Performance of adhesive waterproofing as regards of lateral water filtration

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KEYWORDS

- Waterproofing
- Lateral filtration
- Underground structures
- Membrane system
- Watertightness
- Concrete structures
- Self-bonding layers

ABSTRACT

In order to simplify construction, to decrease the amount of special auxiliaries, to decrease the damages due to faults, to increase safety and to decrease the necessary space, material producers developed such waterproofing systems which can establish mechanical or chemical working together capability with in situ reinforced concrete load bearing structures. These technologies differ significantly from customary waterproofing in practice. They participate in water displacement not as a separate layer, but as the integral part of an underground civil engineering structure. As long as a waterproofing system functions properly, any type is appropriate. The difference becomes significant only, when due to a breach a fault of the waterproofing system occurs. Only from then on increases the importance of the type of the original system. During our studies we punctured deliberately new, adhesive waterproofing systems and for reference a customary membrane all of which were applied on concrete, hence tested their performance as a structure by concentrating mainly on lateral water filtration.

Introduction

Water infiltration plays an important role in damages of underground loadbearing structures. Hence a reliable waterproofing system to disclose water ingress under hydrostatic pressure is very important. Traditional bituminous membrane waterproofing may require an additional supporting/protecting wall and is known to have problems with lateral water filtration if the membrane is damaged, or not adequately weld-jointed. Under certain circumstances, capillaries or even gaps may form between concrete structures and waterproofing membranes. The result of these channels cause that within the protected structure water will emerge at a different location from where the membrane is punctured. Due to the injury a water layer will spread and at the weakest point of the protected structure the moisture will enter the building, and this

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location will rarely coincide with the place of failure. Such water movement is known as lateral (sideward) water filtration or seepage. Lateral filtration is a serious issue since localising and finding the cause of water ingress is difficult. It could be a good distance away from the visible appearance of water on the internal side of the protected structure. Repair of such damaged waterproofing is extremely time and cost consuming, for it might be several meters underground, or under a thick layer of concrete.

A new generation of adhesively bonding waterproofing membranes emerged in the last couple of years which claim to stop lateral water filtration even when the membrane is damaged. We found no literature regarding capacity testing of these systems except of the technical specifications of the manufacturers. According to the manufacturers, due to the working together capability, adhesive waterproofing systems have the capability to oppose lateral water seepage, but the magnitude of this filtration resistance is hardly known. The different properties of the materials are usually given by the manufacturers. They are based on non-independent self-measurements. A list of standard test results is offered as the technical parameters of a given material. On the contrary the adhesion is established between two materials (concrete and the membrane). There is no general application technology or guideline developed regarding these new systems. During construction, presently the manufacturer’s instructions are the only directives one may rely on during construction. Regarding adhesion or working-together capability of such waterproofing systems, only the measurement of mechanical adhesion is regulated (ÚT 2-3.406:2000 Annex: M1.).

The examined materials are tested by the manufacturers for more or less the same standards (ASTM D 903, ASTM D 5296, ASTM D 5386, EN 1928:2000, MSZ 93-12:1987, DIN 18195/9-c). These sealants are tested regardless their application, like for example for tensile strength, resistance against mechanical effects or water tightness. In case of the materials used for underground structures further declared performances are mentioned, like radon or methane permeability. Although these materials are being used for the same reason – protection against hydrostatic pressure -, their application are different. That is why there are many different kind of standards against which they are being tested.

The most important testing methods from the point of our investigation are those which are targeting the water permeability and the adhesion of the membranes to concrete. Not in case of all systems is given the standard method regarding adhesion test, while for hydrostastical pressure ASTM D 5385 offers the regulation. Furtherly, as a base to our investigated questions we took into consideration the DIN18195/9-c directives regarding sprayed bituminous seals. It is important to mention that the standards in case of bentonite based blanket felts are significantly different from others. The standard tests give appropriate results for harmless, well applied waterproofing membranes. What we wanted to test is the situation, when the sealant is punctured. For this, the test regarding watertight concrete was chosen (EN 12390-8), since standard test or guidance for lateral water seepage has not yet been worked out.

The main application field of adhesive type waterproofing systems are structures with increased need of safety or which can be hardly or not at all accessed. Generally, such are the slurry walls, drilled pile foundations, sheet piles, underground structures, tunnels and foundation slabs. Since the host interface for the waterproofing layer is offered by the structure itself, the membrane is able to undertake better those stresses, which are arising from the movements of its carrying structure. The application of the waterproofing layer does not require the construction of any auxiliary structure and as such at hardly accessible locations where space is limited the usage can be remunerative.

The aim of our research is to explore the differences in the lateral moisture movement of the waterproofing systems due to material structure properties, and to recognize what kind of processes, material property specificities are the influencing factors of the differences in

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performance if any. Hence the necessity of this guiding study across a certain range of these products seemed to be inevitable.

**The tested waterproofing systems and their properties**

**Preprufe® the Pre-Applied Waterproofing Membrane System**

Preprufe® water sealing felts are cold installed, at the strip edges self-adhesive membranes, consisting of several layers. They incorporate a resilient, High Density Polyethylene (HDPE) layer, an easily activating compression sensitive reagent layer and a walkable microporous protective layer against weather. The reagent activates due to the complex effect of pressure, water and the pH value of concrete. The membranes develop a continuous adhesive bond to concrete poured against it. This forms micro-compartments to prevent water migration between the structure and the membrane, substantially reducing the risk of leaks. To apply the material, no dry surface is necessary, may be applied till -10 °C ambient temperature and it can resist a hydrostatic head of more than 70 m.

![Diagram of Preprufe® membrane application](http://www.preprufe.com/about-preprufe/)

Fig. 1 Application of a Pre-applied waterproofing system (source: http://www.preprufe.com/about-preprufe/)

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SikaProof® the Fully Bonded Sheet Membrane system

SikaProof® A is a fully and permanently bonded, self-adhesive, composite sheet membrane waterproofing system for RC structures. It consists of an embossed flexible polyolefin (FPO) based membrane which is laminated with a sealant grid and a non-woven fleece. Adheres with fresh concrete, forming a strong mechanical connection. Against water seepage it offers a permanent protection due to the full mechanical contact with concrete. In case of a possible injury of the membrane, water will filtrate between the layers of the waterproofing felt, due to what the material of the sealant grid will swollen which blocks lateral water seepage. This action is favourable when localizing the failure location, which may be repaired much more easily. SikaProof® A is cold-and pre-applied, as it is installed without heat or open-flames, before the steel reinforcement is fixed and the concrete is poured. The membrane is highly resilient and able to bridge over cracks.

From our point of view, the common in the first two waterproofing system is their surface to be able to fully bond to freshly poured concrete, being a kind of plastic membrane which is supplied in rolls, and when the sheets are unrolled, the overlapping is self-adhesive. In a way they are similar to traditional bituminous felts, except that they are cold laid and the bond between concrete and the membrane is developing sort of automatically. The last property eliminates the installers inadequate relevant workmanship of the full bonding necessity to eliminate lateral water seepage. The next described system differs from the first two in the sense of that, it becomes waterproof when gets into contact with moisture or water, and it is rather a blanket than a membrane.

![Fig. 2 The layers in SikaProof fully bonded sheet membrane (source: http://nzl.sika.com/en/solutions_products/construction-markets/sika-waterproofing-solutions/02a015/02a015sa01/02a015sa01ssa03.html)](source: http://nzl.sika.com/en/solutions_products/construction-markets/sika-waterproofing-solutions/02a015/02a015sa01/02a015sa01ssa03.html)
**VOLTEX® Self-bonding, bentonite geotextile waterproofing system**

VOLTEX® is a highly effective waterproofing composite of high strength geotextile and sodium bentonite. The high swelling, low permeable sodium bentonite is encapsulated between a non-woven and woven geotextile. A patented needle-punch process interlocks the geotextiles, forming an extremely strong composite that maintains the uniform coverage of bentonite, as well as protecting it from inclement weather and construction related damage. When the application of this kind of felt has appeared, such kind of a sealant was invented, which could be laid as a sheet (blanket), but acts like mass waterproofing. In such a way it combines the white and black water-keeping material category (Weiße Wanne, Schwarze Wanne) and also the brown category (Braune Wanne) according to the German terminology. The blanket is produced out of environment friendly materials and technology. When wetted, unconfined bentonite can swell up to 15 times its dry volume. When confined under pressure the swell is controlled, forming a dense, impervious waterproofing layer. The swelling action of VOLTEX® can self-seal small concrete cracks caused by ground settlement, concrete shrinkage, or seismic action; problems over which there is normally no control. VOLTEX® forms a strong mechanical bond to concrete when the geotextile fibres are encapsulated into the surface of poured-in-place concrete. Due to the expanding capabilities of bentonite, smaller injuries are sort of self-healing. Bentonite without fatigue is able to withstand for a long period of time the alternation in drying and moistening and water pressure.

![Fig. 3 The layers in Voltex fully bonded sheet](source: http://www.cetco.co.uk/Portals/0/02_PDFs/PM_VOLTEX_EMEA EN 201605 V6.pdf)

**MC Expert Proof eco, flexible and bituminous-free, two-component waterproofing**

MC Expert Proof eco is a Fast hardening, flexible and bituminous-free, economical two-component waterproofing coat. After homogenising the liquid and the powder component by a low speed mixer it can be applied to all mineral substrates ether by spraying by trowelling or by brushing. Due to the properties of the silicate crystals on the coat surface and its chemical composition, it is able to work together in a continuous surface with the poured on concrete. The biggest advantage of sprayed technology is that, an even and homogenous layer may be produced, time saving and no overlapping is formed. The coat can work together with the structure as a homogenous envelop.

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Villas (now Icopal) E-G 4 F/K modified bituminous membrane

As a control, regarding of lateral water seepage we tested the behaviour of an in Hungary common, most widely used bituminous waterproofing felt, which is “Villas E-G 4 F/K” thick bituminous felt. In the name of the felt the meaning of E is: the applied bitumen is elastomer-modified; G stands for: glass fibre fabric carrying layer; 4 is the thickness in mm; F indicates a polypropylene foil lamination; and finally K means that the top surface is quartz sanded. Due to the technology of application (gluing 100% of the surface by flame melting of bitumen) has a certain resistance against lateral water seepage. Since the adhesive layer is manmade on the construction site, this resistance may greatly depend on the quality of workmanship.

At first look the investigated sealing materials are very different, and are categorized differently by the conventional classifying systems. Despite the differences in their material,
structure, application technology, from the point of our investigation they represent well their category. This enabled us to compare these categories that is the groups of waterproofing materials instead of testing uncountable systems from lateral water seepage point of view.

The phenomenon of lateral water movement is known since long, and there were made attempts to prevent it. Some of the waterproofing membranes, which are able to work together with the structures are new materials. For increased safety, these membranes are used in combination with watertight concrete, the properties of which are described in countless places. Our aim was finding the factors leading to certain construction faults, while aiding designers in correct material choosing.

The study of Zhou and Xu (2009) was dealing with the necessity of waterproofing in case of bridges, and the need of its adhesion to concrete. The most important fault is described as the corrosion of the steel structures due to water penetration, which significantly lowers the service time period of a bridge. Several delicate circumstances are incorporated, so an extremely trustable waterproofing layer is necessary. By the researchers three different bituminous waterproofing materials – APP modified, self-adhesive rubber and liquid polymer modified – treatments were tested under different temperature, structural, material structure and usage conditions. As a result of the study they stated that the adhesion failure may occur in three ways: the connection fault due to particles or dust, the cohesion mistake of the carrying layer of the bituminous felt or mortar cohesion fault. The most critical factor is the adhesion strength. The roughness of the surface plays a great role in such performance, so its texture is to be designed and prepared. Critical role is played by the temperature of the compressed bitumen in the bonding. The study realized the importance of the adhesion between concrete and the waterproofing layer and approached it from the point of adhesion strength. When adhesion ceases and through breach of any nature on the sealant water ingresses between concrete and the sealant, lateral water filtration occurs.

In a study considering shotcrete withstanding waterproofing is stated that between others VOLTEX® membranes are felts, which are so strong that they may not get harmed due to the mechanical attack of shotcrete. Shotcrete is used since 100 years in Western United States and is popular for civil engineering structures all over the world. In the past decade, its application is living its renaissance, and the usage has increased. The paper analyses most of the problems which may arise when shotcrete is applied on a waterproofing membrane.

Materials and testing methods

Four different bonding waterproofing systems and a bituminous flame melting-bonding felt were used, as detailed in point 2. Plain, unprotected concrete watertightness test (MSZ EN 12390-8) served as reference to get information regarding the concretes water permeability. Two concrete mixes were designed. A normal structural concrete (C25/30) and one having higher compressive strength (C45/55), which was expected to be more watertight. The idea was that the higher strength concrete has lower permeability and the easier route for water filtration would be rather lateral, between the waterproofing membrane and the concretes surface, than in concrete, just below its surface.

During the tests we used standard cubic concrete specimens according to the standard (MSZ EN 12390-8) with an edge length of 150 mm. For casting the specimens, we used steel moulds. With the exception of the bituminous felt, we cut the waterproofing sheets to squares with sizes of 150x150 mm, and smoothened them into the bottom of the moulds prior to concreting. MC Expert Proof eco was brush applied on a carrying felt out of geotextile and the necessarily sized sealing membranes were tailored after the coat on the felt has dried. By using each of the adhesive waterproofing systems 2-2 specimens were produced. Out of each concrete strength class 4-4 unsealed specimens were produced, 2-2 for the bituminous felt post
waterproofing and 2-2 for the 28 days mean compressive strength determination. The sample matrix is given in the next table (Table 1.).

<table>
<thead>
<tr>
<th>Concrete class</th>
<th>MC Expert Proof eco</th>
<th>SikaProof® A</th>
<th>Preprufe® 300 R</th>
<th>VOLTEX®</th>
<th>Bituminous felt</th>
<th>None, for comp. str.</th>
</tr>
</thead>
<tbody>
<tr>
<td>C25/30</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
</tr>
<tr>
<td>C45/55</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
<td>2 pieces</td>
</tr>
</tbody>
</table>

Table 1. Matrix of 24 specimen types.

Samples were stripped after 1 day and furtherly cured in a room where the temperature of 20±2°C and 65% RH were maintained. The bituminous sheet was applied to the appropriate concrete samples at their age of 14 days. For both mixes 2 samples were kept under water at the temperature of 20±2°C for 28 days for compressive strength testing.

To simulate real life conditions better, during the repeated examination the specimens were tested for 72 hours using 2-3-4 bars pressure steps. The pressure was increased after every 24 hours by 1 bar. After the water permeability test, the samples were split and the visible waterline was marked.
**Results**

The main purpose of the research was to find the parameters which are influencing the resistance of lateral water movement. The possible effecting properties are the concrete class, the way of loading and its magnitude, the height of water-head (hydrostatic pressure), time, etc. Furtherly, the plane of lateral water movement is also questionable, it could be located in the concrete or at the boundary surface of the two materials. The tests were essentially based on the standard procedure to determine the depth of penetration of water under pressure into concrete (EN 12390-8:2001). The measurement is carried out by applying a water pressure of 5 bar on a circular surface for 72 hours. Then the specimen is to be split into two, and the shape and depth of water penetration were to be recorded. The obtained results of the first test series were not to our expectations. Presumably the cross cut on the sealant was too small to fail most of the waterproofing materials, they sort of self-healed. This is why for the second test series we applied a bigger, Ø 12 mm drilled hole to breach the membranes.

**Concrete without waterproofing**

Samples for both mixes and water permeability condition were tested to determine the water penetration depth and shape of the concrete material itself, as reference. The C25/30 mix showed the typical curved waterfront with a maximum water penetration depth of 40 mm. The mixture of C45/55 sample had small water ingress below the surface, typically less than 10 mm. The water ingress was practically the same for the two testing situations of the first: 5 bars for 72 hours; and the modified: 2-3-4 bars, increasing after every 24 hours by 1 bar.
Waterproofed concrete

Just below a hole on the waterproofing layer, the pressurized water can only penetrate deeply into concrete if the pressure of the water does not cease away due to lateral water filtration. If water is able to escape between the sealant and the concrete’s surfaces, pressure will drop, and the moisturizing of the concrete will occur due to capillary suction at first (Fig. 9.).

![Water seeps in concrete](image1.png) ![Water seeps between concrete and the sealant](image2.png)

Fig. 9 Possible ways of water seepage due to pressure

Later by time, the water pressure might rebuild between the membrane and concrete, then the water between the two layers will find its way into the interior of the structure at – from the point of watertightening capability – its weakest location.

During the first experiment the test with the MC Expert Proof eco membrane was not successful. The hydrostatic pressure did not attack the plane between the concrete and the membrane. Water escaped between the rubber sealing ring of the instrument and the carrying geotextile felt. During the second test series the same perforated steel plate was used for the MC Expert Proof eco membrane as for the earlier described case regarding VOLTEX® membrane. By using this setup the test was successful.

Bituminous felt waterproofing

In case of the lower strength class concrete, the first test method with small, + shaped scalpel cut damage the concrete’s surface below the sealing felt was wet all-over, and the maximum water penetration depth was bigger, 60 mm, compared to the etalon sample with no waterproofing. The bond between the concrete and bituminous membrane was weak and water not only could migrate laterally but the capillary flow was deeper by 60 mm, than the etalon sample with no waterproofing. The bond between the concrete and bitumen was weak, and water could filtrate laterally.

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When the pressure was applied at increasing steps, and the drilled puncture was on the sealant, the water penetration had a similar shape, but smaller in depth if compared to the etalon sample.

In case of the higher strength concrete, there was local water ingress under the damage on the sealant and only a certain lateral seepage could be experienced after both tests. Although the depth of water penetration into concrete was similar to the case of without waterproofing, it is not obvious whether the water moved laterally between the bituminous felt and the concrete sample or within the concrete, since there was a larger ingress at the area close to the damaged point.

After all, the critical parameter was the applied pressure that determined the water ingress while the size of the sealant damage was less important. Significant lateral water seepage occurred only in case of the lower (C25/30) concrete class specimens at higher water pressure. In case of the higher (C45/55) concrete class specimens, of which the permeability was low, water was not able to penetrate the concrete significantly farther from the damaged area.
VOLTEX®

VOLTEX® waterproofing system has a different mechanisms compared to the other adhesive bonding systems and the results were also different from the other three. For the C25/30, the small cut damage and high pressure showed the same water ingress as for the etalon sample, the VOLTEX® bentonite waterproofing made no difference the water permeability. In case of the larger drilled hole and increasing pressure, significant lateral water movement appeared and the whole cross-section of the sample was wet.

For the C45/55 concrete, the maximum water penetration was very similar to the etalon for both setups. However, when the damage was a small cut, the water ingress was restricted to a smaller area. For the larger, drilled hole, the VOLTEX® did not seem to have any effect on the water ingress, if compared to the etalon. It is possible that a small amount of lateral movement appeared as the wet area is slightly wider, but that could be within the variation of the samples. Even using a small amount of samples, the behaviour was very different for a small cut and a bigger damage by a drilled hole. The applied pressure had a less significant role.
Adhesive bonding systems

All three adhesively bonded waterproofing systems behaved very similarly, therefore only one, the Preprufe® results will be presented here in detail. For both mixes and test setups, the adhesive bonding clearly showed that the water ingress was minimal and localized only to the damaged area. There was no visible water ingress for a small cut for the higher strength concrete. For larger driller holes, the water ingress was just around the actual damage for both mixes.
All three adhesive bonding waterproofing systems showed that the water ingress was local and there was no lateral water movement even in case of high pressure or larger damage. This is a great advantage for underground structures where damage can often occur.

**Comparison of the tested waterproofing systems**

For a better comparison on the effectiveness of waterproofing of different concretes and damage set ups, a comparison chart is shown below (Table 2.). The red square indicates the usual water ingress shape with no waterproofing and the blue square indicates a similar shape but reduced in depth and width.

Table 2. Comparison of different waterproofing systems, which are applied on two different compressive strength class concretes.

<table>
<thead>
<tr>
<th></th>
<th>5 bar 72h 5mm cut damage</th>
<th>2-3-4 bar 3x24h 12mm drilled hole</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concrete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C25/30</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td>C45/55</td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>Bitumen</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>VOLTEX®</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>Preprufe®</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>SikaProof®</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
<tr>
<td><strong>MC Experproof</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>![Image]</td>
<td>![Image]</td>
</tr>
</tbody>
</table>

Regarding all of the four tested laterally rebinding waterproofing materials, it can be stated that: under the normal or much higher hydrostatical pressure circumstances, which can be found in Hungary, no lateral water movement occurs. Local perforation/injury causes only local water ingress, the magnitude of which depend on the own watertighting capability of the concrete on the protected side.

The compressive strength class of concrete does not influence the working together capability with the rebinding membranes and the resistance against lateral water movement.

Water ingress into concrete may take different shapes, what can be observed on the split concrete surfaces after the effect of the hydrostatical pressure. The ingress shapes could be

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sorted according to their curve, of which we presented by their pictograms. Since we have determined the watertightening capability of the unprotected concretes as well, we could separate the events due to the properties of the sealants from the ones, which are due to the properties of concrete. As it could be expected, the compressive class of concrete influences the shape of water ingress curve. In case of the not rebounding waterproofing felt, due to lateral water movement, a uniform water ingress occurs on the entire surface of concrete.

Table 3. Typical water ingresses for the different cases.

<table>
<thead>
<tr>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>No lateral water movement. No water ingress around the damaged area in the concrete.</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>Typically SikaProof® A and Preprufe®, C45/55 mix.</td>
<td></td>
</tr>
<tr>
<td>No lateral water movement visible. Visible water penetration around the damaged area in the concrete.</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Typically Expert Proof eco and VOLTEX® with C45/55 strength class or a SikaProof® A and Preprufe® with C25/30.</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>Visible water penetration, not just around the damaged area, but at the overall surface where the waterpressure was applied.</td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Typically VOLTEX® with C 25/30 and reference concrete samples</td>
<td></td>
</tr>
<tr>
<td>Visible water ingress at the surface and lateral water movement.</td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
<tr>
<td>Typical for the non-adhesive bonded bitumen.</td>
<td></td>
</tr>
</tbody>
</table>

The results may be seen from the curves, which are drawn by the water ingress on the split surface of concretes. As expected, into concrete with lower compressive strength class the water penetration is bigger. It can also be seen that in the case of Preprufe® and SikaProof® types of waterproofing layers water penetration did not occur if a small punching is made on the membranes. The performance of these materials does not depend on the quality of the protected concrete. If water penetrates through the damaged sealing membrane, then the significance of concrete watertightening capability gains importance (VOLTEX®, bituminous felt). In case of C45/55 compressive strength class concrete – which is expected to be watertight on its own – if through the wound water penetrates, the depth of ingress into concrete is the same or smaller, regardless of the size of the harm on the waterproofing layer (Table 4.).
Table 4. Water ingress depending on the size of the damage on the waterproofing layer.

<table>
<thead>
<tr>
<th>Type of test specimen</th>
<th>Concrete of class C25/30 having 5 mm puncture</th>
<th>Concrete of class C25/30 having 12 mm puncture</th>
<th>Concrete of class C45/55 having 5 mm puncture</th>
<th>Concrete of class C45/55 having 12 mm puncture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete (without waterproofing)</td>
<td>40</td>
<td>40</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Concrete (with bituminous felt)</td>
<td>60</td>
<td>40</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Concrete with VOLTEX®</td>
<td>60</td>
<td>60</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

In case of the VOLTEX® type membrane expectably the penetration decreases with the increase of the compressive strength of concrete, but the behaviour is much more influenced by the magnitude of the puncture. In case of small injury (5 mm cut) the intrusion of water is similar as in case of the concretes without waterproofment, only smaller and there is no lateral water movement even at higher water penetration. However at bigger injury like the 12 mm one in diameter, lateral water movement is starting between the surface of concrete and the sealing material, the magnitude of which is strongly dependant on the strength class of the protected concrete. In case of bituminous felts in all cases, we found lateral water movement. The magnitude of concrete moistening strongly depended on the strength class of concrete.

Conclusions

The separation of a waterproofing system from the building structure and applying it on waterproofing-holding structure (“Schwarze Wanne”) is a logical mistake, causing several problems in the practice, e.g. differential movement of the two or the question of the continuity of protection. Lateral water movement between adhesive waterproofing layers and concrete significantly depends on the type of sealant. The compressive strength class of concrete does not influence the working together capability with the rebinding membranes and the resistance against lateral water movement. As it could be expected, the compressive class of concrete influences the shape of water ingress curve. In case of the not rebounding waterproofing felt, due to lateral water movement, a uniform water ingress occurs on the entire surface of concrete. In such a case water will find its way through the background, supporting structure at its weakest point into the defended space.

The main fault reasons of the coat and felt waterproofing is their thin, membranous nature and the fact of their accepting surface is being a separate structure from the building. In case the sealing material is wounded, and due to its membranous nature there is no further border against leakage. The water film spreads between the back structure and the sealant, so the position of the leakage cannot be localized.

The solution to this problem are the adhesive waterproofing products. As long as a waterproofing layer is not damaged, nothing is problem. We investigated the case that the layers were damaged. Minimal failure (thin cutting) and major failure (drilled) were tested. In ideally cases, the damaged layer did not leak the water under pressure (it was self-healing).
In case of major failure, the water can plow throw the layer but do not start lateral filtration. The failure of layer and visible water problem are in same place. We know how have to repair the structure. This research was claimed by the manufacturers, but did not exist an independent scientific study in the literature.

References


Standards

ASTM D 903 – Standard Test Method for Peel of Stripping Strenght of Adhesive Bonds
ASTM D 5295 – Standard Guide for Preparation of Concrete Surfaces for Adhered (Bonded) Membrane Waterproofing Systems
MSZ 93-12:1987 - Test methods for fabrics. Tear strength
MSZ EN 12390-8:2001 –Testing hardened concrete. Part 8: Depth of penetration of water under pressure
DIN 18195 / 9-c – Bauwerksabdichtungen (Structural waterproofing)

Homepages

Sikaproof: https://www.sikawaterproofing.co.uk/products-systems/sikaproof/