-35	-28
Fluorescence micr.				

4.3 Conclusion

After years in service there seem to be minor changes in properties of bituminous waterproofing materials. Lower temperatures in the waterproofing area and lack of oxygen compared to conditions for waterproofing materials on roofs seem to contribute to this behaviour. The use of oxidized bitumen sheets was accompanied by non optimized pretreatment of the concrete deck. As a consequence variations in bond strength of the waterproofing system can be observed . The use of polymer modified hot bonding compound, polymer modified bitumen sheets and the pretreatment of the concrete deck with epoxy resin improved quality to the standard observed at bridges under investigation.

5. European Standardization

One part of the project deals with the impact of European Standardization on the national regulations. Tensile bond, shear resistance and crack bridging ability had been selected for special investigations. At the time of this report the complete series of tests is not yet finished. The results are reported for the waterproofing system with polymer bitumen sheets.

Table 7: European Standards - bitumen sheets for bridge deck waterproofing

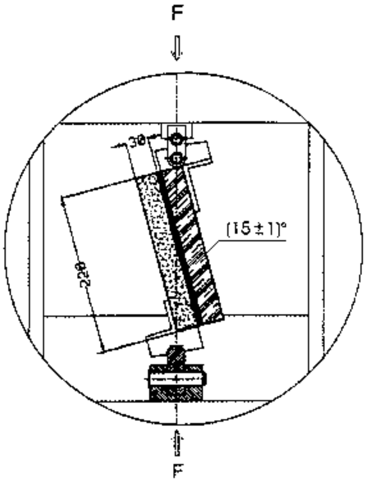
Sheet characteristics	**Performance related characteristics**
Visible defects	Specimen preparation
Dimensions, tolerances, mass per unit area	Bond strength
Water tightness	Shear strength
Initial amount of surface protection	Crack bridging ability
Tensile properties	Compatibility by heat ageing
Water absorption	Resistance to compaction of an overlay
Flexibility at low temperature	Behaviour of polymer bitumen sheets at application of coarse aggregate mastic asphalt
Flow properties at elevated temperatures	
Dimensional stability at elevated temperatures	
Long-term stability at elevated temperature	**Product standard**

5.1 Determination of shear strength

The European standard prEN 13 653 is here compared with Austrian RVS 15.361

Table 8: Shear strength – comparison of test parameters

	RVS 15.361	prEN 13653
Number of specimens	3	≥ 3
Dimension of specimens	250 x 250 mm^2	220 x 110 mm^2
Test temperature	(50±2)°C	(23±1)°C
Test angle	30°	15°
Deformation Stress rate	(50±3) mm/min	(10±1) mm/min



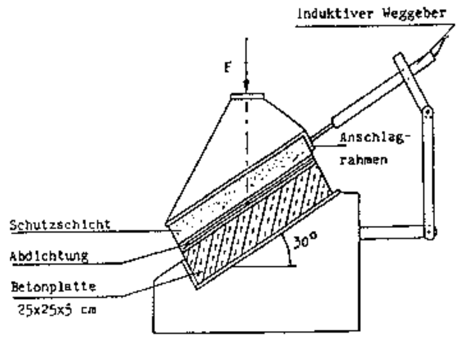


Figure 27: Shear strength - prEN 13 653

Figure 28: Shear strength - RVS15.361

Table 9: Shear strength – test results

		RVS 15.361				prEN 13 653				
specimen	T [°C]	dimensions [cm]		F_{max} [kN]	τ_{max} [N/mm²]	T[°C]	dimensions [cm]		F_{max} [kN]	τ_{max} [N/mm²]
1	50	25.00	24.80	12.290	0.0991	25	220.00	110.00	5.95	0.239
2		24.70	24.60	9.688	0.0797				6.69	0.276
3		24.70	24.60	11.390	0.0937				6.94	0.284
4									5.830	0.237

The testing according to RVS 15.361 is performed with the „Keildruck"-method [10]. The selected test temperature is 50 °C. This temperature is beyond the maximum temperatures which can be expected in the waterproofing layer of bridge decks during the hot season.

5.2 Bond strength

The test methods of Austrian RVS 15.362 and European prEN 13 596 are compared .

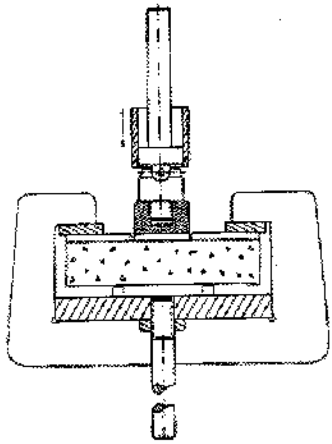


Figure 29: Test device acc. to pr EN 13 596

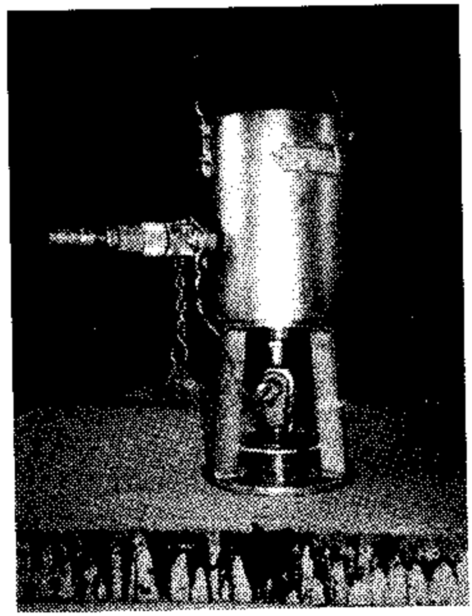


Figure 30: Test device acc. to RVS 15.362

Table 10: Bond strength - prEN 13 596

Specimen	T [°C]	Fmax [kN]	σmax [N/mm²]	separating layer
system - 100/100 mm - v = 1000 N/s				
1	RT	4.2	0.42	AB / EL
2		5.7	0.57	
3				
system - 100/100 mm - v = 1000 N/s				
1	RT	1.3	0.53	AB / BB
2		1.5	0.60	2. EL
3		2.0	0.79	AB
1st layer/concrete - 100/100 mm - v = 1000 N/s				
1	RT	5.3	0.53	Platte
2		8.7	0.87	Platte
3		3.7	0.37	GM
2nd layer/AB - 100/100 mm - v = 1000 N/s				
1	RT	2.4	0.24	BB / AB
2		3.6	0.36	AB
3		4.4		
AB...asphalt concrete, EL...reinforcement,			GM...bonding bitumen BB...bitumen sheet	

Table 11: Bond strength – RVS 15.362

Specimen	T [°C]	Fmax [kN]	σmax [N/mm²]	separating layer
1		1.40	0.70	
2	30	1.35	0.68	DM
3		1.35	0.68	
4		2.18	1.09	DM / EL
5	20	2.10	1.05	DM
6		2.00	1.00	
7		3.20	1.60	EL
8	10	2.95	1.48	
9		2.75	1.38	DM
10	0	4.00	2.00	EL /DM
11		4.00	2.00	EL
DM...coating,		EL...reinforcement		

The relation between bond strength and temperature is shown in table 11. In the meantime CEN TC 254 WG 6 changed test area to (50 mm x 50 mm) and stress rate to 0,15 N/mm².s .

5.3. Remarks

European standardization provides harmonized test methods and harmonized characterisation criteria for bridge deck waterproofing materials. It may be difficult to find simple relations between the existing national requirements and the draft versions of the European standards.The finding of close relationships should be regarded as important for bitumen sheet manufacturers, users and the national authorities. This project foresees further testing with different types of waterproofing systems [9].

6. References

[1] G.Möstl , Gestrata Journal 80 (April 1998), S 9-10

[2] H.Ingvarsson, Bo Westerberg, Operation and maintenance of bridges and other bearing structures, Sept.1986, page 11-26, ISBN 0282-8022

[3] RVS 15.361, Brückenabdichtungen, Abdichtungen mit