MFPA Leipzig GmbH

Recognised Test Office for Construction Materials, Components and Types

Test, Monitoring and Certification (PÜZ) Office according to the State Building Code (SAC 02), Building Product Law (NB 0800)

Deutscher Akkreditierungs Rat DAR

DAP-PL-4077.00

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MFPA

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

Work Group: Building Structure Sealing

Test Report

PB 2.2/07-286

dated 24 January 2008 1st of 3 copies

Object: *DRYset injection profile* - tests for obtaining a general building supervisory test certificate as per building regulations list A, part 2, number 1.4

Applicant: Drytech Group AG Heidiland
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Testing period: October 2007 to January 2008

This test report consists of 12 pages and 1 annex.

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Table of Contents

1 Task

Technical applicability tests will be used to investigate the suitability of the single-channel injection channel *DRYset injection profile* from the *Drytech Group AG Heidiland* as a joint insert for sealing working joints. The test to be carried out will form the basis for issuing a general building supervisory test certificate as per building regulations list A, part 2, consecutive number 1.4 entitled „Normally Inflammable Joint Seals for Building Components Made of Concrete with High Water Penetration Resistance against Pressurised and Non-Pressurised Water and Soil Moisture" (Normalentflammbare Fugenabdichtungen für Bauteile aus Beton mit hohem Wassereindringwiderstand gegen drückendes und nichtdrückendes Wasser und gegen Bodenfeuchtigkeit). The nature and scope of the tests are based on the test principles for joint seals, version of June 2006.

2 Object of the Investigations

2.1 Injection Channel

The orange-coloured *DRYset injection profile* to be studied is a U-shaped rectangular cross-section with dimensions of approximately 30 mm x 10 mm with a formed and rounded transport channel attached to a flexible branch-shaped foamed material layer (dimensions: 25 mm x 20 mm) (Annex 1, Figure 1). While the U-profile is made of HDPE, the manufacturer states that the yellow foam profile is based on polyester. The bonding depth of the foamed material in the plastic profile is 10 mm.

The *DRYset injection profile* is offered in 2 m long elements. The client provides connecting pieces (straight and 90° angle) and end pieces for connecting single elements to one another and finishing off the section ends. 20 m of the injection channel and various accessory parts delivered by the client were available for the tests. The injection channel was filled when it was injected with water-soluble materials via extension hoses (grouting and ventilating ends) connected with the channel via connecting pieces. Non-water-soluble substances such as PUR resin are injected via drillhole and packers inserted in them.

The injection channel is fastened with percussion dowels on the very even, clean and oil-/grease-free concrete subgrade through the predrilled holes arranged at spacings of 30 cm. Fastening on the subgrade has to guarantee that the sealing material cannot change its installation position when concreting. The injection channel is generally ar-

ranged in the middle of the joint. Compressing the foamed material layer when fastening the channel makes it possible to ensure contact over the entire area of the injection profile to the subgrade. The foamed material profile can even out slight roughness.

2.2 Injection Materials

Proof for functional suitability of the injection system is provided with a resin based upon polyurethane and with an acrylate resin. For this purpose the client provided the PUR resin with the name *DRYflex 7* and the acrylate resin *DRYflex 2 with DRYflex plus*.

2.2.1 DRYflex 7

The manufacturer states that the PUR injection resin *DRYflex 7* is a highly elastic closed-pore 2-component injection material based upon polyurethane for closing, sealing and expandable connections of cracks and working joints. The ratio of mixing of A (resin) : B (hardener) is 2:1 mass proportions, which equals a volume ratio of 3:1. The processing period is approximately 45 min at 23° C.

2.2.2 DRYflex 2 with DRYflex plus

DRYflex 2 with DRYflex plus is a modified multiple-component injection material based upon acrylic resins. The filled acrylate resin is water-swellable and flexible. Four components are brought together to make the gel. They are:

stock component	A I	(48.5 m.-%)
catalyst	A II	(2.4 m.-%)
DRYflex plus	B I	(48.8 m.-%)
initiator (salt)	B II	(0.5 m.-%)

The single components are premixed to a A-component and a B–component and brought together with a two-component pump immediately before injecting.

3 Tests

3.1 Identified Tests

The following characteristic values are determined for identifying the injection materials:

- density
- pot life / time of reaction
- refraction index
- viscosity and rise in viscosity
- thermogravimetric analysis (TGA)
- IR spectrum

3.2 Injectability and Rinsability of a 6 m Channel Section

Angled off channel sections with a total length of 6 m are installed circumferentially on the edge of a square concrete slab and covered with concrete to test the injectability of the injection channel for each injection material (Annex 1, Figure 2). Covering the channels has the purpose of preventing the injection material from escaping uncontrolled. On both test specimens we linked the ends of the injection profile with grouting ends that are led out of the concrete. This makes it possible to better check whether the profile allows passage through.

3.3 Function Test - Sealing Test

Proof of the functions of the injection system takes place using sealing tests on two test specimens of the same design with a replicated wall-floor working joint (Fig. 1). The channel is fastened to a floor slab measuring 1.0 m x 1.0 m x 0.3 m (lower part of the test specimen) in single sections to be linked via connecting pieces and angles following the processing instructions. Installing the channel elements applied all of the types of linking and spacing given in the data sheet.

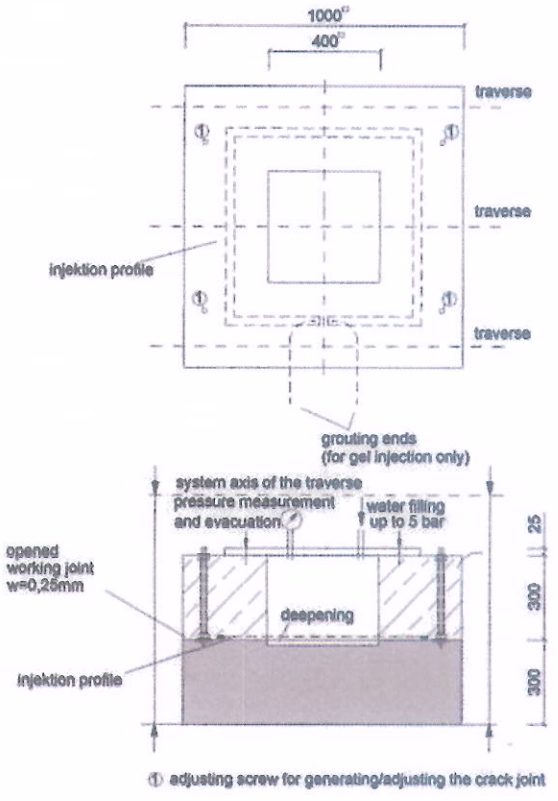
While fabric-reinforced grouting ends are connected on both ends of the injection profile and led out of the formwork for the test specimen to be injected with gel (Annex 1, Figure 3), the injection profile of the test specimen to be grouted with PUR resin is laid in the form of two U-shaped sections in a mirror-reversed arrangement. The ends of the sections are

connected with one another on one side with a straight connecting piece. On the opposite side the ends of the sections are 5 cm apart. Finally, the upper frame is concreted.

The upper reinforced concrete frame corresponding to the wall can be lifted for producing the crack with the reinforcing cage to be set down on the plate. The cavity inside of the test specimen measuring 0.4 x 0.4 x 0.3 [m] is used for filling water and exposing the injected wall-floor working joint to pressurised water.

The adjustment of the working joint width from 0 to 0.25 mm takes place with the aid of the built-in adjusting screws and is checked with 4 dial gauges fastened on the sides above the joint. Steel traverses are spanned around the test specimen in order to fix the joint in place.

Co-workers of the test office inject the test specimens opened to a joint width of 0.25 mm with the injection substances specified in Paragraph 2.2 in the client's presence.



Then, sealing is tested by applying water pressure on the injected joint at a maximum testing pressure of 5 bar. The water pressure is increased by 0.2 bar every day in the first week and by 1 bar in the second week to the agreed maximum pessure. This pressure is maintained over a period of 28 days.

After relieving the pressure, the water is removed and the test specimen is opened for assessing the degree of joint filling.

Fig. 1: Schematic diagram of the test specimen for the sealing test

4 Results of the Implemented Tests

4.1 Identified Tests

4.1.1 DRYflex 7

Table 1: Results of the identified tests on *DRYflex 7*

characteristic value	result
density	density of the single components: component A: ρ_A = 0.9660 g/cm³ component B: ρ_B = 1.2140 g/cm³ density of the reacted resin: ρ = 1.0443 g/cm³
viscosity and rise in viscosity at 23°C	η = 305 mPa s η = 1000 mPa s after t = 23 min (isothermal) η = 1000 mPa s after t = 16 min (free temperature development)
volatile components	- with water: 0.75 mass % - without water: 0.01mass %

The thermogravimetric analysis was carried out at a heating rate of 10 K/min. The curves were recorded under nitrogen. Oxygen was added at 600° C. You can see the test results in the table below. The TGA curves are stored in the test office, although they are not a component of this test report.

Table 2: TG-DTA curve of the components A and B and the hardened resin

component / decomposition level	loss in mass [m.-%]	DTG peak [° C]	DTA peak [° C]	heat tone	allocation
A 1	99.95	402.5	414.5	exothermal	resin
			518.9	exothermal	soot
B 1	54.89	322.1	344.3	exothermal	hardener, partial component 1
2	11.36		420.1	exothermal	hardener, partial component 2
		511.0	523.0	exothermal	
3	33.14	623.7	638.6	exothermal	soot
		Sch	727.1	exothermal	
total	99.39				
hardened 1	11.4	319.2			uncrosslinked residue
2	82.8	397.9	409.4	exothermal	polymer
		Sch	524.2	exothermal	
3	5.72	672.2 [1)]	680.9 [1)]	exothermal	soot
total	99.92				

[1)] adding oxygen at 655 °C

Table 3: Changing the mass after water storage

test condition	after removing from the formwork			after 14 days of targeted storage			storage to mass constancy[1)]		
		[g]	[%]		[g]	[%]		[g]	[%]
changing mass when storing in normal climate (the mean value of three measurements)	$m_{1.1}$	67.5	100	$m_{3.1}$	66.4	98.37	$m_{5.1}$	66.0	97.78
	$m_{1.2}$	65.8		$m_{3.2}$	64.7	98.33	$m_{5.2}$	64.2	97.57
	$m_{1.3}$	66.4		$m_{3.3}$	65.3	98.34	$m_{5.3}$	64.7	97.44
	MV	**66.57**	**100**	**MV**	**65.47**	**98.35**	**MV**	**64.97**	**97.60**
changing mass when storing in distilled water (the mean value of three measurements)	$m_{2.1}$	66.6	100	$m_{4.1}$	67.3	101.05	$m_{6.1}$	65.6	98.50
	$m_{2.2}$	65.6		$m_{4.2}$	66.9	101.98	$m_{6.2}$	64.5	98.32
	$m_{2.3}$	68.0		$m_{4.3}$	68.0	100.00	$m_{6.3}$	66.7	98.09
	MV	**66.73**	**100**	**MV**	**67.40**	**101.01**	**MV**	**65.60**	**98.30**

[1)] max. 28 days after targeted storage

The IR spectrum is stored at the test office, although it is not a component of this test report. The compatibility of *DRYflex 7* with concrete was proven and documented in a prior test[1].

4.1.2 DRYflex 2 with DRYflex plus

The table below compiles the results of the identifying tests and studies of the characteristic properties of the acrylate resin *DRYflex 2 with DRYflex* plus used.

Table 4: Properties of *DRYflex 2 with DRYflex* plus

characteristic value	result		
pot life	at 6°C: at 15°C: at 20°C: at 23°C:	21.5 min (0.5 % salt) 13.5 min (0.5 % salt) 9.5 min (0.5 % salt) 9 min (0.5 % salt)	32 min (0.25 % salt) 18 min (0.25 % salt) 14 min (0.25 % salt) 13 min (0.25 % salt)
density at 23°C	*DRYflex* 2 A I: *DRYflex* 2 A II:	1.055 g/cm³ 0.930 g/cm³	

[1] PP 5.1/07-384: „Compatibility of *DRYflex 7* with concrete", MFPA Leipzig, 28.07.2006

characteristic value	result		
	DRYflex plus: 1.015 g/cm³		
refraction index at 23°C	A I: 1.4216	A II: 1.4398	
viscosity without component starting the reaction at 23 °C	4.2 mPas (γ = 250 1/s)		
unprevented swelling behaviour in water and KOH	maximum mass increase :	water: $CaOH_2$: KOH:	Δm = 25 % Δm = 18 % Δm = 27 %

4.2 Injecting the 6 m Channel Sections

- **Injecting Polyurethane Resin**

Grouting the 6 m long multiply-angled injection profile with DRYflex 7 indicated that it is possible to fill the injection profile with the PUR resin at this length. After the material escaped on the ventilating end of the channel section, it was clamped off and more material was injected into the working joint while building up the pressure. The test was ended after the resin escaped from the working joint.

- **Injecting Acrylate Resin**

The acrylate resin *DRYflex 2 with DRYflex* plus used for this test was adjusted so that it could be injected about 15 minutes. The injection channel could be filled on one side over its entire length of 6 m and was rinsed about 5 minutes with water 10 min after completing the gel injection and it could be injected again with *DRYflex 2 with DRYflex* plus after another 10 minutes without any restrictions (Annex 1, Figure 4).

4.3 Function Test - Sealing Test

The implemented functional tests are intended to prove the suitability for retrospective sealing of working joints that have a constant joint width of 0.25 mm. The following tables compile the results of the sealing tests carried out.

Table 5: The sealing test results of the working joint injected with DRYflex 7

testing period [d]	water pressure [bar]	flow-through [ml]	remarks
-	-	-	drillhole of the injection channels on the opposite sides of the test specimen and opening the working joint to 0.25 mm
-	-	-	material escaping from the working joint on all sides when injecting the channel with *DRYflex 7* over both drilling channels (Annex 1, Figure 5)
4	0.2-0.8	0	increasing the test pressure by 0.2 bar/day working joint sealed immediately at the beginning of exposure to pressurised water
3	1.0	0	sealed
4	2.0-4.0	0	sealed
28	5.0	0	no water at all escaping from the working joint

The working joint opened to 0.25 mm could be filled and sealed on all sides with polyurethane resin. The impermeability of the working joint filled with *DRYflex 7* was proved with the subsequent exposure to water pressure up to 5 bar. Opending the test specimen after the end of the sealing test revealed even distribution of the polyurethane resin in the working joint and the foamed material of the channel (Annex 1, Fig. 6). It was not possible to identify any signs of cement particles in the channel cross-section after disassembling the *DRYset injection profile* remaining in the concrete of the wall frame.

Table 6: The sealing test results of the working joint injected with *DRYflex 2 with DRYflex* plus

testing period [d]	water pressure [bar]	flow-through [ml]	remarks
-	-	-	- filling the injection profile until material escapes at the ventilating end - sealing the ventilating end and building up pressure until material escapes from the working joint while injecting the other end of the channel until material escapes on all sides - material regrouted after a break of 3 minutes - rinsing the injection profile with water after a break of 10 min. - Annex 1, Figure 7

testing period [d]	water pressure [bar]	flow-through [ml]	remarks
3	0.2-0.6	cannot be meas-ured	- increasing test pressure by 0.2 bar/day - working joint immediately sealed at the beginning of exposure to pressurised water - slight local leaks that do not reduce at 0.6 bar
1	0	0	- pressure shut off - injection profile rinsed with water - widening the working joint by 0.1 mm and injecting with gel again
4	0.2-0.8	0	- increasing test pressure by 0.2 bar/day - working joint immediately sealed at the beginning of exposure to pressurised water
3	1.0	0	sealed
2	2.0-3.0	0	sealed
28	4.0	0	no water at all escaping from the working joint

The working joint opened to 0.25 mm and widened by another 0.1 mm could be filled and sealed on all sides with acrylate resin. The impermeability of the working joint filled with *DRYflex 2 with DRYflex* plus could be proved with the subsequent exposure to water pressure up to 4 bar water pressure. Opening the test specimen after the end of the sealing test revealed even distribution of the material in the working joint and in the foamed material of the channel (Annex 1, Figure 8). It was not possible to identify any signs of cement particles in the channel cross-section after disassembling the *DRYset injection profile* remaining in the concrete of the wall frame.

5 Assessment and Summary

A series of experiments were carried out to test the *DRYset injection profile* suitability *from the Drytech Group AG Heidiland for sealing working joints*. The tests showed the properties below:

- A 6 m channel section encased in concrete was tested for injectability with *DRYflex 7 and DRYflex 2 with DRYflex* plus and this test revealed that the injection channel can be injected with the specified injection materials over this length.
- The working joint sealed with *DRYflex 7* via the *DRYset injection profile* is waterproof up to the water pressure of 5 bar.
- The working joint sealed with *DRYflex 2 with DRYflex* plus via the *DRYset injection profile* is waterproof up to a water pressure of 4 bar.

The tested working joint seal can only function properly if waterproof concrete is used, the geometry of the working joint is faultless and the *DRYset injection profile* is installed correctly in accordance with the processing instructions of the DBV Technical Information Leaflet[2].

Leipzig, 24 January 2008

i. V.

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[2] DBV Merkblatt „Grouted injection hoses for working joints" (Verpresste Injektionsschläuche für Arbeitsfugen), version of June 1996

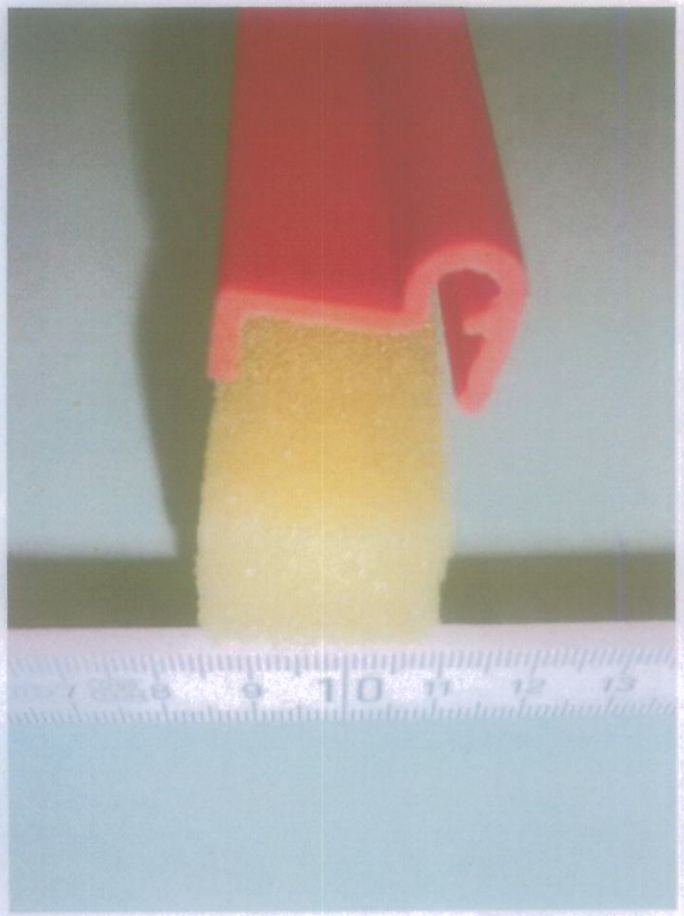

Fig. 1: DRYset injection profile

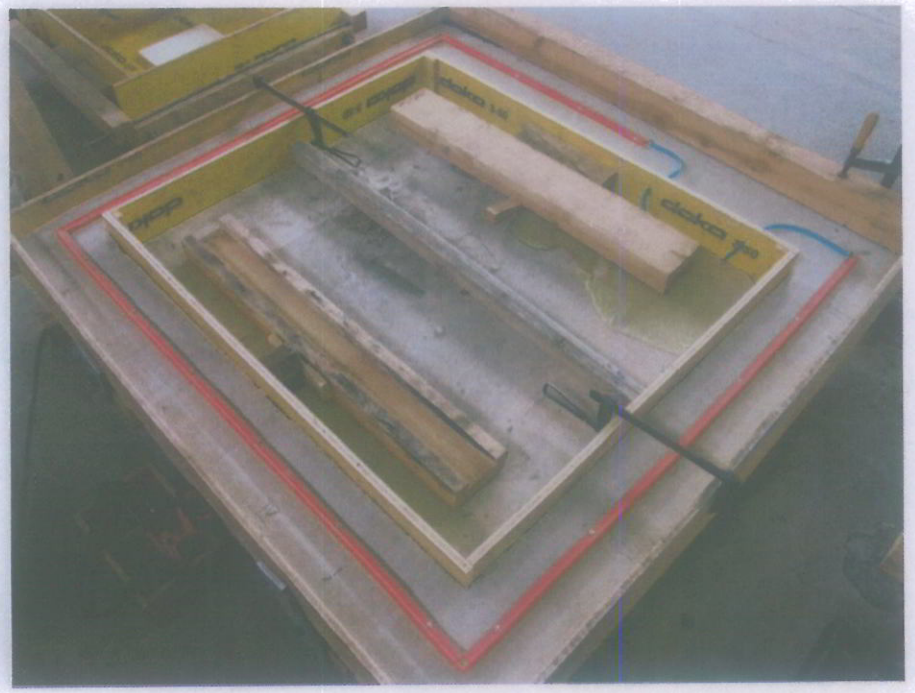

Fig. 2: Installing the DRYset injection profile to test the injectability of a 6 m section

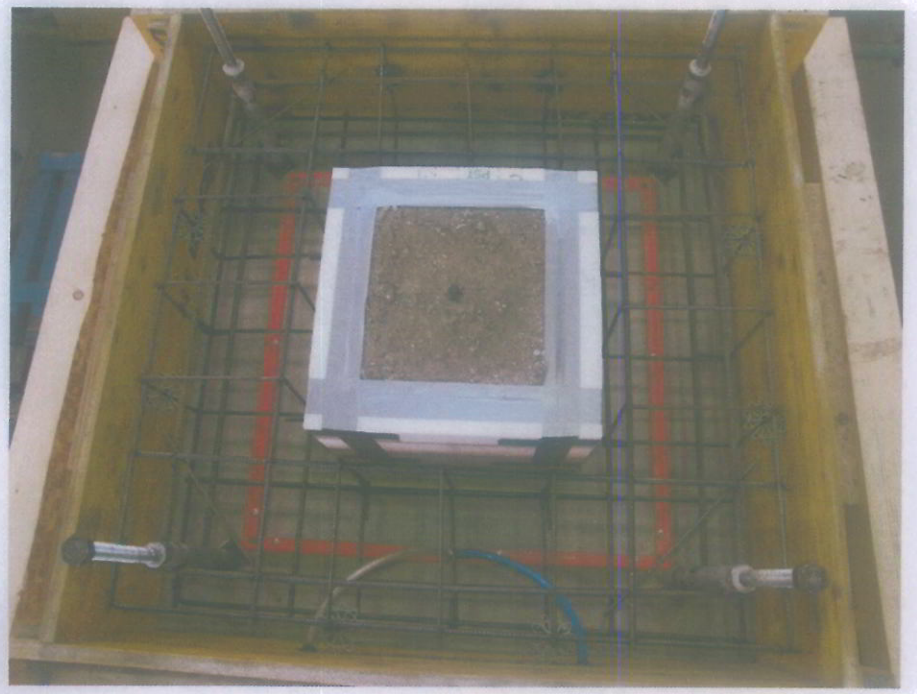

Fig. 3: Sealing test specimen with injection profile installed on the base plate before concreting the wall frame

Fig 4: Material escaping from the working joint when injecting the 6 m channel section with *DRYflex 2 / DRYflex plus*

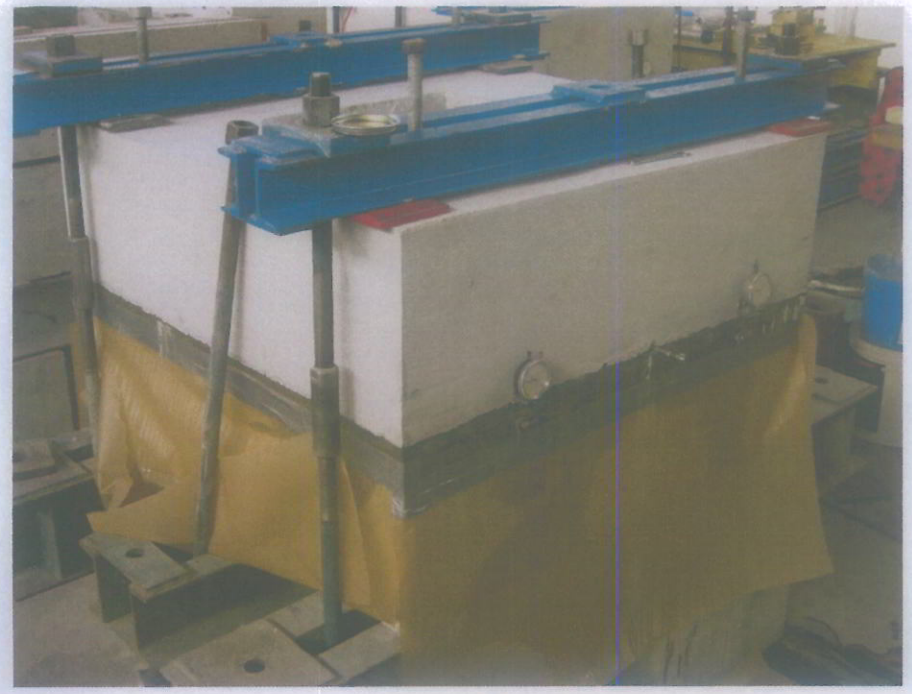

Fig. 5: Injecting the sealing test specimen with *DRYflex 7* via packers

Fig. 6: Disassembled wall frame of the sealing test specimen injected with *DRYflex 7* distributing the injection material over a large area

Fig. 7: 2nd sealing test specimen when injecting with *DRYflex 2 / DRYflex plus*

Fig. 8: Exposed injection profile after disassembling the wall frame where the distribution of the *DRYflex 2 / DRYflex plus* can be easily seen