Test Report

No. 11-002686-PR04 (PB-K05-09-en-01)*

Date of Report 15. September 2011

Client

HILTI AG
Befestigungstechnik
Feldkircherstraße 100

9494 Schaan
Fürstentum Liechtenstein

Order Comparative adhesion test of PUR foam filled in a joint - in initial state and following exposure to mechanical load (ea. 3,000 cycles elongation/compression, transverse shear, longitudinal shear)

Object PUR-foam - designation
„CS-F JS“

Contents

*) Transcription of Test Report 105 35276e dated 31 August 2009

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1. Order

The company HILTI AG, FL-9494 Schaan, commissioned the **ift** Rosenheim with the transcription of the test report 105 35276e dated 31 August 2009 according to identity declaration of the customer dated 18 August 2011. The original test report documents the comparative adhesion test of PUR foam filled in a joint - in initial state and following exposure to mechanical load (ea. 3,000 cycles elongation/compression, transverse shear, longitudinal shear).

2. Object

3.1 Description of test specimen

The original client made available to the **ift** ea. 2 test specimens per foam type, composed of a concrete lintel (W x H x L: 90 mm x 60 mm x 1,200 mm), a white plastic window profile section, ea. of 1,000 mm length, and PUR foams filled into the joint of approx. 20 mm width.

The PUR foams are the products listed below:

Designation	CS-F JS
Material / Base	moisture-cure, one-component installation foam (in-situ foam) PUR based, colour: light yellow
Weight per unit area	approx. 25 kg/m^3
Cell structure	fine to medium-sized pores

Comparative product:

Designation	PU foam
Material / Base	moisture-cure, one-component installation foam (in-situ foam) PUR based, colour: light yellow
Weight per unit area	approx. 22 kg/m^3
Cell structure	fine to medium sized pores, mainly closed pores

3.2 Representation of test specimen

Fig. 1 shows a model of the test set-up.

Fig. 1 Test specimen

3. Procedure

3.1 Sampling

The specimens were selected by the original client.

Number	4
Delivered on	9 September 2008, by the original client
Registration No.	24522/001 to 004
Preparation	The test specimens had been prepared by the original client and were delivered ready for testing. Before the test the test specimens were conditioned at standard atmosphere (23℃ / 50 % air humidity) for at least seven days.

3.2 Test method

For the adhesion test, the test programme agreed was as follows: one test specimen of one foam type each was first exposed to mechanical load. The mechanical load was represented by a cyclical joint movement and applied at standard atmosphere. For this the PUR foam is compressed and extended in succession as a function of joint width (approx. 20 mm) by ± 12.5 % (equal to ± 2.5 mm) and shear stress is applied to the joint in transverse and longitudinal direction.

Movement frequency was 1.0 min^{-1} comprising a total of 9,000 movements (3,000 cycles per direction of movement). The directions of movement are presented in Fig. 2.

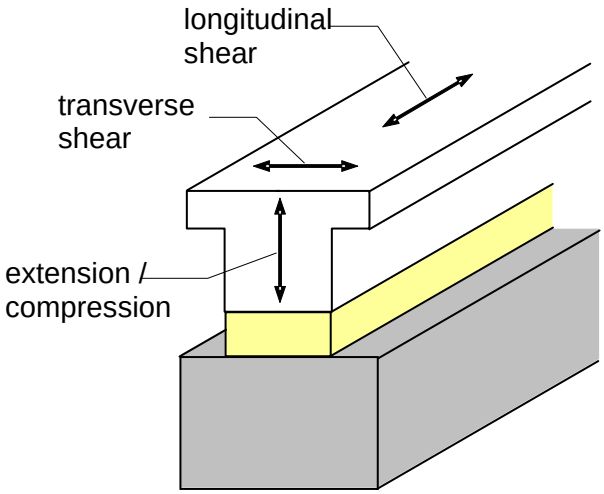


Fig. 2 Directions of movement for application of mechanical load

Fig. 3 shows an exemplary load cycle (plotter window showing 4 amplitude movements). Figs. 4 to 6 show the test set-up for the three directions of load application.

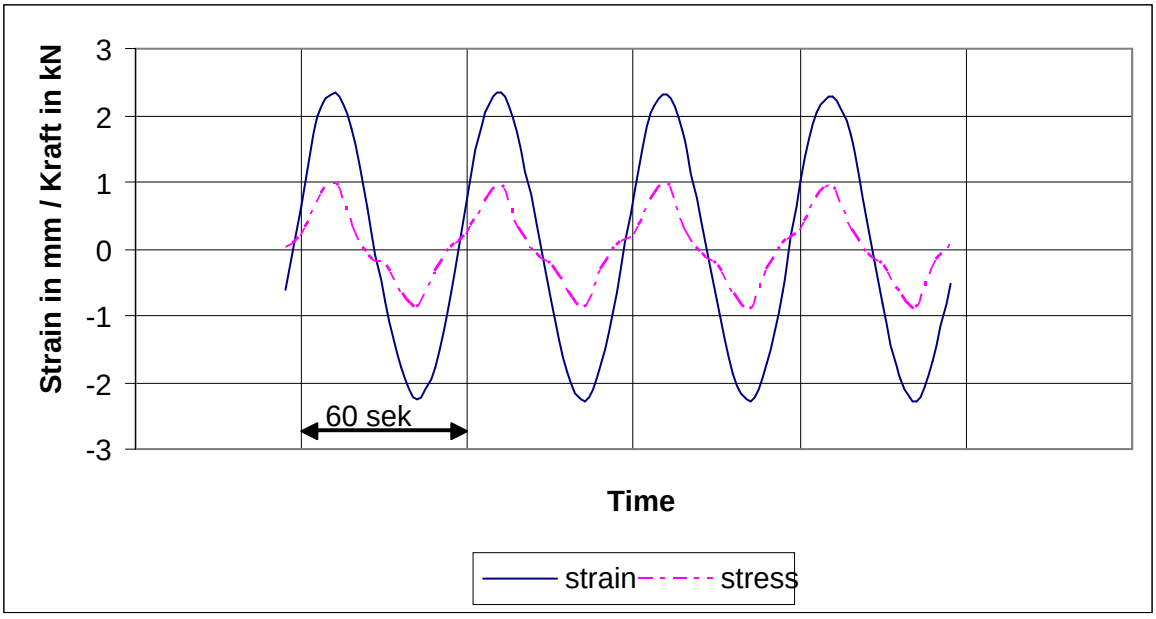
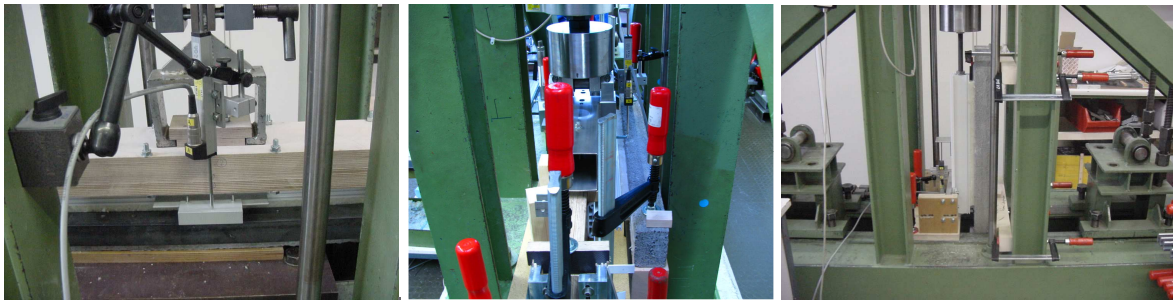


Fig. 3 Window of 4 amplitude movements from the load cycle



Figs. 4 to 6 Test set-up for mechanical cyclical load application (extension/compression (left), transverse shear (centre) and longitudinal shear (right)

This is followed by determination of tensile strength by load application to the exposed test specimens and comparison with unexposed samples (initial state). The specimens are tested at standard atmosphere, applying a feed rate of 5 mm/min. For this the test specimens are cut into pieces of equal length by application of separating cuts in the area of the PVC profile and the foamed joint. In addition to strength the failure pattern is evaluated. Fig. 7 shows an example of the test set-up.

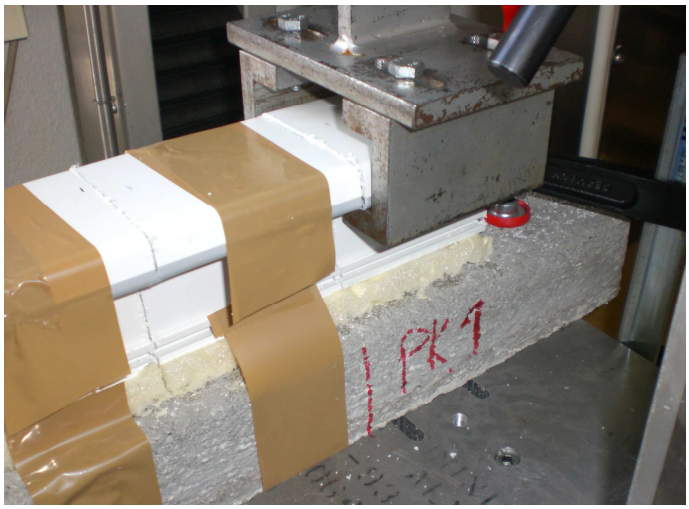


Fig. 7 Test set-up for tensile test

3.3 Test equipment

Table 1 Test equipment

Type of test	Test equipment	Device No.
Pre-conditioning	Standard atmosphere chamber	22040
Mechanical alternating load	Materials testing machine II as per DIN EN ISO 7500-1	22500
Tensile test	Materials testing machine I as per DIN EN ISO 7500-1 Calliper gauge	22933 22413

3.4 Testing

Date/Period 7 January to 16 March 2009

Test engineer/s Robert Happach
Wolfgang Jehl, Dipl.-Ing. (FH)

4. Results

4.1 Alternating mechanical load

Table 2 below sums up the findings and results of testing.

Table 2 Summary of results

No	Type of test	Amplitude movement *	Cycles	Findings
CS-F JS (effective joint width b = 18,4 mm)				
1	Extension/ compression	± 2.3 mm	3000	No detachments or crack formation in the area of the foamed joint
2	Transverse shear	± 2.3 mm	3000	No detachments or crack formation in the area of the foamed joint
3	Longitudinal shear	± 2.3 mm	3000	No detachments or crack formation in the area of the foamed joint
Comparative product (actual joint width w = 20.0 mm)				
1	Extension/ compression	± 2.5 mm	2719	After 2,719 cycles continuous foam breakage, test aborted
2	Transverse shear	--	--	not tested
3	Longitudinal shear	--	--	not tested
*) 12.5 % of effective joint width				

After a total of 9,000 cycles, the product CS-F JS did not show any apparent damage in the area of the foamed joint.

After approx. 1,500 cycles, the foamed joint of the comparative product showed initiation of crack formation as a result of extension and compression. After 2,719 cycles continuous foam breakage was detected. The test was aborted.

4.2 Tensile test, comparative test of unexposed/exposed specimens

Tables 3 and 4 below sum up the detailed values referring to tensile strength obtained from exposed and unexposed specimens. The evaluation states the average and the standard deviations. The failure patterns are expressed as percentage of cohesive loss in the PUR foam and/or adhesive loss towards the PVC profile.

Table 3 Results of testing unexposed specimens

Specimen No.	Tensile strength in N/mm²	Displacement in mm	Failure pattern, percentage of loss	
			Cohesion	Adhesion to PVC
1	0.0142	9.16	5 %	95 %
2	0.0241	10.81	10 %	90 %
3	0.0362	12.74	5 %	95 %
4	0.0284	11.80	5 %	95 %
5	0.0355	12.57	15 %	85 %
6	0.0330	13.02	5 %	95 %
7	0.0362	13.54	50 %	50 %
8	0.0367	12.24	45 %	55 %
9	0.0382	13.02	55 %	45 %
10	0.0366	13.15	60 %	40 %
Average value	0.0319	12.21	-	-
Standard deviation	0.0076	1.32	-	-

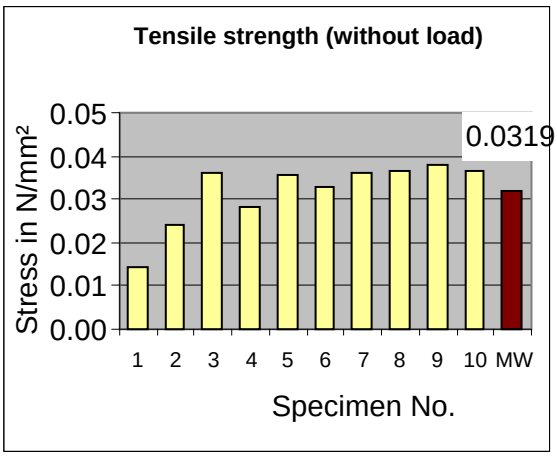
Table 4 Results of testing exposed specimens

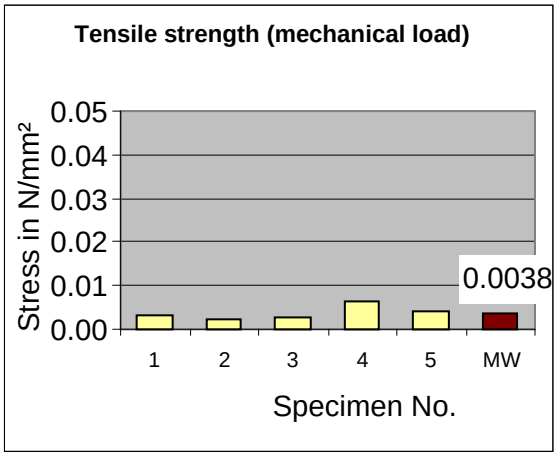
Specimen No. *)	Tensile strength in N/mm²	Displacement in mm	Failure pattern, percentage of loss	
			Cohesion	Adhesion to PVC
1	0.0032	3.33	95 %	5 %
2	0.0023	7.11	90 %	10 %
3	0.0026	7.47	65 %	35 %
4	0.0064	6.82	97 %	3 %
5	0.0043	7.16	94 %	6 %
Average value	0.0038	6.38	-	-
Standard deviation	0.0017	1.72	-	-

*) The number of test specimens decreased to 5, because the test specimen had to be cut to 500mm in length for mounting in the testing apparatus for the longitudinal shear test

Comparison of results obtained from unexposed/exposed specimens

The following diagrams 1 and 2 plot the results of tensile testing obtained from the two tests.

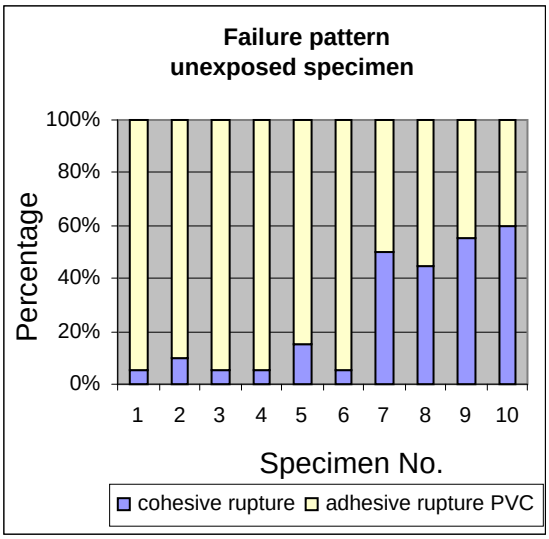


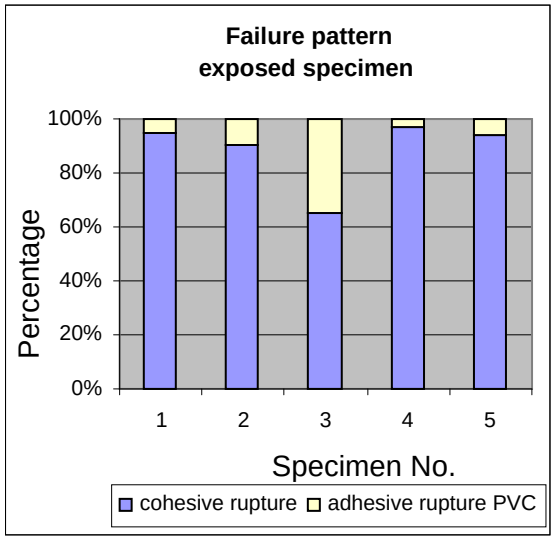


Diagrams 1 and 2 Tensile strength of unexposed specimen and specimen exposed to mechanical load (column MW = average value)

Following ageing by application of mechanical load, the average tensile strength of the test specimens had decreased considerably. As compared to the unexposed specimen the deviation was -91.6%.

Diagrams 3 and 4 plot the evaluated failure patterns (percentage of cohesive-/adhesive loss) of the unexposed and exposed test specimens.





Diagrams 3 and 4 Plot of failure patterns of unexposed specimen and specimen exposed to mechanical load.

When comparing the failure patterns of the exposed and unexposed specimens, it results that the types of failure are different. The unexposed specimens show an interference with lower percentage of cohesive failure in the PUR foam and high percentage of adhesive loss towards the PVC profile, whereas the type of failure of the exposed specimens is mainly cohesive loss in the PUR foam. A negative impact on the adhesion of the PUR foam to the substrate caused by the mechanical load cannot be seen.

5. Notes on using ift-Test Documents

The enclosed Guidance-Sheet "Conditions and Guidance for the Use of **ift** Test Documents“ lays down the rules for using the test reports. The cover sheet can not be used as abstract.

Transcription of Test Report 105 35276e dated 31 August 2009.

ift Rosenheim
15 September 2011

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