INSTITUT FÜR BAUFORSCHUNG AACHEN

Test Report
M 1299/2

Testing on Reinforcement Continuity Systems (Shear Tests) according to the Leaflet "Rebending" of the German Association of Concrete and Structural Engineering

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SUBJECT Testing on Reinforcement Continuity Systems (Shear Tests) according to the Leaflet "Rebending" of the German Association of Concrete and Structural Engineering

Test Report No. M 1299/2 dated 17.04.2009

Development of Subject Prof. Dr.-Ing. M. Raupach

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1 USE OF REINFORCEMENT CONTINUITY SYSTEMS

For simplifying formwork for reinforced-concrete members, reinforcing bars may be rebent if the reinforcement at construction joints is penetrated. The pre-bent section of the reinforcing bars are arranged in the inner side of the formwork in such a way that, after the formwork is struck, the reinforcing bars are exposed and then can be straightened horizontally.

For further simplifying this work, some manufacturers offer prefabricated reinforcement continuity systems in which the pre-bent reinforcing bars are placed inside them. These reinforcement continuity systems are fixed to the inner side of the formwork. After the formwork is struck and the reinforcing bars are rebent, the rear part of the sheet-metal casing remains in the member.

The prerequisites and recommendations for this method and the constructive conditions are summarized in the leaflet entitled "Rebending" of the German Association of Concrete and Structural Engineering (des Deutschen Beton- und Bautechnikverein e.V (dbv)) which, in the edition of January 2008, takes into account the guidelines of DIN 1045-1:2008-08. In the appendix of this leaflet, shear tests performed in longitudinal and cross-sectional direction on reinforcement continuity systems are described which allow these reinforcement continuity systems to be classified in roughness classes according to table 14 of DIN 1045-1 and, thus, allow proof of shear stress at the site of the remaining back panel of the reinforcement continuity system casing.

2 GENERAL

The company Nevoga GmbH Znaimerstrasse 4 in 83395 Freilassing market reinforcement continuity systems bought from different producers. All of them manufacture reinforcement continuity systems with the identical specifications.

The company Nevoga commissioned the Institute of Building Materials Research in Aachen (*ibac*) with the creation of a testing report which summarizes the preceding, reinforcement continuity system tests of ibac that were performed in longitudinal direction and in cross-sectional direction.

This summary is possible and sensible, because the two different tests took place on specimens of reinforcement continuity systems from the same delivery to *ibac*.

The sections of the reinforcement continuity systems used for the tests were delivered to *ibac* on November 10, 2008.

3 SPECIMENS

Reinforcement continuity systems with a length of 400 mm and a width of ca. 145 mm were applied for testing; according to specifications, these had been delivered to *ibac* on November 10, 2008.

For testing, two-component shear-test specimens were casted in concrete according to Appendix 2 of the leaflet "Rebending". Figure B1, page B1, systematically depicts the testing in longitudinal direction, whereas figure B2, page B2, shows the testing in cross-sectional direction. For each testing direction, three two-component concrete specimens with reinforcement continuity systems were manufactured and investigated; for comparison, two homogeneous reference members were also fabricated and tested.

For precisely describing the geometry and profiling, the galvanized-steel (sheet-metal) back panel was measured, and the height profile of the dimples was determined. The established measurements are presented in a total overview in figure B3, page B3. The position of the profile lines can be recognized from the figures B5 and B6, pages B4 and B5, respectively. The individual values of the profile measurements are compiled in tables A3 and A4, pages A3 and A4, respectively.

4 PRODUCTION OF THE TEST SPECIMENS

The test specimens were produced with concrete of consistency KR and of the grading curve AB 16. The composition of the concrete is found in table 1.

Table 1: Concrete composition

Grain size	Cement content	w/z-Value
mm	kg/m³	-
1	2	3
Grading curve AB16	320	0.58

Table 2: Compaction spread of the fresh concrete mixture and the compression strength of the mixture at the testing time

Test in	Mixture	Compaction spread	Compression strength at the time of the shear test
-	-	cm	N/mm²
1	2	3	4
Longitudinal direction	1	44	36.0
	2	45	29.6
Cross-sectional direction	1	45	35.5
	2	45	32.5

Table 2 depicts the compaction spread of the concrete mixtures and the compression strengths measured on the cubes of 150 mm edge length at the time of the shear tests.

Photographs of the test specimen fabrication before and after the casting of the first test specimens are presented in figures B7 and B8, page B6.

5 SHEAR TESTS

The shear tests took place on a compression testing machine according to EN 12390-4 of Class1 with a maximum load of 10 MN in the load range of 500 kN. The load rate was 4 kN/s.

Exemplary photographs of the test specimens after the break are illustrated in figures B9 to B12, pages B7 and B8.

The ultimate loads established in the test in longitudinal direction are listed in table 3.

Table 3: Ultimate loads of the shear tests in the direction "longitudinal" with respect to a reinforcement continuity system with a width of 144 mm

Test specimen	No.	Ultimate Load		Mean value based on the reference value[1)]
		Single value	Mean value	
-	-	kN		%
1	2	3	4	5
With reinforcement continuity system	1	184.7	164.6	54
	2	149.7		
	3	159.4		
Homogeneous reference specimen	1	305.7	288.8	
	2	271.8		

1) at least 300 kN

The ultimate loads established in the shear tests in cross-sectional direction are found in table 4.

Table 4: Ultimate loads of the shear tests in the direction "cross-sectional" with respect to a reinforcement continuity system with a width of 144 mm

Test specimen	No.	Ultimate Load		Mean value based on the reference value[1)]
		Single value	Mean value	
-	-	kN		%
1	2	3	4	5
With reinforcement continuity system	1	125.5	121.4	40.5
	2	107.3		
	3	131.4		
Homogeneous reference specimen	1	279.9	291.1	
	2	302.2		

1) at least 300 kN

6 COMPARISON WITH THE REQUIREMENTS

In accordance with the leaflet "Rebending", the proof of shear transfer in joints for the reinforcement continuity system, manufactured identically according to specifications, took place corresponding to the surface structure "smooth" (roughness coordinate $c_j = 0.20$; shear coordinate $\mu = 0.6$) for both directions "longitudinal" and "cross-sectional". This was proven through separate tests in both directions.

Die Institutsleitung

Prof. Dr.-Ing. M. Raupach

Der Sachbearbeiter
i. A.

Dipl.-Ing. J. Leißner

Table A1: Compression strength of the members for the shear test in longitudinal direction measured on cubes with an edge length of 150 mm

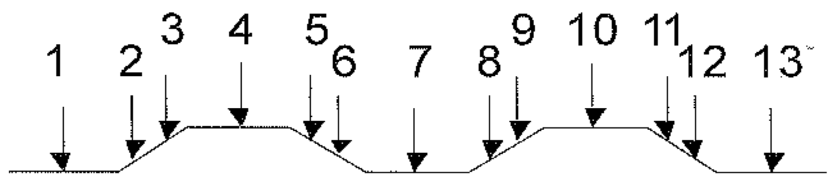
Test member	Age at test	Compression strength
-	d	N/mm²
1	2	3
1	0.88	5.71
	6	28.5
	9	32.7
	13	34.7
	16	35.2
2	0.88	5.74
	4	22.9
	8	28.0
	11	28.6
	11	30.0

Table A2: Compression strength of the members for the shear test in cross-sectional direction measured on cubes with an edge length of 150 mm

Test member	Age at test	Compression strength
-	d	N/mm²
1	2	3
1	0.83	6.7
	0.90	9.2
	4.0	24.6
	9.0	31.9
	14.0	34.3
	28.0	36.7
	28.0	40.1
	28.0	37.1
	28.0	36.3
2	0.92	9.6
	3	25.3
	6	29.4
	9	31.2
	9	31.1
	9	35.2
	28	40.6
	28	37.7
	28	39.5
	28	36.9
	28	39.6
	28	37.2

Table A3: Dimple heights in the back panel of the reinforcment continuity system casing; profile section in longitudinal direction according to Fig. B3 and Fig. B6

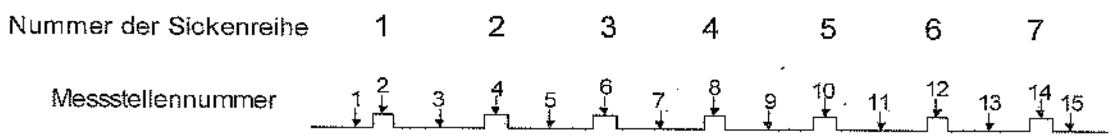
Measurement site within dimple row	Distance in height of the measurement points in dimple row i to a random reference plane						
	i=1	i=2	i=3	i=4	i=5	i=6	i=7
	mm						
1	2	3	4	5	6	7	8
1	1.49	1.69	1.13	1.70	1.45	1.33	0.79
2	2.28	2.20	1.50	2.10	2.00	2.15	1.41
3	3.00	2.90	1.90	2.50	2.53	2.73	1.99
4	3.32	3.54	2.25	2.98	3.15	3.15	2.62
5	2.60	2.80	1.85	2.53	2.60	2.49	1.97
6	1.90	2.10	1.29	1.91	2.03	1.83	1.23
7	1.43	1.63	0.98	1.47	1.33	1.14	0.63
8	2.02	2.44	1.27	1.74	2.01	1.78	1.32
9	2.84	3.17	1.74	2.24	2.63	2.40	1.96
10	3.30	3.53	2.12	2.71	3.02	3.00	2.60
11	2.80	2.80	1.70	2.30	2.45	2.32	1.95
12	1.90	2.10	1.30	1.80	1.89	1.48	1.31
13	1.48	1.70	0.88	1.30	1.28	1.04	0.72



Numbering of the measurement sites

Table A4: Dimple heights in the back panel of the reinforcement continuity system casing; profile section in cross-sectional direction according to Fig. B3 and Fig. B6

Measurement site within the profile section	Dimple row, see Fig. B5	Distance of the measurement site to the starting point of the measurement line	Distance in height of the measurement points in the dimple row to a random reference plane	
			Measurement 1	Measurement 2
		mm		
1	2	3	4	5
1	-	0	0.97	1.10
2	1	4.2	3.06	3.10
3	-	11.0	1.09	1.09
4	2	17.8	3.56	3.60
5	-	24.6	1.36	1.36
6	3	31.4	2.60	2.56
7	-	38.2	1.56	1.45
8	4	45.0	3.10	2.92
9	-	51.8	1.61	1.51
10	5	58.6	3.37	3.29
11	-	65.4	1.45	1.39
12	6	72.2	3.51	3.31
13	-	79.0	1.21	1.02
14	7	85.8	3.28	3.13
15	-	90.0	1.40	1.26



Numbering of the measurement sites

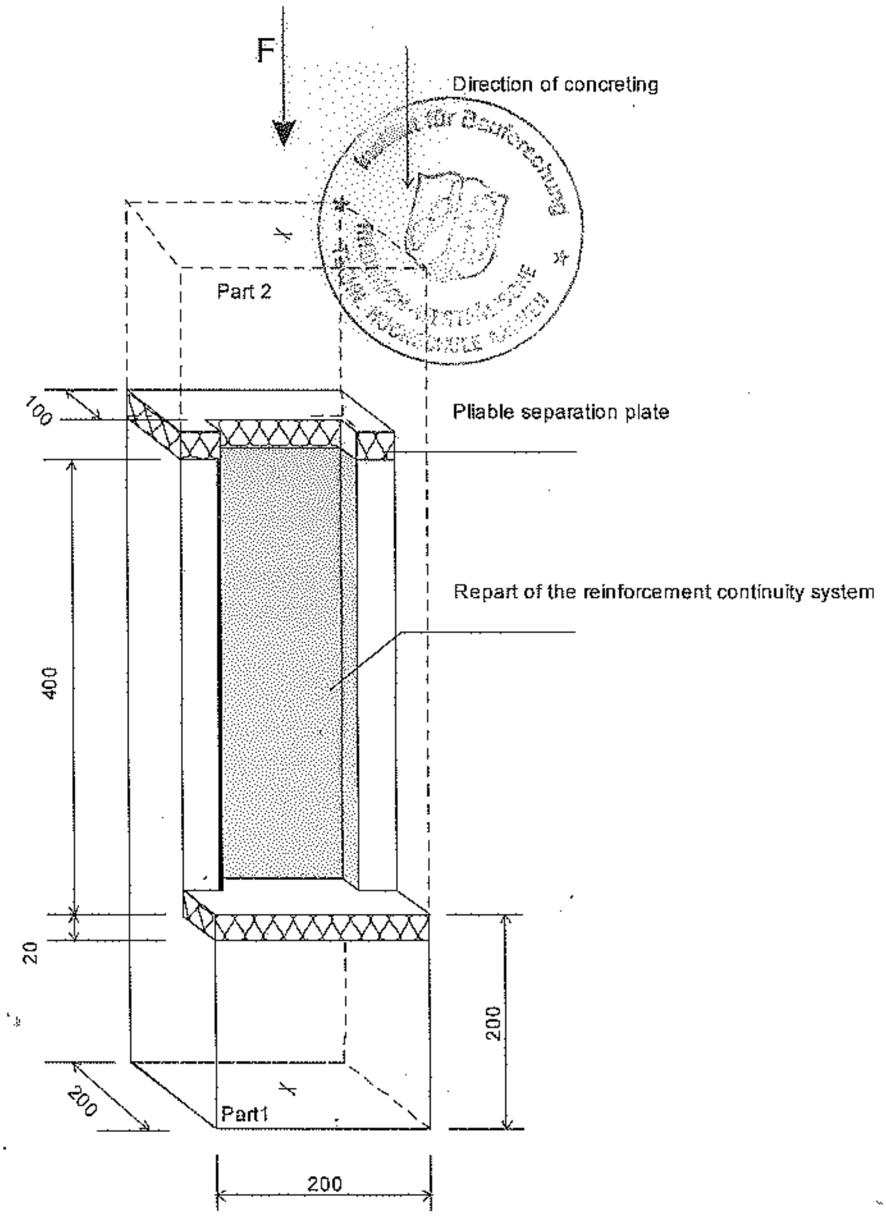
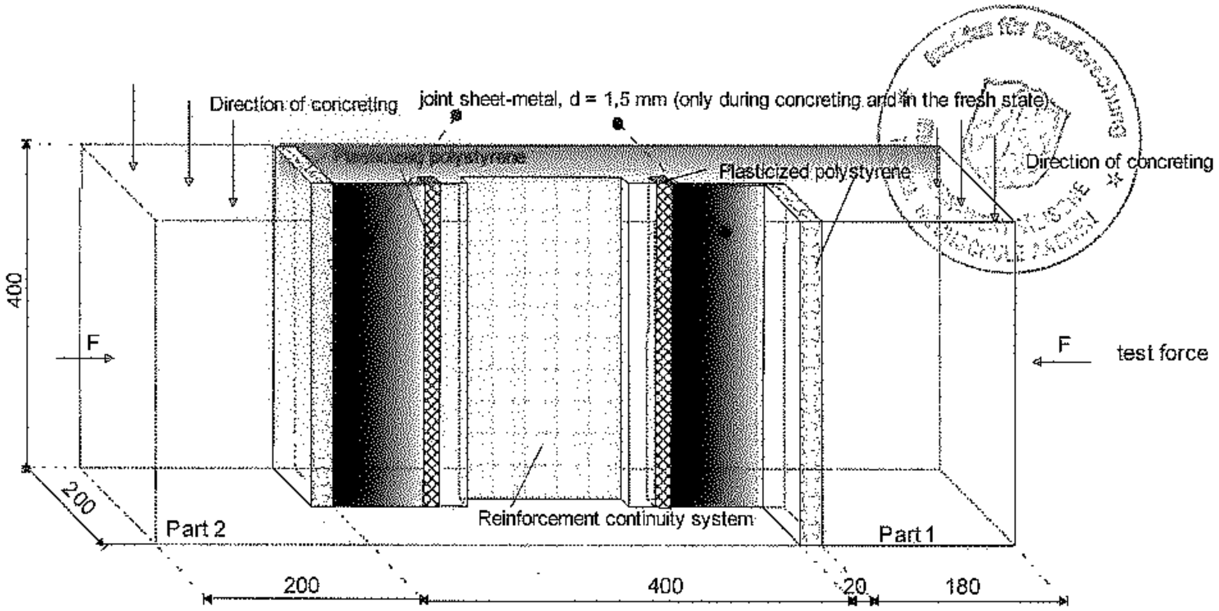


Fig. B1: Systematic presentation of the shear test specimen in the testing direction "longitudinal" according to the leaflet "Rebending"



<u>Fig. B2</u>: Systematic presentation of the shear test specimen in the testing direction "cross-sectional" according to the leaflet "Rebending"

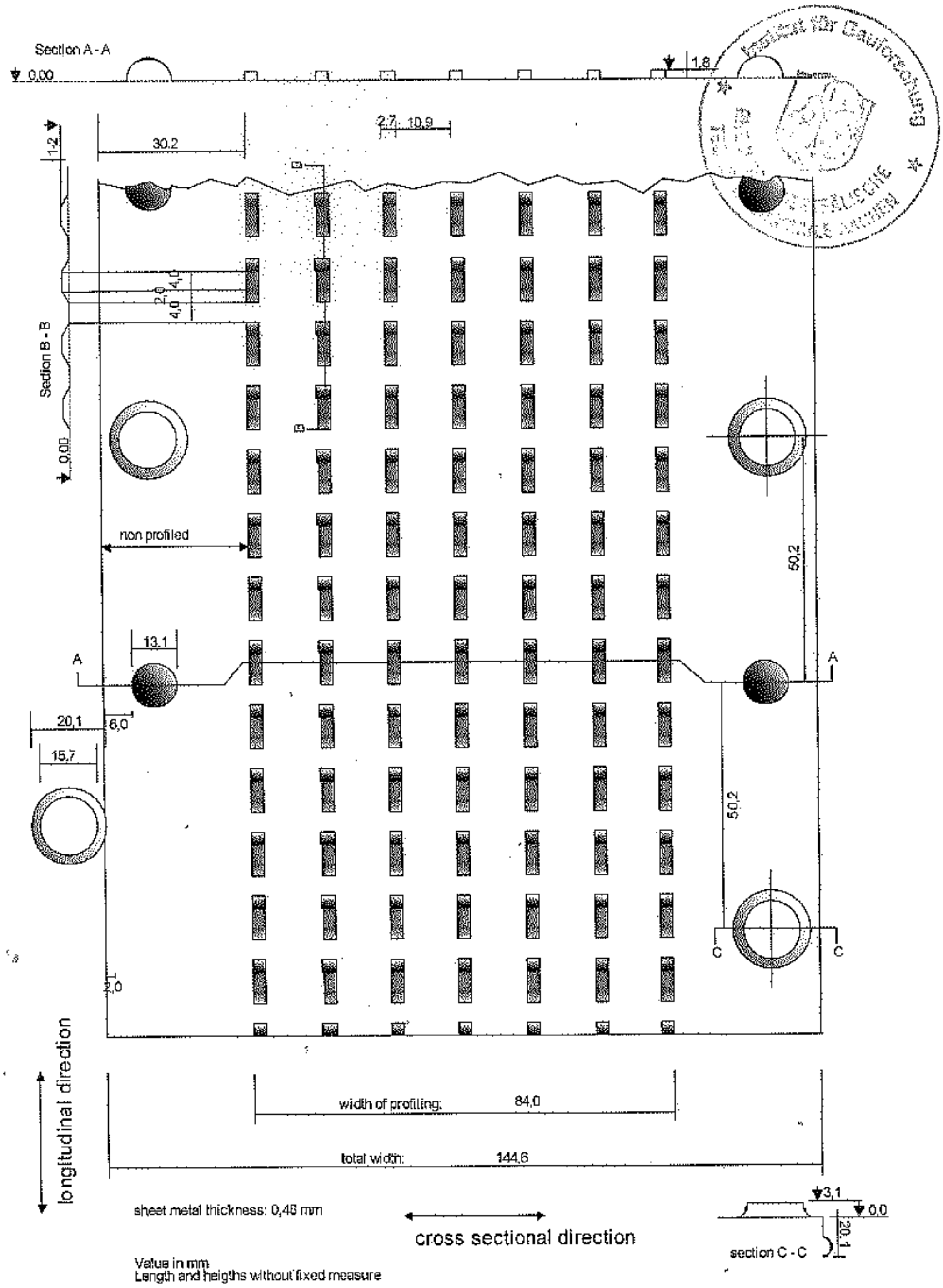


Fig. B3: View of the back panel

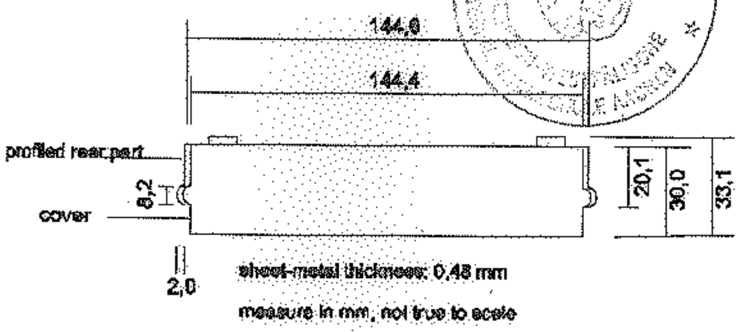


Fig. B4: Cross-section of the back panel and of the cover

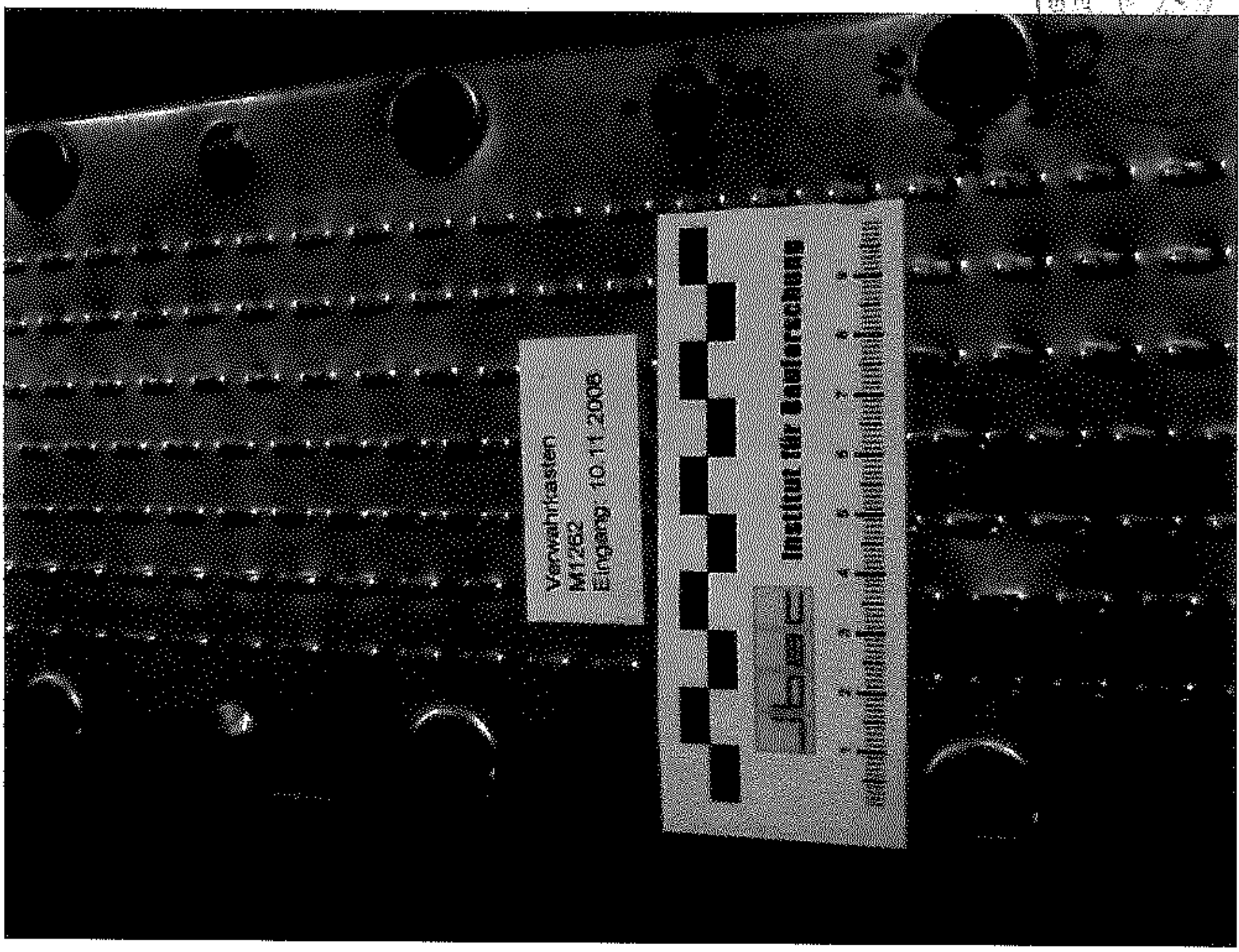


Fig. B5: View of the back panel

Fig. B6: Position of the profile measurements on the back panel (detailed presentation)

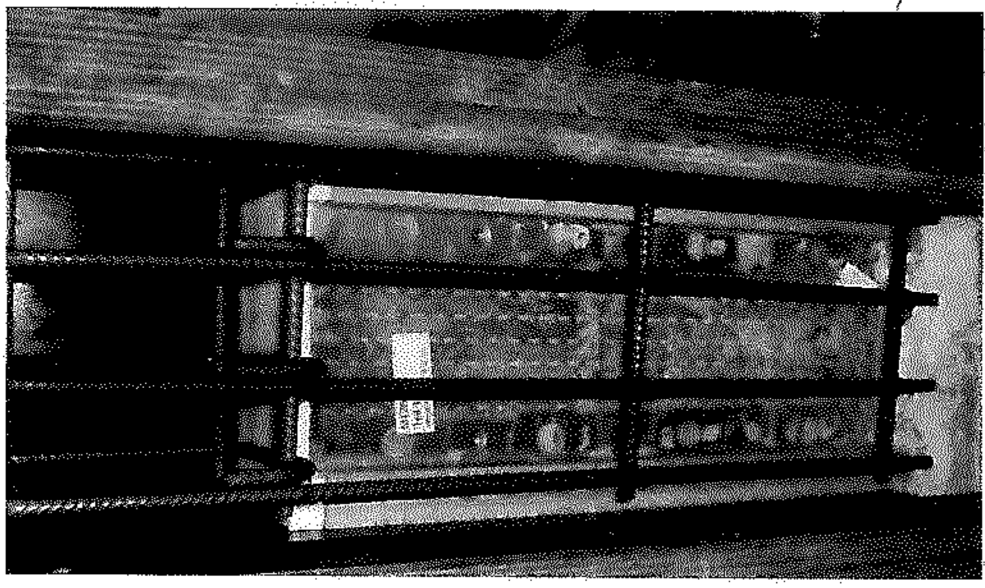


Fig. B7: Shear test in longitudinal direction with reinforcement continuity system: Test specimen prior to the concreting of the second part

Fig. B8: Shear test in cross-sectional direction with reinforcement continuity system: Test specimen prior to the concreting of the second part

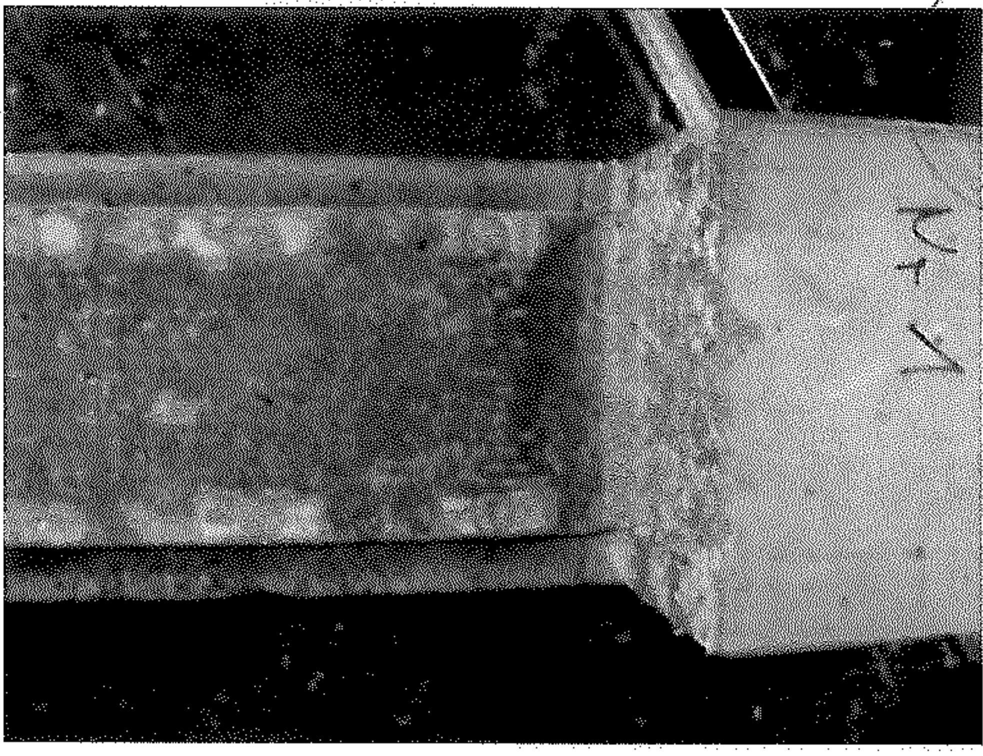


Fig. B9: Shear test in longitudinal direction with reinforcement continuity system: Example of the fractured surface of a test specimen with the reinforcement continuity system

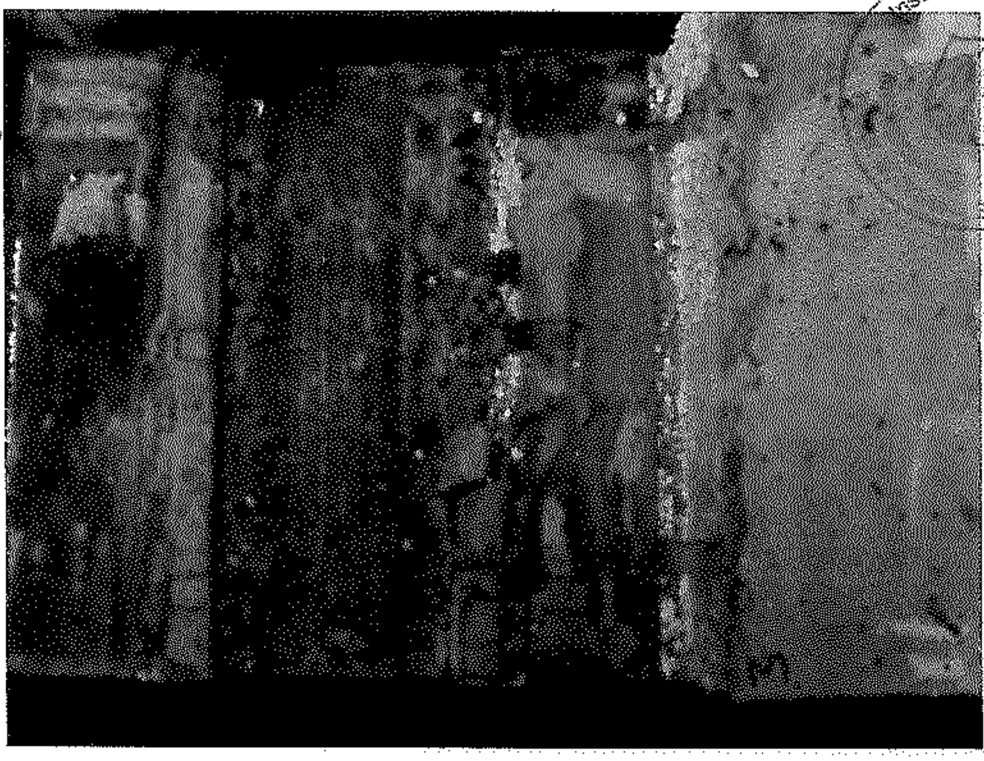


Fig. B10: Shear test in cross-sectional direction with reinforcement continuity system: Example of the fractured surface of a test specimen with the reinforcement continuity system

Fig. B11: Shear test in longitudinal direction with reinforcement continuity system: Overview of a fractured reference member

Fig. B12: Shear test in cross-sectional direction with reinforcement continuity system: Fractured surface of a reference member