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DAP-PL-4077.00

**Business division V – Civil and underground engineering**
Head of the Business Division: Prof. Dr.-Ing. Olaf Selle

**Working Group 5.1 – Structural Sealing**

# Test Report

PB 2.2/07-160

dated 23/07/2008  1st of 3 copies

**Object:** **FlexproofX® 1** -
Testing the single-component sealing material as an exterior joint seal according to the Building Regulation List A, part 2, consecutive no. 1.4

**Applicant:** StekoX GmbH Abdichtungstechnik
Markgröninger Straße 55/1
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**Officer in charge:** Dipl.-Ing. Jüling

**Test period:** August 2007 – July 2008

This test report consists of 11 pages and 1 annex.

-This translation of the original German version not checked by MFPA Leipzig-



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# 1 Task

These applications-oriented tests have the purpose of investigating the functionality of the single-component liquid plastic designated FlexproofX® 1 from StekoX GmbH Abdichtungstechnik as a strip-shaped exterior seal for joints. These tests will also be the prerequisite for issuing a general building supervisory test certificate according to the building regulation list A part 2, item 1.4 "Normally Flammable Joint Seals for Building Components Made of Concrete with a High Level of Water Penetration Resistance against Pressurised and Non-Pressurised Water and Soil Moisture". The type and scope of tests are based on the test principles for joint seals as per July of 2007.

# 2 Object of the Investigations

FlexproofX® 1 is a solvent-free SMP-based liquid plastic that hardens in air to an elastic product. FlexproofX® 1 is offered in various viscosities in accordance with its application and it is normally applied by spraying, with a roller, with a brush or with a spatula in several layers on the concrete base. The sealing compound has to be applied on an even base without any dust or separating or loose components. No particular requirements are made of the base moisture, although water-saturated concrete should be dried before application.

The client supplied the following samples for tests:

- FlexproofX® 1: 15.0 kg (sample received on July 30, 2007 / receipt number: 508)
  9.5 kg (sample received on February 27, 2008 / receipt number: 574)
  15.0 kg (sample received on July 9, 2008 / receipt number: 626)

# 3 Specimens and Tests

## 3.1 Identifying Tests

FlexproofX® 1 was identified not only by recording its general properties (such as consistency and colour), but also by carrying out the tests in Table 1.

***Table 1:*** Identifying Tests

| parameter | determination process |
|---|---|
| volatile components | DIN EN ISO 3251 (1 h at 105°C) |
| ignition residue | DIN EN ISO 3451-1 (at 550 °C to constant mass) |
| infrared spectrum | DIN EN 1767; DIN 51451 |
| density, hardened system | DIN EN ISO 1183-1 (immersion method, determination in ethanol) |
| thermogravimetric analysis | DIN EN ISO 11358 |

### 3.2 Test of Properties Important for Its Function

All tests are made and the equipment and materials are stored in the normal climate in conformity with DIN 50014-23/50-2[1] unless otherwise stated. The properties below are ascertained depending upon the intended purpose.

#### 3.2.1 Adhesion to the Base

The tear-off resistance of FlexproofX® 1 between the base and coating is determined to check the endurance of the adhesive bond when stored in water following DIN EN 1542[2]. Concrete slabs made of FD concrete are used as the base and the test is carried out at a take-off speed of 300 N/s.

The slabs are at least 28 days old and are coated in strips by applying 2 strips 7 cm wide on each slab parallel to the longitudinal direction. The strips are arranged to ensure that a free concrete edge remains on both sides of the seal system (Annex 1, Figure 1). The slabs are stored in water after a drying time depending upon the system and the adhesive tensile strengths are ascertained at fixed intervals. After the test, the slabs that have a seal strip not yet tested are placed in water until the time of the next test.

The fracture patterns are then described along with a statement of the tear-off resistance.

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[1] DIN 50014: Climates and their technical application; Normal Climate; edition 7/1985
[2] DIN EN 1542: Products and Systems for Protecting and Maintaining Concrete Supporting Structures Test Methods – Measuring the Adhesive Strength in the Tear-Off Test, July 1999

### 3.2.2 Stability

The sealing material is applied to the horizontally directed formwork-smooth side of a concrete slab for the maximum potential thickness per layer to ascertain the drainage inclination on vertical surfaces. The coating's stability behaviour is observed on the concrete slab to be set vertically immediately afterwards during the hardening process. The type and scope of any identifiable changes such as flowing, slippage etc. should be recorded. Any changes in the layer thickness should be documented.

### 3.2.3 Reduction in Layer Thickness with Thorough Drying

This test ascertains the reduction in layer thickness of the coating after 7 days of storage in a normal climate (23/50-2). The percentage reduction in layer thickness of the dry layer thickness should be given in relation to the wet layer thickness as the test results.

### 3.2.4 Resistance to Exposure to Alkaline Liquids

The coating has to be resistant to exposure to alkaline liquids. This is documented on 2 samples each of the reinforced sealing material with the slotted disc water pressure test following DIN EN 1928 on water impermeability. The samples are made with fabric as a free film at the specified minimum layer thickness. Samples with a diameter of 140 mm are cut out from this film after 14 days of drying. While two of the samples are put to a sealing test after drying, the two other samples are stored in 5% KOH solution at 23°C over 28 days. The 72-hour slotted disc water pressure test is carried out at a pressure of 4 bar immediately after storage. The findings should be given together with the layer thicknesses of the samples.

### 3.2.5 Normal Flammability

It should be proved that in terms of fire behaviour, the joint seal satisfies the requirements of building material class B 2 "normally flammable" in conformity with DIN 4102, part 1 or at least building material class E in conformity with EN 13501.

## 3.3 Function Test – Sealing Test

The sealing tests described below have the purpose of testing the functionality of the coating FlexproofX® 1 applied over working joints and controlled crack joints by gradually widening the joints and exposing them to water.

Two test specimens with the dimensions of 1.0 x 0.70 x 0.25 [m] made of C25/30 concrete (maximum aggregate size of 16 mm) in conformity with DIN 1045-1, concrete with a high level of water penetration resistance in conformity with DIN 1045-2 are used to replicate joints within a straight and even wall made in two concreting sections. The concreting joint is in the middle of the short side and has an area of 1.0 x 0.25 [m] (Figure 1).

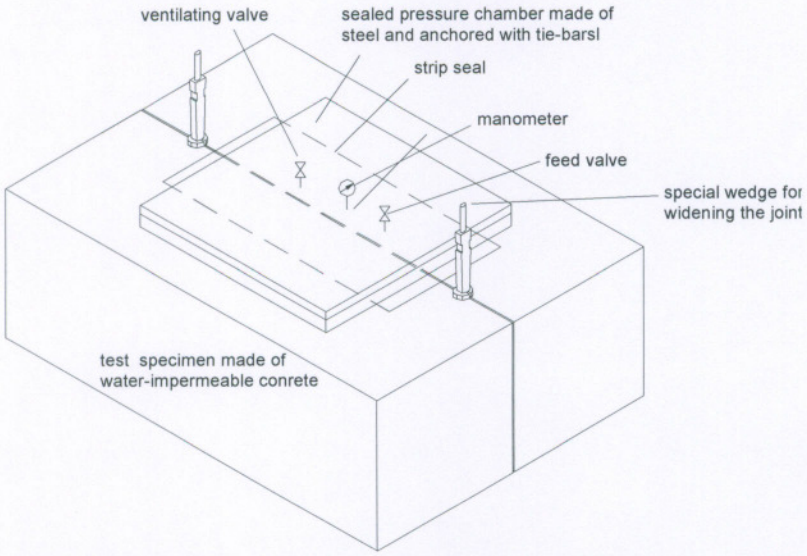


***Figure 1***:
Specimen without depiction of horizontal bracing

Special wedges are used for the even opening of the joint after applying the seal. The widened joint is stopped via tie-bars braced horizontally around the specimen. Two dial gauges were above the joint to check the width of the joint. The formwork-smooth surface of the underside is available as a coating base after rotating the braced test specimen. The base is mechanically freed of cement paste residues before applying the coating.

### *Description of Application*

A spatula and smoothing tool are used to apply the strip seal to both specimens on a dry base without any dust or loose components (Annex 1, Figure 2).
While FlexproofX® 1 is applied to a test specimen without reinforcing fabric, the second test specimen to be exposed to higher test pressures is given a reinforcement layer made of FlexproofX® 1 reinforcing fabric in the middle of its layer thickness. Enough is applied to ensure 4 mm of dry layer thickness on the test specimen without a reinforcement layer and approximately 2.6 mm of dry layer thickness with the coating reinforced with mesh fabric.

The initial joint widths are adjusted to 0.25 mm wide two weeks after applying the coatings. Then, the test equipment needed for generating pressure was mounted (Annex 1, Figure 3)

above the systems to be tested. The pressure chamber dimensions guarantee that the lateral edges are exposed to water pressure. The specified set-up not only tests the seal for water impermeability in the joint zone, but also back-running. Water exposure begins by continually increasing pressure after linking the pressure generating equipment with the specimens and filling the cavities caused by the seals with water.

The pressure is boosted to ensure that the selected test pressure is applied within two weeks. The maximum pressure is kept constant over 28 days, after which the working joints are gradually widened maintaining the maximum water pressure. The function test is passed if no water penetration can be recorded in the course of water pressure loading. A visual inspection is made of the condition of the sealing system after finishing the test.

## 4 Results of the Tests Made

### 4.1 Identifying Tests

The results of the tests on FlexproofX® 1 described in Section 3.1 are shown in Table 2. They are used for characterisation or identification.

***Table 2:*** Characterising FlexproofX® 1

| property | value | |
|---|---|---|
| colour / consistency | bright grey / viscous | |
| volatile components [%] | 1.43 (mean of 3 measurements) | |
| ignition residue [%] | 56.32 (mean of 3 measurements) | |
| density, hardened [g/cm³] | 1.654 (mean of 5 measurements) | |
| thermogravimetric analysis | temperature range [°C] | relative mass loss [%] |
| | 25-590 | 41.0 |
| | 590-650 | 0.8 |
| | 650-850 | 23,4 |
| | ash [%] | |
| | 975 | 34,8 |

The IR spectrum and the thermogram are at the test office; they do not constitute a component of the test report.

## 4.2 Most Important Functional Properties

### 4.2.1 Adhering to the Base

The results of the adhesive tensile tests and the description of the fracture patterns are shown as a summary in the table below.

***Table 3:*** The results of the adhesive tensile tests

| sample number | water storage [d] | mean of the tear-off resistance [N/mm²] | remarks / fracture patterns |
|---|---|---|---|
| 1 | 7 | 0.37 | 30-70% cohesion fracture in the coating<br>70-30% adhesion fracture between the coating and concrete |
| 2 | 14 | 0.45 | 25-75% cohesion fracture in the coating<br>75-25% adhesion fracture between the coating and adhesive |
| 3 | 28 | 0.26 | 100% adhesion fracture between the coating and concrete |
| 4 | 56 | 0.28 | 100% adhesion fracture between the coating and concrete (Annex 1, Figure 4) |

The values dropped after an increase in the adhesive tensile values after 14 days of exposure and remained constant over the further test period. The adhesive tensile value ascertained after 56 days is identical with the adhesive tensile values ascertained after 4 months of water pressure loading on function test specimen 2.

### 4.2.2 Stability

The test of the drainage inclination of FlexproofX® 1 showed that a wet layer thickness of 2.5 mm is possible applying a single-layer coating without causing identifiable changes such as flowing or slippage (Annex 1, Figure 5).

### 4.2.3 Reduction of Layer Thickness with Thorough Drying

There was a 1.95% reduction in dry layer thickness in relation to wet layer thickness after storing for 7 days in a normal climate (23/50-2). This value was ascertained on a FlexproofX® 1 film with a wet layer averaging 2.56 mm thick.

### 4.2.4 Resistance to Exposure to Alkaline Liquids

The results from testing resistance to alkaline liquid are summarised in the table below by proving water impermeability.

***Table 4:*** The results of the resistance test

| sample | storage medium after drying | layer thickness after drying [mm] | layer thickness after storage [mm] | results |
|---|---|---|---|---|
| 1 | 5% KOH solution | 2.82 | 2.87 (Δ = +1.8%) | passed |
| 2 | - | 2.44 | - | passed |
| 3 | - | 2.55 | - | passed |
| 4 | 5% KOH solution | 2.66 | 2.68 (Δ = +0.9%) | passed |

The mean increase in mass of samples 1 and 4 was 3.5% and 2.8% respectively in connection with 28 days of being stored in KOH solution.

### 4.2.5 Normal Flammability

This test was made in conformity with DIN EN ISO 11925 part 2, section 7.3.3.1 (surface flaming) and 7.3.3.2 (edge flaming) on freely suspended samples. They were flamed for 15 s. The result of the tests was classifying FlexproofX® 1 in class E in conformity with DIN EN 13501 for fire behaviour.

## 4.3 Function Test - Sealing Test

The results of the exterior strip-shaped seal carried out on test specimens with and without fabric reinforcement are shown as a summary in the tables below.

***Table 5:*** The results of the sealing test of FlexproofX® 1 without fabric

| water pressure [bar] | joint width [mm] | test duration [d] | flow-through [ml] | remarks |
|---|---|---|---|---|
| - | 0.25 | - | - | adjusting the crack and filling the cavity with water |
| 0-1.0 | 0.25 | 1 | 0 | gradual increase in pressure |
| **1.0** | **0.25** | **28** | **0** | **no water penetration** |
| 1.0-2.5 | 0.25 | 3 | 0 | gradual increase in pressure |
| **2.5** | **0.25** | **28** | **0** | **no water penetration** |
| - | 0.5 | - | - | widening the crack when unpressurised |
| 0-1.0 | 0.5 | 1 | 0 | gradual increase in pressure |
| 1.0-2.5 | 0.5 | 3 | 0 | gradual increase in pressure |
| **2.5** | **0.5** | **28** | **0** | **no water penetration** |
| - | 1.0 | - | - | widening the crack when unpressurised |
| 0-2.5 | 1.0 | 1 | 0 | gradual increase in pressure |
| **2.5** | **1.0** | **28** | **0** | **no water penetration** |
| - | 1.0 | - | - | ending the test and disassembling the test equipment |

There were never any leaks at any time for the entire 4 months of water pressure loading.

The seal system was visually inspected after finishing the test. The opened working joint marked itself in the coating, although it did not show any incipient crack or other peculiarities (Annex 1, Figure 6).

Ø 50 mm adhesive tensile stamps were glued with a single-component pasty adhesive and the coating was cut open to the concrete's surface to check the coating adhesion on the base after the sealing test. The adhesive tensile values averaged 0.27 N/mm². All stamps were 100% torn off between the coating and the concrete (Annex 1, Figures 7 and 8).

***Table 6:*** The results of the sealing test of FlexproofX® 1 with fabric

| water pressure [bar] | joint width [mm] | test duration [d] | flow-through [ml] | remarks |
|---|---|---|---|---|
| - | 0.25 | - | - | adjusting the crack and filling the cavity with water |
| 0-1.0 | 0.25 | 1 | 0 | gradual increase in pressure |
| 1.0-5.0 | 0.25 | 4 | 0 | gradual increase in pressure |
| **5.0** | **0.25** | **28** | **0** | |
| - | 0.5 | - | - | widening the crack when unpressurised |
| 0-1.0 | 0.5 | 1 | >0 | gradual increase in pressure, slight leak (not measurable) |
| - | 0.5 | - | - | ending the test and disassembling the test equipment |

There were never any leaks during the 4 months of water pressure loading at 5 bar, although there were slight leaks after widening the joint to 0.5 mm. Then the test was finished.

## 5 Summary

The applications-oriented tests investigated the properties and functionality of the liquid plastic FlexproofX® 1 from StekoX GmbH as an exterior seal for working joints.

We found that FlexproofX® 1 is suited as an exterior seal for working joints and controlled crack cross-sections in water-impermeable concrete and reinforced concrete constructions if the working instructions are followed and good workmanship is used to apply it to concrete components with a high level of water penetration resistance.

Leipzig, July 23, 2008

Prof. Dr.-Ing. Selle
*Head of Business Division*

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Dipl.-Ing. Jüling
*Officer in Charge*

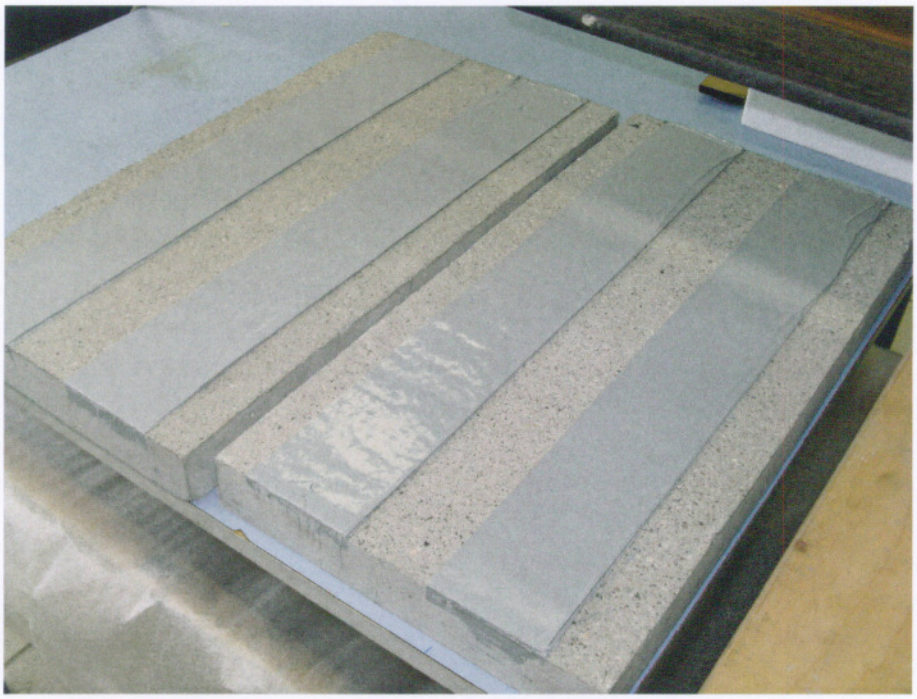

Fig. 1: Test specimens coated with FlexproofX® 1 for checking the endurance of the adhesive bond when stored in water

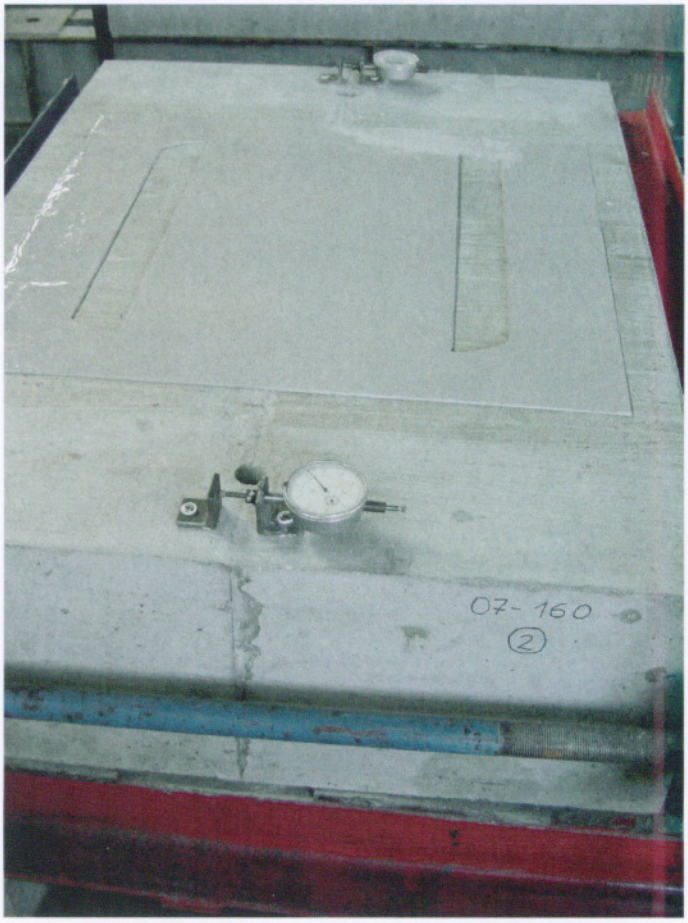


Fig. 2:
Strip-shaped seal with FlexproofX® 1 applied for the function test on a test specimen for leaks

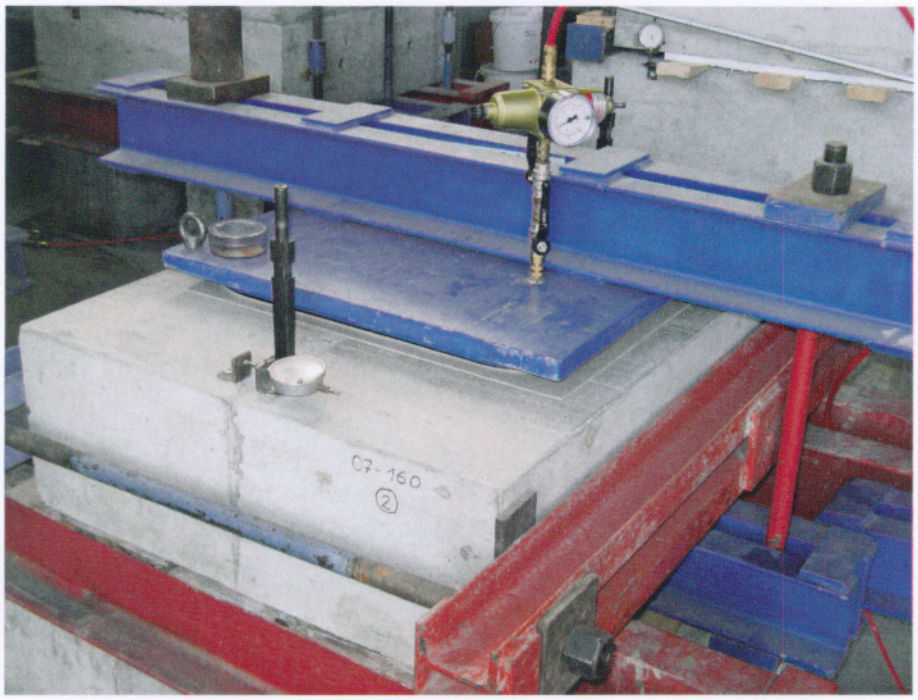


Fig. 3: Test specimen with widened joint during the sealing test

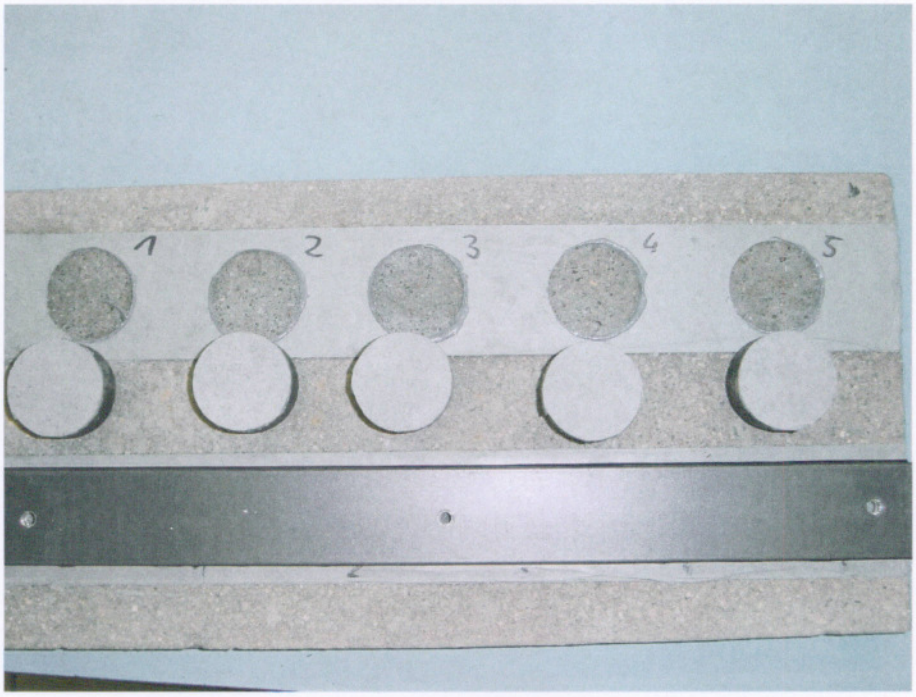


Fig. 4: Testing the adhesive bond of FlexproofX® 1 after being stored in water for 56 days with a complete adhesion fracture between the coating and the concrete

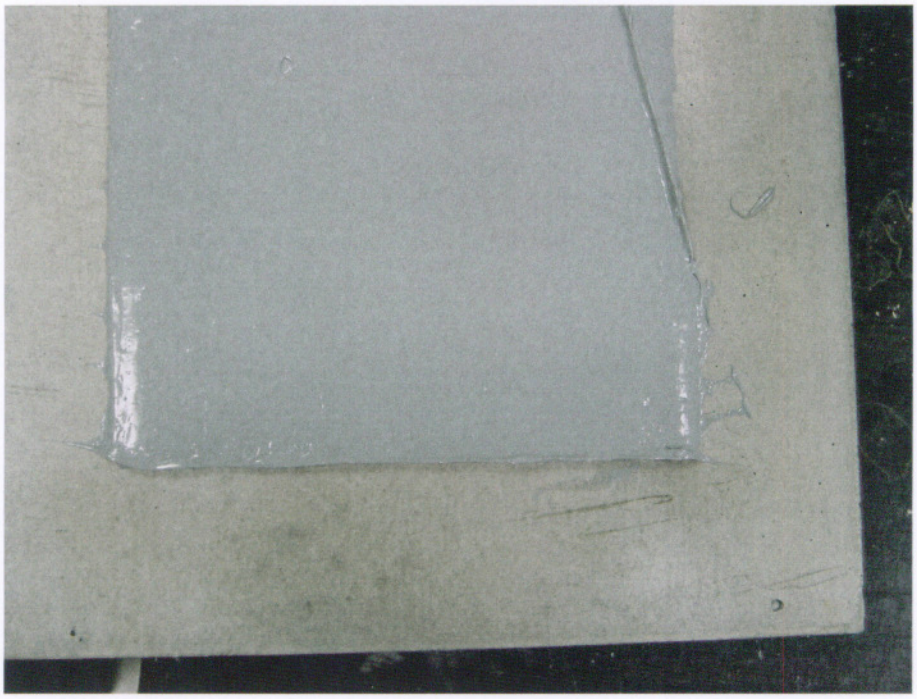

Fig. 5: Testing stability - without recognisable changes in the lower edge

Fig. 6:
Disassembled test specimen after the sealing test with the marking of the joint under the coating

Fig. 7: Testing the tear-off resistance after the coating was exposed to pressurised water for 4 months

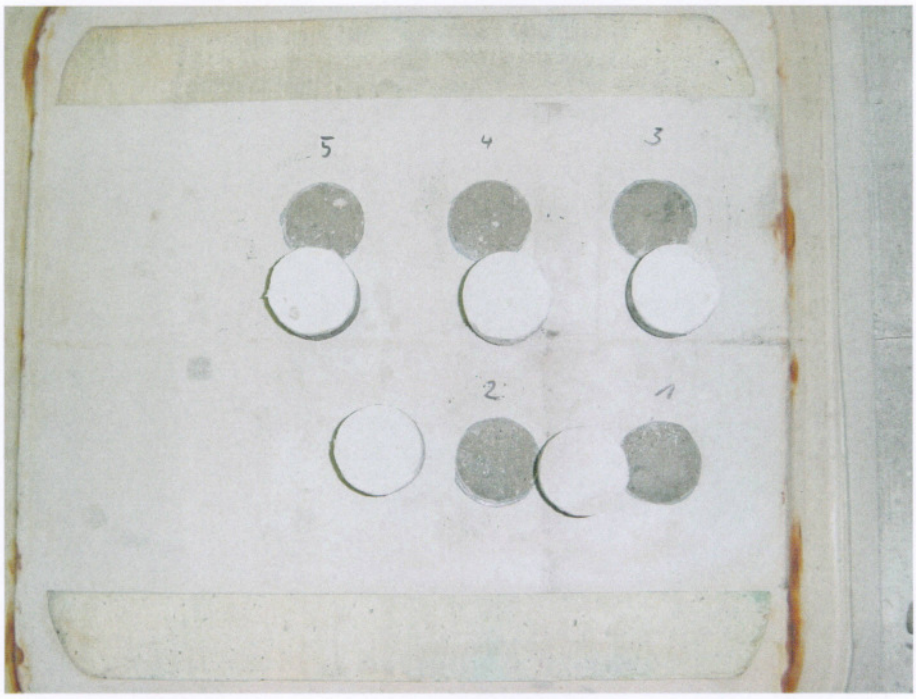


Fig. 8: Testing the adhesive bond of FlexproofX® 1 after the coating was exposed to pressurised water for 4 months with a complete adhesion fracture between the coating and concrete