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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 2.2/07-202

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Object: ***PolyproofX® 1*** **-**
Tests for obtaining the general building supervisory test certificate according to the Building Regulation List A, part 2, consecutive no. 1.4

Applicant: StekoX GmbH Abdichtungstechnik
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Officer in charge: Dipl.-Ing. Jüling

This test report consists of 10 pages and 3 annexes.

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

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Annex 2	Unobstructed swelling behaviour of PolyproofX® 1 with alternate storage in testing liquids at varying pH-values
Annex 3	Swelling pressure build-up from PolyproofX® 1

1 Task

Applicability tests will be used to investigate the functionality of the swelling tape *PolyproofX® 1* from the sealing technology company StekoX GmbH Abdichtungstechnik as a joint insert for sealing working joints. The tests to be carried out will form the basis for issuing a general building supervisory test certificate pursuant to building regulations list A, part 2, item 1.4 „ Normally Inflammable Joint Seals for Building Components Made of Concrete with a High Water Penetration Resistance against Pressurising and Non-Pressurising Water and Soil Moisture" (Normalentflammbare Fugenabdichtungen für Bauteile aus Beton mit hohem Wassereindringwiderstand gegen drückendes and nichtdrückendes Wasser und gegen Bodenfeuchtigkeit"). The tests and their scope are based on the test principles for joint seals as per June of 2006.

2 Object of the Investigations

The manufacturer states that *PolyproofX® 1* is a TPE-based polymer swelling tape. The client offers this blue swelling joint tape in various dimensions and cross-sections. There is not only the longitudinal-groove profile submitted for testing with the dimensions 20 mm x 5 mm (nob profile in Annex 1, Figure 1), but also the cross-sections 20 mm x 10 mm (nob profile) and 30 mm x 30 mm (square profile) and Ø 30 mm (round profile) made of the same material.

TPE swelling joint tapes are used to seal working joints in concrete and reinforced concrete construction against pressurising and non-pressurising water. The swelling joint tape absorbs water when exposed to it so that the material increases in volume. If this process is prevented in the installation state, swelling pressure builds up which seals the joint.

PolyproofX® 1 is fastened on the even, clean and dry concrete base with the contact adhesive SuperX 1 offered by the client. The tape has to be fastened on the base to ensure that the sealing material cannont change its installation position during the concreting process. The joint tape is generally placed in the middle of the joint. *PolyproofX® 1* is offered in the form of rolls. The client supplied 12 m of the swelling joint tape with the dimensions 20 mm x 5 mm for tests and they were registered under the sample receipt number 485.

3 Specimens and Tests

3.1 Identifying Tests

A section of joint tape 1 m long will be measured, density will be ascertained and a thermogravimetric analysis is carried out. Density is determined on five partial samples via differential weighing in air and water. The thermogravimetric analysis is carried out on a partial sample with a heating rate of 10 K/min in the range of 23 °C to 1,000 °C under nitrogen atmosphere adding oxygen from 600 °C to combust the pyrolysis soot. This ascertains the total loss in mass.

3.2 Determination of the Properties Important for Function

3.2.1 Unobstructed Swelling Behaviour

A special property used for the sealing function is the swelling capability both in water and in liquids which are generally encountered in concrete construction. Three samples of each swelling tape are stored in different testing liquids in order to record the swelling behaviour while alternating several times between water storage and drying and to record how the swelling process functions over time. Samples 150 mm long each are cut from the joint tape supplied. They are marked and stored in the testing liquids. The material behaviour is not only visually observed when it is constantly exposed to the effects of a liquid, but the change in mass is also determined at regular intervals. The following testing liquids are used:

PF 1: distilled water, pH value 7

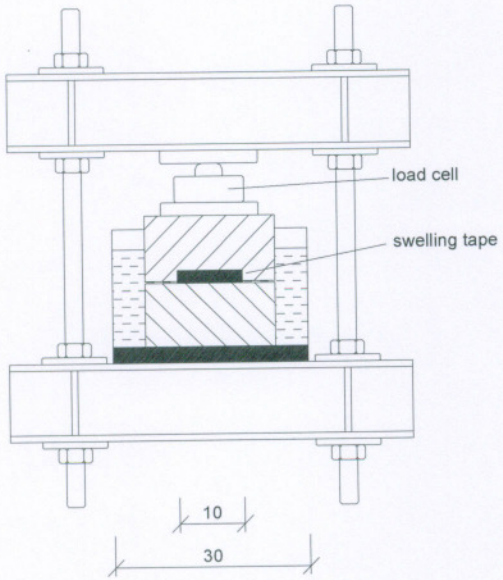
PF 2: very highly concrete-corroding liquid as per DIN 4030, pH value 4.5; SO_4^{2-} content > 4000 mg/l

PF 3: alkaline liquid; liquid in conformity with ETAG 004 corresponds to the pore liquid of concrete: 1 l of water with 1 g of NaOH; 4 g of KOH and 0.5 g of $Ca(OH)_2$

The samples are stored until they reach their maximum increase in mass in these testing liquids above and are then dried at room temperature until they reach their initial weight again. They go through a total of three cycles.

3.2.2 Determining Swelling Pressure

A swelling pressure develops when the volume increase is obstructed by the water absorption capability of the swelling tape. Its magnitude depends upon the joint tape and degree of obstruction. Three two-part concrete test specimens measuring 20 x 20 x 20 [cm] are made to measure the swelling pressure developing. A section 10 cm long of the swelling tape to be tested is fastened on the lower half of the test specimens before concreting the upper parts. Two days after concreting the upper parts, the working joint is opened to a joint width of 0.25 mm so that water can get to the inside swelling joint tape via the open joint.



The test specimen is installed into a low-deformation frame with a force measuring instrument while mounting a preload immediately after the working joint is opened. The concreted-in joint tape and the test specimen design sufficiently obstruct swelling to make it possible to record the swelling pressure. The lower part of the test specimen and the working joint are in the testing liquid.

Fig. 1: Test stand for measuring swelling pressure

Tap water is used as the testing liquid. The experiments are carried out until the change in readings is ≤ 2 % within 48 hours, but at least one month.

3.3 Function Test

A sealing test is used to prove the functionality of the swelling joint tape for sealing working joints. The swelling joint tape is installed into a two-component test specimen with a replicated wall-floor working joint (Figure 2). The joint tape is glued over the entire surface of the floor plate with the dimensions of 100 x 100 x 30 [cm] (the lower part of the test specimen). The ends of the swelling tape are butt-jointed (Annex 1, Figure 2). Then the upper frame is concreted after the contact adhesive dried sufficiently.

The test specimen has four adjusting screws that are concreted into the upper half of the test specimen. They are used for spreading and stopping the working joint gap. After adjusting the joint gap over a width of 0.25 mm with the adjusting screws, the swelling joint tape is exposed to water by filling the inside space of the test specimen with water. The test is initially carried out over a period of 3 days at no pressure. Then the water pressure is raised on a daily basis so that the swelling joint tape is exposed to a pressure of 1 bar after the first week. The pressure is increased in the second test week again to the agreed maximum test pressure of 5 bar that is kept constant over a period of 14 days. After exposing to water pressure, the water is removed from the inside space and the test specimen is dried for 6 weeks at room temperature. The test cycle of water exposure and drying is carried out three times altogether.

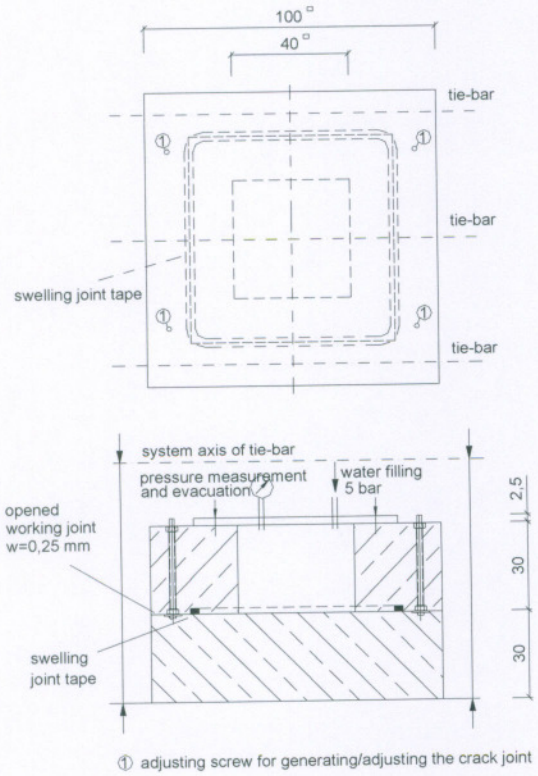


Fig. 2:

Schematic diagram of the function test.
Top: Top view of the test specimen.
Bottom: Cut through the test specimen

4 Results of the Implemented Tests

4.1 Identifying Tests

The simultaneous thermal analysis was carried out on a sample of *PolyproofX® 1* with the test instrument NETZSCH STA 409C/CD in the temperature range of 25°C-1,000°C. The heating rate was 10 K/min. Nitrogen was used as the carrier gas with a flow velocity of 75 ml/min to a temperature of 600°C (scale input). Oxygen was also injected at 100 ml/min from

600°C to combust the pyrolysis soot (sample input). The thermogram is at the testing office. The table below has the characteristic parameters.

Table 1: The characteristic parameters for the thermogravimetric analysis

stage	temperature range [°C]	mass loss [mass-%]	DTG peak [%]
1	23 – 205	2.5	132.6
2	206 – 519	55.9	453.0
3	520 – 626	3.4	611.0
4	627 - 1000	15.8	761.1
total	(23 – 1000)	77.6	-

We can summarise the dimensions and masses ascertained on five partial samples of a section of joint tape 1 m long as follows:

Table 2: The results of measurement and determining mass

partial sample	length [mm]	width [mm]	thickness [mm]	mass [g]	line weight [g/m]
1	102.0	20.05	5.15	11.7	114.7
2	134.2	20.07	5.15	15.4	114.8
3	109.4	20.05	5.15	12.5	114.3
4	120.9	20.07	5.16	13.9	115.0
5	114.9	20.05	5.17	13.2	114.9
Mean Value	-	**20.05**	**5.16**	-	**114.8**

The density from 5 individual measurements as delivered was 1.264 g/cm³.

4.2 Behaviour with Unobstructed Swelling

All specimens tested had more volume and mass after a brief period of time if they were completely stored in the test liquids. While the mass increased most quickly during the initial storage in liquid in distilled water, the mass of the swelling tapes increased somewhat more slowly in alkaline testing liquid and concrete-corroding testing liquid and much less in testing liquid 2 (concrete-corroding).

The mass did not increase any more in any of testing liquids in the course of initial storage after no more than 80 days. The process of mass increase is much quicker in other loading cycles; in other words, mass did not increase any more after storing a maximum of 10 days in liquid. *PolyproofX® 1* swells immediately again after starting storage in liquid even after several phases of drying. However, compared to other testing liquids, the mass increases much less in water that is very corroding to concrete.

Table 3 shows the mass changes reached at maximum for all cycles. Annex 2 has the graph of the results of measurements. Figure 3 in Annex 1 shows the cross-sections of the samples stored in various testing liquids in comparison to the original cross-section.

Table 3: Maximum increase in mass during storage in liquids

testing liquid / exposure	neutral liquid pH value 7	alkaline liquid pH value 13	concrete-corroding liquid pH value 4.5
1st water storage	267.9 %	290.1 %	133.5 %
2nd water storage	257.2 %	248.3 %	144.6 %
3rd water storage	228.7 %	259.6 %	146.6 %

The tests showed that *PolyproofX® 1* begins to swell immediately when it is stored in the chosen testing liquids which represent the media normally encountered in construction work.

Studying the behaviour with unobstructed swelling has the primary purpose of assessing the swelling capability of the joint tape in different liquids or when exposed to alternating influences. Determining the volume increase or mass increase at a particular time makes it possible to check quality with a minimum of effort right at the construction site. However, we should bear the fact in mind that this test cannot realistically represent the actual conditions predominant in a working joint since proper installation would rule out the swelling joint tape being flushed with liquid over the entire surface and since the sealing principle of the swelling joint tapes is based on obstructing the volume increase.

4.3 Behaviour with Obstructed Swelling - Determining Swelling Pressure

The experiment has the purpose of ascertaining the swelling behaviour of *PolyproofX® 1* when installed. The swelling joint tape was installed in a total of three test specimens so that

the working joint 0.25 mm wide allowed the testing liquid to get to the joint tape. Annex 3 has a graph of the test results. The swelling pressure is given as force per meter of joint tape length since the joint tape exerts a linear load on the concrete.

The swelling force increased continuously within the first weeks and after about 8 weeks it reached its limit. This was 14.4 kN/m on the average with a maximum single value of 19.3 kN/m and a minimum single value of 10.4 kN/m. The swelling forces ascertained equal medium swelling pressures ranging from 7.2 bar or approximately 0.7 N/mm² taking the geometry of the joint tape into account.

After completing the tests, the test specimens were removed and split in the joint. The tapes were slightly swollen, two stayed in the upper half of the test specimen and it was difficult to remove them from the concrete due to swelling (Annex 1, Figure 4).

4.4 Sealing Test with Alternating Exposure to Water

The function of the swelling joint tape was tested when installed in a working joint in the course of the sealing test. The joint width was a constant 0.25 mm during the entire testing period. A total of three cycles were run through with three weeks of pressurised water exposure each to a testing pressure of 5 bar and subsequent drying over six weeks. These tests took approximately 6 months and they showed that this material sealed the 0.25 mm wide working joint exposing it to pressurised water all three times.

The leak caused at the beginning of the initial pressurised water exposure during unpressurised water exposure over a couple of hours was increasingly stopped by the swelling behaviour of the joint tape. The tape reliably sealed the working joint when pressure was subsequently boosted. It was still functional without any restrictions in the course of multiple alternate drying and subsequent water pressure exposure.

After the sealing test with alternating water exposure, we increased the test pressure by 2 bar to 7 bar within two days and maintained it over a period of 14 days, where the swelling joint tape *PolyproofX® 1* also reliably sealed the working joint.

After finishing the test, the test specimen in the working joint was split and the swelling joint tape was inspected visually. There was no evidence of the concrete and swelling tape influencing one another.

5 Evaluation and Summary

A series of experimental tests were carried out on the swelling joint tape *PolyproofX® 1* from StekoX GmbH Abdichtungstechnik to test its suitability for sealing working joints with restricted movement. The tests we made detected the properties below:

- Varying volume and mass increase could be observed without a delay when stored in liquids with different pH values.
- Even after phases of drying, *PolyproofX® 1* showed the swelling capacity needed for functioning when exposed to water again. In comparison to the initial storage, its swelling capacity decreased slightly after phases of drying with the neutral and alkaline liquids or increased slightly with the testing liquid corroding concrete.
- A swelling pressure built up where swelling was obstructed that reached its maximum value of an average of 0.7 N/mm² after 8-12 weeks. This swelling pressure builds up almost continuously until it approaches a limit.
- A working joint 0.25 mm wide sealed with *PolyproofX® 1* was impermeable to water over three test cycles with intermediate drying at a test pressure of 5 bar. The joint was also sealed at a water pressure of 7 bar.
- There was no evidence of the concrete and swelling tape influencing one another when the test specimen was opened.

Altogether, the conclusion to be drawn is that the *PolyproofX® 1* swelling joint tape is suited for sealing working joints. However, the surrounding concrete has to be of proper condition and properly installed and material swelling has to be sufficiently obstructed to allow swelling pressure to build up.

Leipzig, December 18, 2007

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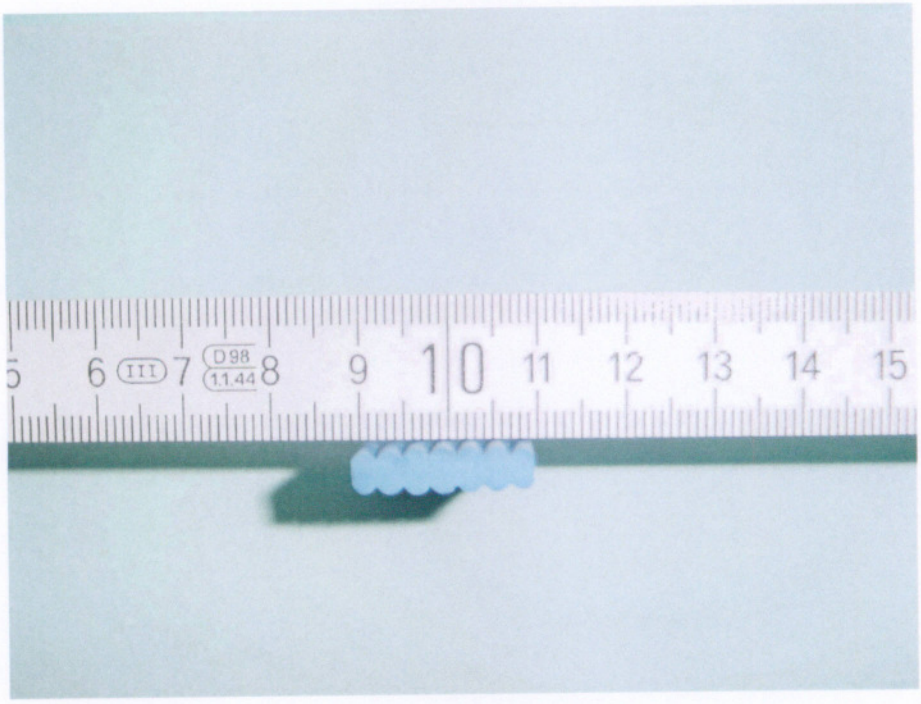


Fig. 1: Swelling joint tape *PolyproofX® 1*

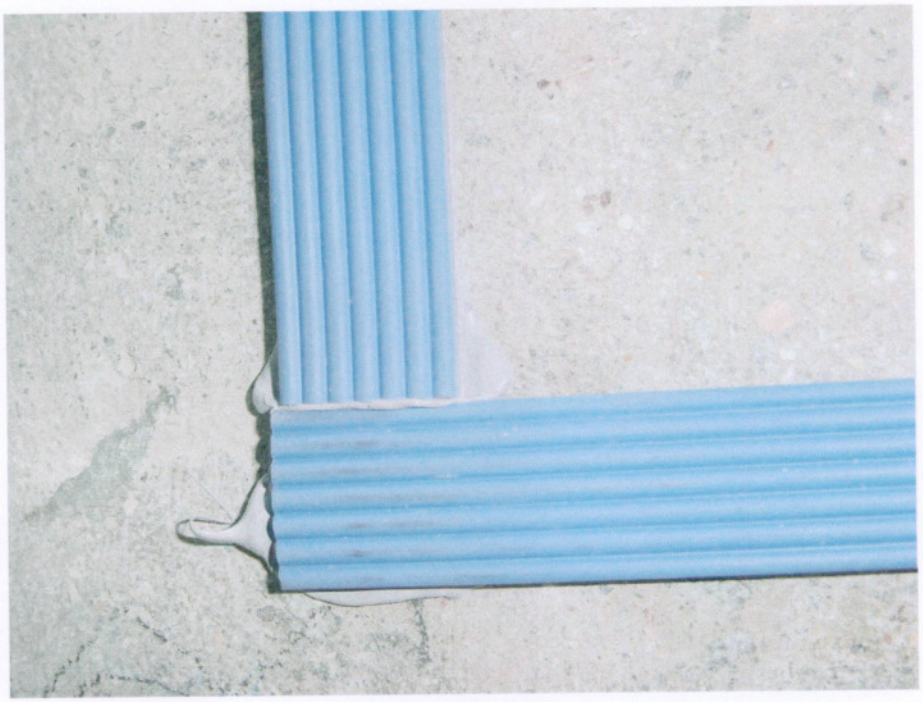


Fig. 2: Gluing the swelling joint tape on the floor plate

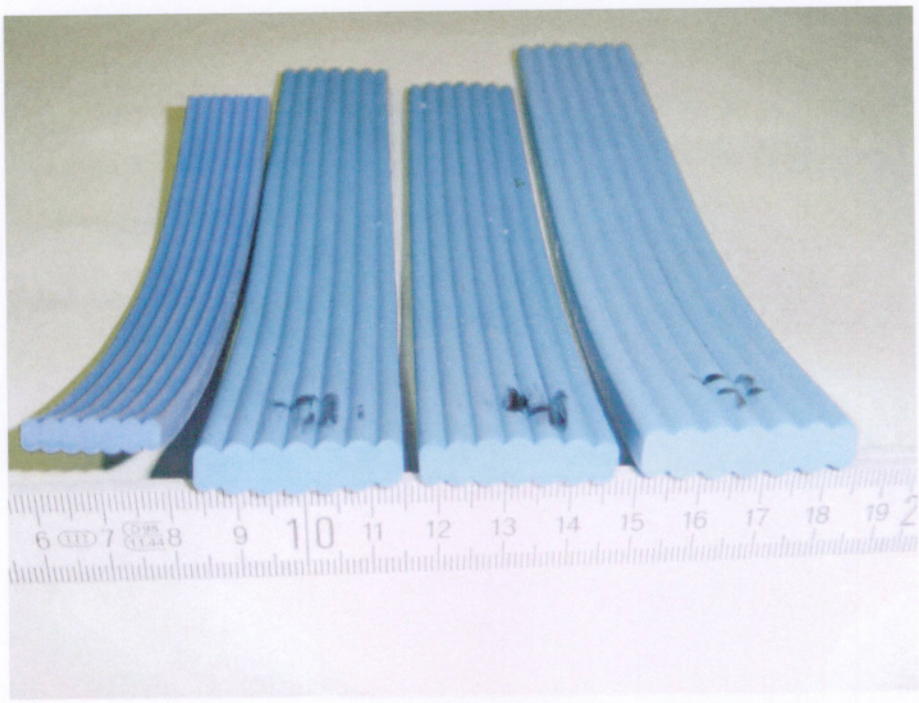


Fig. 3: The *PolyproofX® 1* swelling joint tape after various types of storage from left to right: original cross-section, stored in distilled water, in test liquid that corrodes concrete and in alkaline test liquid

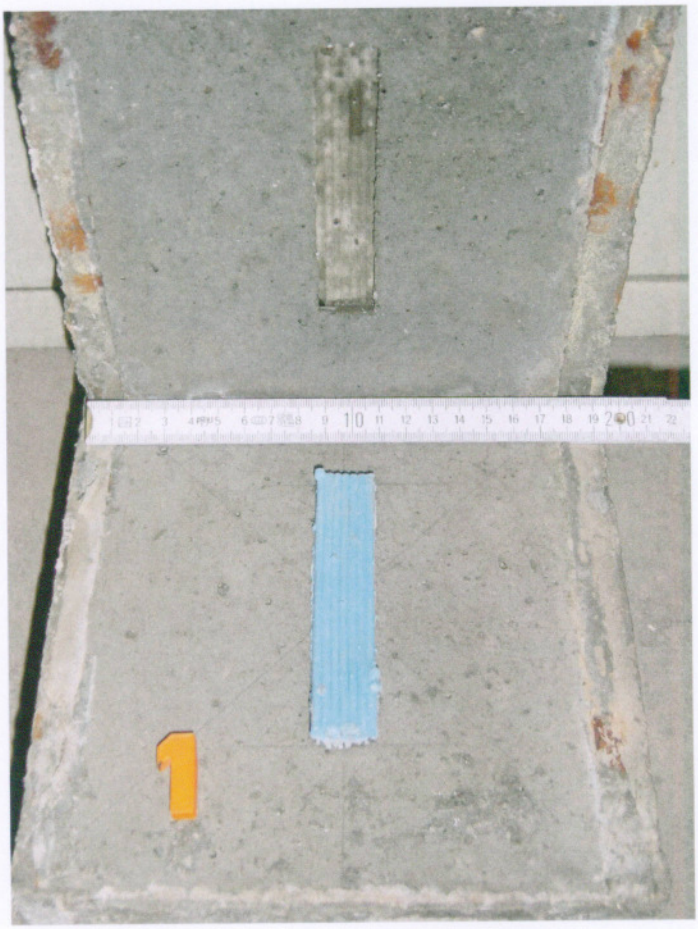
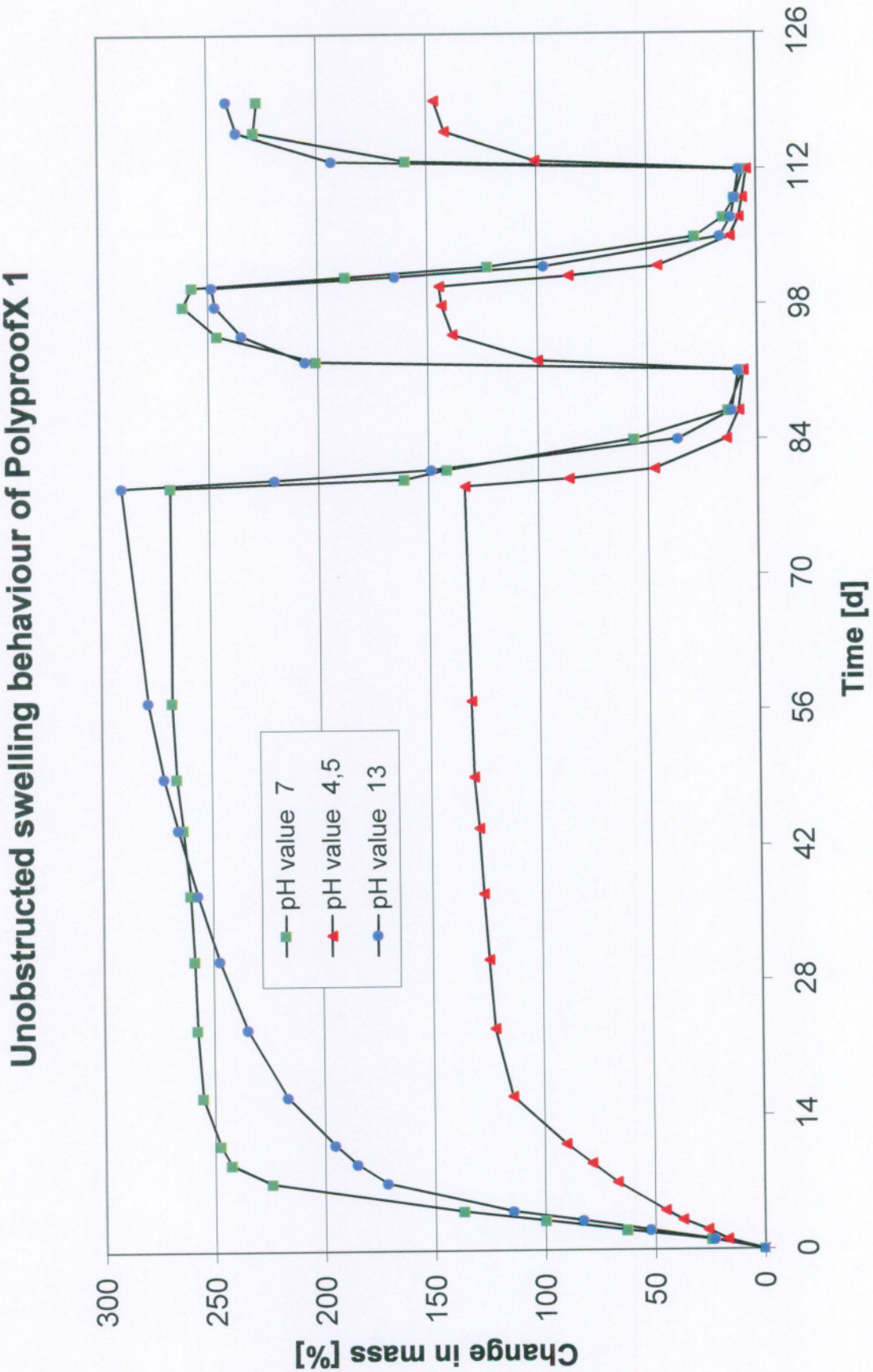
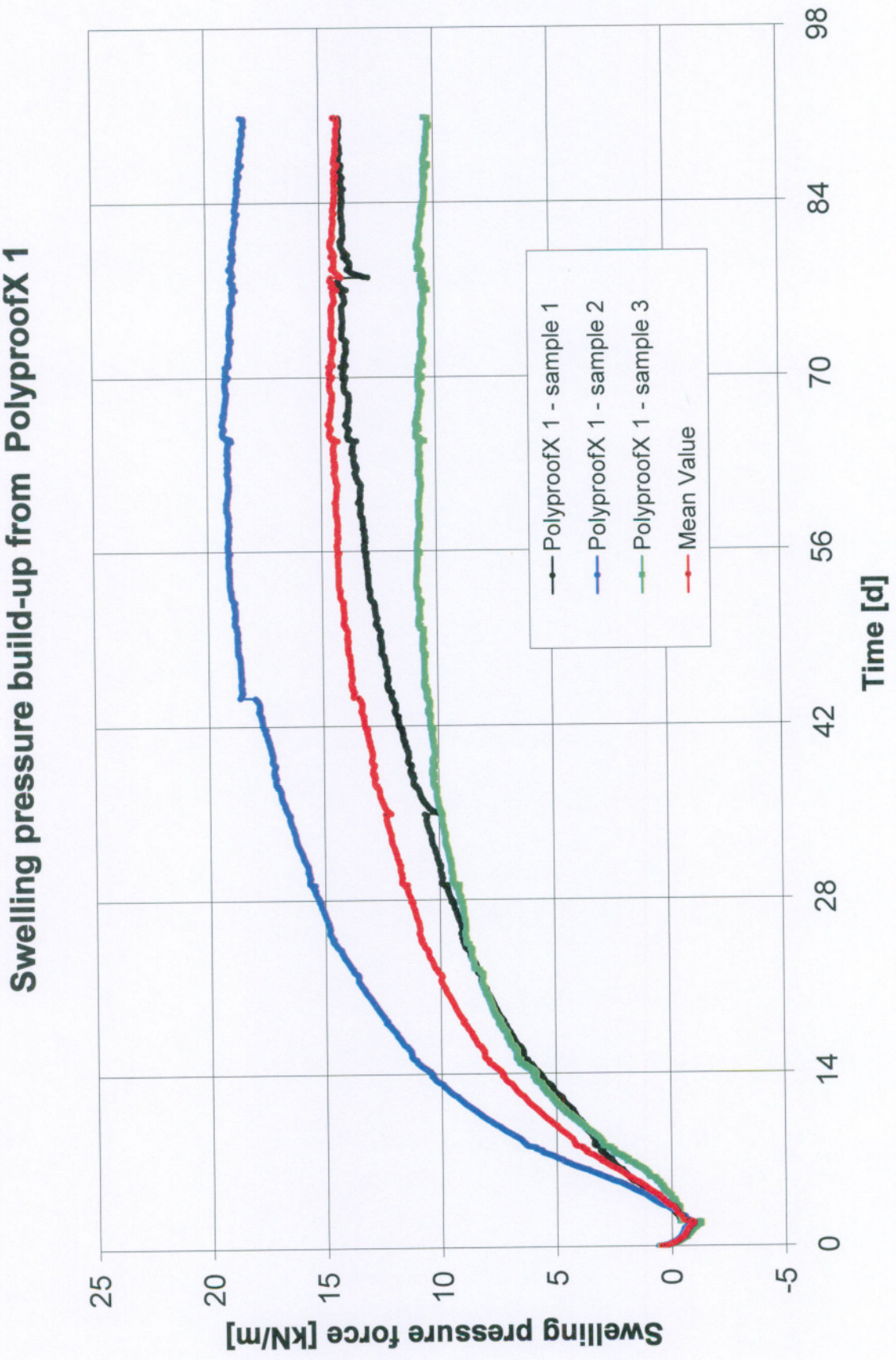


Fig. 4:
The swelling pressure test specimen when opened with the swelling tape still adhering well to the lower part


Unobstructed swelling behaviour of PolyproofX 1
Change in mass [%]
300
250
200
150
100
50
0
0
14
28
42
56
70
84
98
112
126
Time [d]
pH value 7
pH value 4,5
pH value 13


Swelling pressure build-up from PolyproofX 1
Swelling pressure force [kN/m]
25
20
15
10
5
0
-5
0
14
28
42
56
70
84
98
Time [d]
PolyproofX 1 - sample 1
PolyproofX 1 - sample 2
PolyproofX 1 - sample 3
Mean Value