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Test Report

DUR2-Test of Sandwich panels with perforated top layer

DUR2-Test of Sandwich panels with perforated top layer

Test Report No.: B097/21

Order No.: P402101073

Issued by Department Plastics and Composites

Laboratory for Plastic Testing

Test Report
DUR2-Test of sandwich panels with perforated top layer
Test Report No.: B097/21

Test Location(s):	IMA Materialforschung und Anwendungstechnik GmbH, Wilhelmine-Reichard-Ring 4, Dresden
Test Specimen:	Sandwich panels with perforated top layer on one side and a core of mineral wool
Customer:	Metecno Bausysteme GmbH Am Amselberg 1 99444 BLANKENHAIN GERMANY
Order no. of the Customer:	122529, dated 14.04.2021
Test Specimen received on:	04.10.2021 (KE21/895)
Test Period:	11.10.2021 - 28.02.2022
In Charge:	Dipl.-Ing. Jörg Finnberg
Distribution List:	1 x Metecno Bausysteme GmbH, Mrs. Ritter 1 x IMA Dresden

Authorized
Dresden, 29.07.2022
IMA Materialforschung und
Anwendungstechnik GmbH

Dipl.-Ing. Jörg Finnberg
Deputy Head of Department Plastics and Composites

This test report was translated from German by Dr. Karoline Lenke.

Test Report
DUR2-Test of sandwich panels with perforated top layer
Test Report No.: B097/21

History

Date of release	Report no.	Page(s)/Chapter	Modification	Author
29.07.2022	B097/21	15	Initial Issue	Dipl.-Ing. Jörg Finnberg

Table of Contents

List of Symbols

Symbol	Unit	Value
a	mm	Thickness or length
b	mm	Width
l	mm	Length
d	mm	Thickness, continuous thickness
m	kg	Mass
m_0	kg	Initial mass – reference value (without conditioning)
m_1	kg	Mass after conditioning {7d, 28d, 56d}
Δm	kg, %	Change of mass
t	s	Time
T	°C	Temperature
v	mm/s	Test speed
ρ	kg/m³	Density
F	kN	Load
F_{max}	kN	Maximum load
$f_{Ct, RT}$	MPa	Transverse tensile strength at room temperature
$E_{Ct, RT}$	MPa	Transverse tensile modulus at room temperature
$\varepsilon_{Ct, RT}$	%	Transverse strain at transverse tensile strength value at room temperature
s (x N)	mm	Deformation at specific load (determination of elastic modulus)
f_{ct0}	MPa	Transverse tensile strength at room temperature – reference value (without conditioning)
f_{ct7}	MPa	Transverse tensile strength at room temperature – after 7 days of conditioning
f_{ct28}	MPa	Transverse tensile strength at room temperature – after 28 days of conditioning
f_{ct56}	MPa	Transverse tensile strength at room temperature – after 56 days of conditioning

Test Report
DUR2-Test of sandwich panels with perforated top layer
Test Report No.: B097/21

1 Task

The company Metecno Bausysteme GmbH assigned IMA Dresden with the conduction of durability test (DUR2) of sandwich panels (core: mineral wool, top layers: steel, one top layer perforated (acoustic panel)). Therefore, the tests were performed following DIN EN 14509:2013.

2 Testing material[1]

The approval test comprises the following test specimen configuration:

- Sandwich panels: wall panel, producer: Metecno Bausysteme GmbH
- Top layers steel, double-sided; one side perforated
- Core material mineral wool

The testing material was delivered safely packed at IMA Dresden.

Figure 1: Incoming testing material, delivered on 04.10.2021 (KE21/895)

2.1 Specimen Machining and preparation

The sandwich panels were manufactured and cut by the customer. The test specimens were delivered ready for testing.

2.2 Specimen Identification

The test specimens were identified with an individual code as follows:

Test report no. – duration of conditioning – consecutive number

e.g.: B097.21 **–** 7d – 08 (7d = 7 days of conditioning (example), duration of conditioning {7d, 28d, 56d})

[1] Information based on customer information

3 Test Execution

3.1 DUR2-Conditioning and Flatwise Tensile Test at SA following DIN EN 14509

3.1.1 Standard

- DIN EN 14509:2013 Self-supporting double skin metal faced insulation panels – Factory made products – Specification; German version EN 14509:2013

3.1.2 Personnel

- Technician: Mr Böge (A2100)
  Mr Bärwald (A2100)

3.1.3 Test Equipment

- Testing machine: Universal testing machine TIRA2,
  accuracy class 1 according to ISO 7500-1 (inventory-no.: 9023842)
- Load cell: 10 kN
- Displacement measurement: Displacement sensor DDA50
- Test speed: 3 % of specimen thickness / min
- Load introduction: Load introduction parts made of steel, bonded to top layer of specimen at both sides
- Conditioning chamber: climate chamber Tira TCC4120ES (inventory-no.: 9905832)
- Control of saturation/stabilisation: analytical scale Sartorius (inventory-no.: 9904521)

3.1.4 Test Conditions

- Test execution following DIN EN 14509 B.3
- Conditioning conditions (DUR2): T = (65 ± 3) °C, relative humidity (98 ± 2) %
- Test atmosphere (flatwise tensile test): standard atmosphere according to DIN EN ISO 291:2008, class 2:
  T = (23 ± 2) °C, (50 ± 10) % rel. humidity
- Specimen dimension: 100 mm x 100 mm x 600 mm
- Number of specimens: 7 per conditioning and/or reference value
- Conditioning time: 0 d (reference value), 7 d, 28 d, 56 d
- Determination of: humidity content after conditioning time,
  load-displacement curve, maximum load, tensile strength,
  tensile modulus, evaluation of the durability test according acceptance criteria in DIN EN 14509 B.3.4.2

3.1.5 Test Execution

- 3 measurements of length, width and thickness with an accuracy of ±0,1 mm
- Determination of specimen mass (m_0) before conditioning
- Conditioning of the specimens for 7 d, 28 d, 56 d at T= (65 ± 3) °C, rel. humidity (98 ± 2) %
- Determination of specimen mass (m_1) after conditioning and continuous weighing until constant mass is achieved (increase < 1 % within 24 h)
- Application of the load introduction on both top layers
- Execution of flatwise tensile test at standard atmosphere according to DIN EN ISO 291:2008, Kl.2: T = (23 ± 2) °C, (50 ± 10) % rel. humidity

4 Evaluation

4.1 Durability test (DUR2) – Flatwise Tensile Test after Conditioning

Table 1: Flatwise tensile test (reference, without conditioning); test series B097.21-0d-08...14

Specimen-no.	a (mm)	b (mm)	F_{max} (N)	$f_{Ct,RT}$ (MPa)	$E_{Ct,RT}$ (MPa)	$\varepsilon_{Ct,RT}$ (%)	s(F=400N) (mm)	s(F=600N) (mm)
B097.21-0d-08	100,3	100,1	1476	0,147	20,28	0,99	0,222	0,282
B097.21-0d-09	100,3	99,9	1089	0,109	26,71	0,55	0,077	0,123
B097.21-0d-10	100,0	100,4	914	0,091	18,50	0,76	0,232	0,298
B097.21-0d-11	100,4	99,9	1280	0,128	25,38	0,74	0,147	0,194
B097.21-0d-12	100,6	99,8	1455	0,145	27,23	0,70	0,150	0,194
B097.21-0d-13	100,1	100,0	1624	0,162	32,91	0,57	0,079	0,117
B097.21-0d-14	100,2	100,4	1458	0,145	27,82	0,58	0,104	0,148
Average value:				**0,132**	**25,55**	**0,70**		
Standard deviation:				**0,025**	**4,85**	**0,15**		
Coefficient of variation:				**18,9%**	**19,0%**	**21,4%**		
Max:				**0,162**	**32,91**	**0,99**		
Min:				**0,091**	**18,50**	**0,55**		
5%-fractile (n = 7; k = 2,25; w = 75%):				**0,082**	**16,13**	**-**		

The strain at tensile strength of specimen B097.21-0d-08 differs significantly from the results of the test series. No pre-damage of the specimen or influence of the test equipment during the test was observed. Thus, this result was considered in the statistical evaluation of the test series.

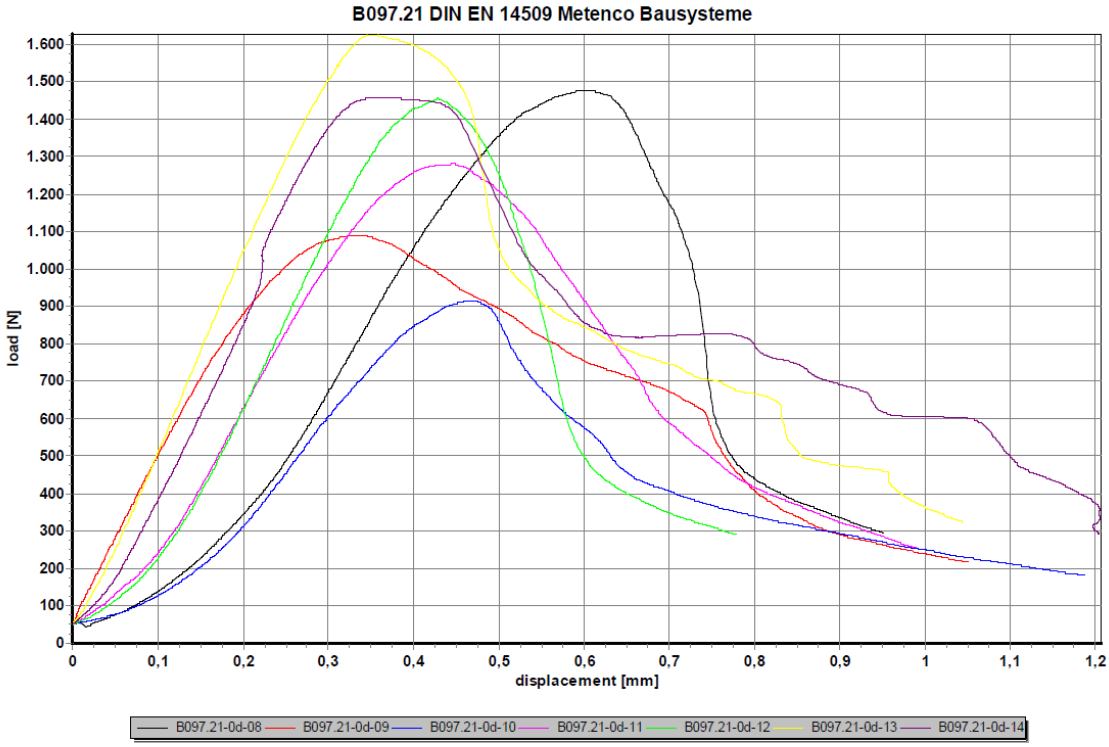

Figure 2: Load – displacement curves of flatwise tensile test (reference, without conditioning); test series B097.21-0d-08…14

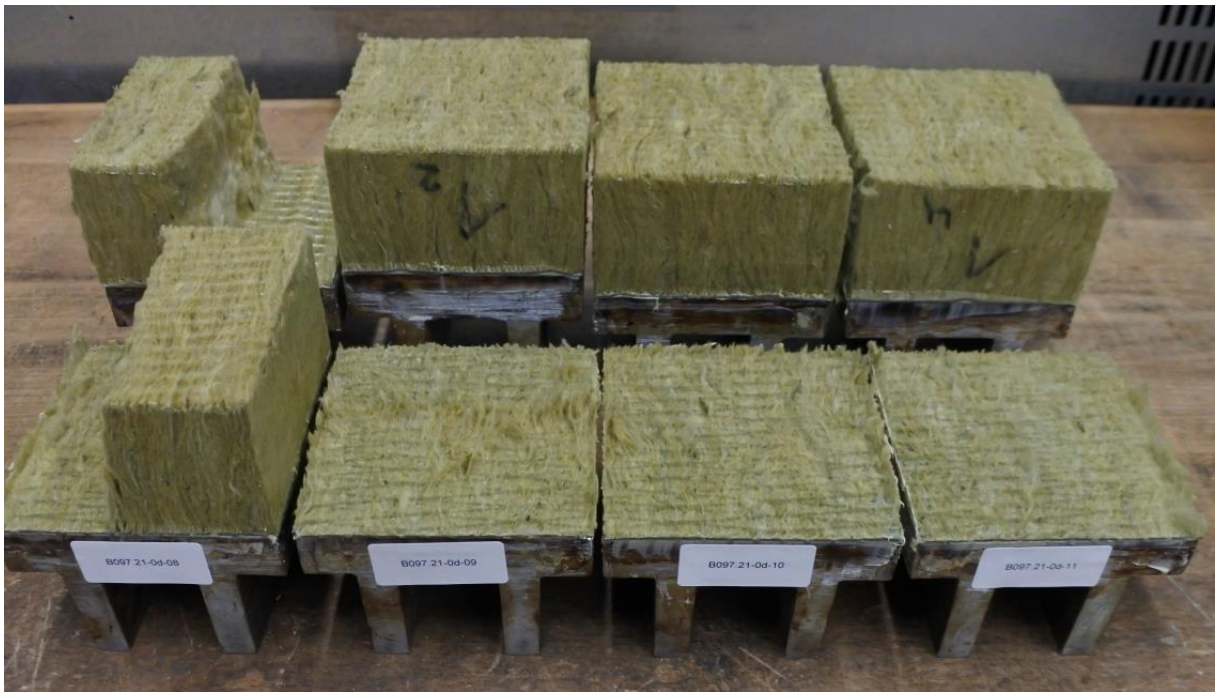

Figure 3: **Failure figures of flatwise tensile test (reference, without conditioning); test series B097.21-0d-08…14, specimens -08…-11**

Figure 4: **Failure figures of flatwise tensile test (reference without conditioning); test series B097.21-0d-08…14, specimens -12…-14**

Table 2: Flatwise tensile test after 7 d of conditioning (DUR2); test series B097.21-7d-08...14

Specimen-no.	a (mm)	b (mm)	F_{max} (N)	$f_{Ct,\,RT}$ (MPa)	$E_{Ct,\,RT}$ (MPa)	$\varepsilon_{Ct,\,RT}$ (%)	s(F=400N) (mm)	s(F=600N) (mm)
B097.21-7d-08	100,2	100,0	999	0,100	20,58	0,59	0,113	0,173
B097.21-7d-09	100,3	99,9	1137	0,114	17,08	0,85	0,152	0,223
B097.21-7d-10	100,3	100,0	1021	0,102	22,84	0,57	0,128	0,182
B097.21-7d-11	100,7	100,9	1020	0,100	18,70	0,71	0,144	0,208
B097.21-7d-12	100,5	100,1	1213	0,121	20,77	0,66	0,116	0,174
B097.21-7d-13	100,2	100,0	1090	0,109	16,66	0,95	0,299	0,373
B097.21-7d-14	100,0	100,2	1458	0,146	24,03	0,72	0,091	0,141
Average value:				**0,113**	**20,09**	**0,72**		
Standard deviation:				**0,016**	**2,79**	**0,14**		
Coefficient of variation:				**14,2%**	**13,9%**	**19,4%**		
Max:				**0,146**	**24,03**	**0,95**		
Min:				**0,100**	**16,66**	**0,57**		
5%-fractile (n = 7; k = 2,25; w = 75%):				**0,083**	**14,57**	**-**		

The force-displacement curve of specimen B097.21-7d-13 differs significantly from the other specimens of the test series. As a result, the absolute values of the deformation range for the modulus determination deviate significantly from the other specimens. Considering the modulus results of specimen -09 and -13, the results cannot be considered as an outlier and are considered in the statistical evaluation of the test series.

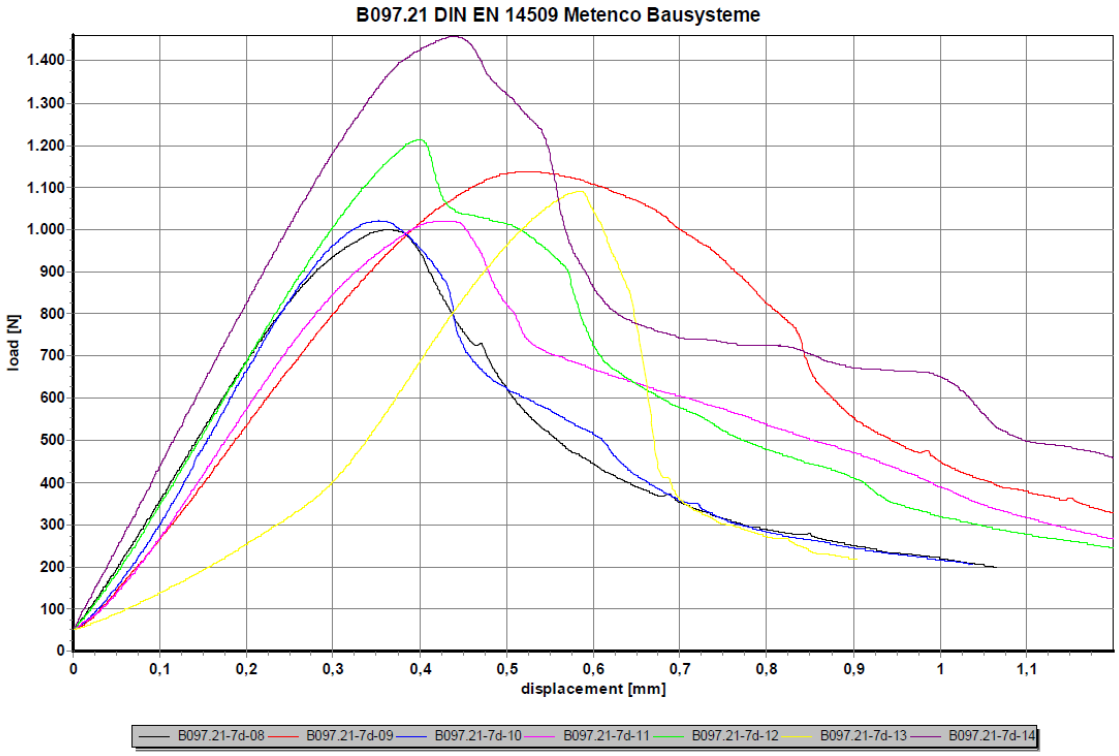

Figure 5: Load – crosshead displacement curves of flatwise tensile test after 7 d of conditioning (DUR2); test series B097.21-7d-08…14

Figure 6: **Failure figures of flatwise tensile test after 7 d conditioning (DUR2); test series B097.21-7d-08…14, specimens -08…-11**

Figure 7: **Failure figures of flatwise tensile test after 7 d of conditioning (DUR2); test series B097.21-7d-08…14, specimens -12…-14**

Table 3: Flatwise Tensile Test after 28 d of conditioning (DUR2); test series B097.21-28d-08...14

Specimen-no.	a (mm)	b (mm)	F_{max} (N)	$f_{Ct,RT}$ (MPa)	$E_{Ct,RT}$ (MPa)	$\varepsilon_{Ct,RT}$ (%)	s(F=400N) (mm)	s(F=600N) (mm)
B097.21-28d-08	100,6	100,1	1087	0,108	19,34	0,68	0,130	0,193
B097.21-28d-09	100,7	99,9	858	0,085	18,48	0,57	0,119	0,185
B097.21-28d-10	100,0	100,2	1015	0,101	19,96	0,55	0,118	0,179
B097.21-28d-11	100,3	100,2	751	0,075	18,25	0,43	0,119	0,186
B097.21-28d-12	100,3	99,8	306	0,031	-	0,89	-	-
B097.21-28d-13	100,2	100,2	774	0,077	14,97	0,55	0,130	0,211
B097.21-28d-14	100,2	100,0	971	0,097	17,80	0,72	0,182	0,251
Average value:				**0,082**	**18,13**	**0,63**		
Standard deviation:				**0,026**	**1,73**	**0,15**		
Coefficient of variation:				**31,7%**	**9,5%**	**23,8%**		
Max:				**0,108**	**19,96**	**0,89**		
Min:				**0,031**	**14,97**	**0,43**		
5%-fractile (n = 7; k = 2,25; w = 75%):				**0,029**	**14,26**	**-**		

Due to the low maximum load of specimen B097.21-28d-12 the evaluation of the tensile modulus was not possible. Thus, no tensile modulus value could be considered in the statistical evaluation. The fractile value of the tensile modulus was therefore only calculated with 6 values (k=2,34).
The modulus of specimen B097.21-28d-13 differs significantly from the results of the test series. No pre-damage of the specimen or influence of the test equipment during the test was observed. Thus, this result was considered in the statistical evaluation of the test series.

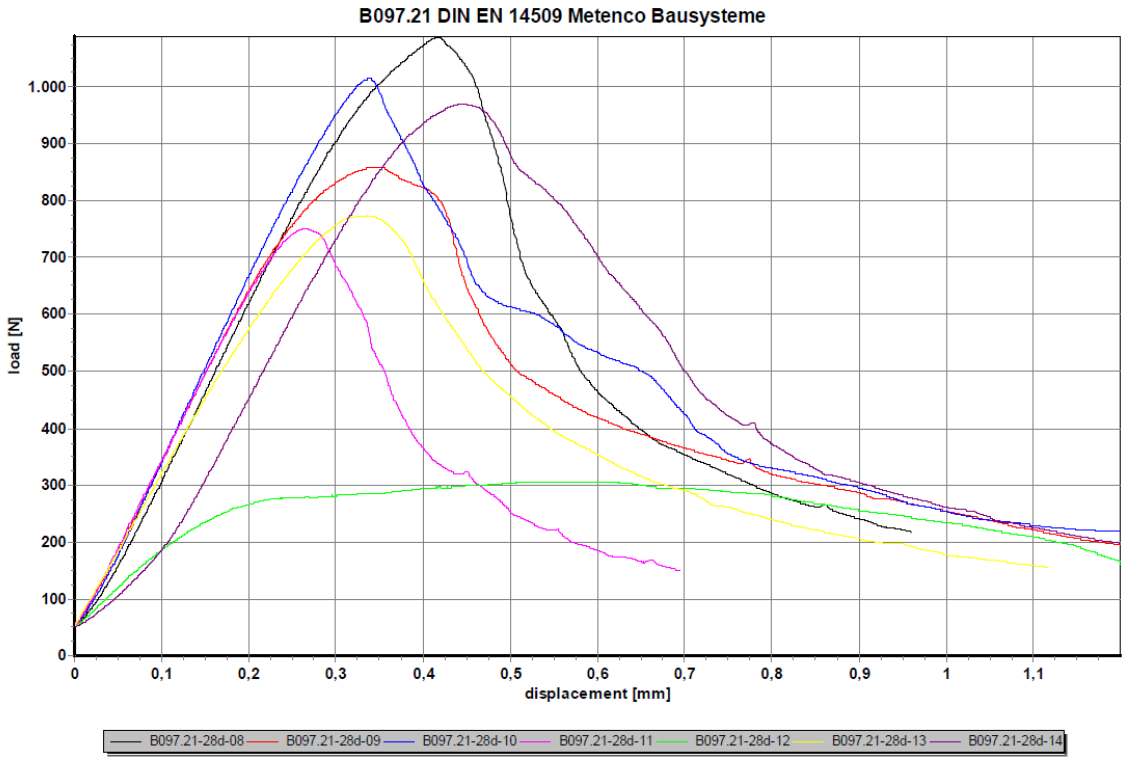

Figure 8: Load – displacement curves of flatwise tensile test after 28 d of conditioning (DUR2); test series B097.21-28d-08…14

Figure 9: **Failure figures of flatwise tensile test after 28 d of conditioning (DUR2); test series B097.21-28d-08…14, specimens -08…-11**

Figure 10: **Failure figures of flatwise tensile test after 28 d of conditioning (DUR2); test series B097.21-28d-08…14, specimens -12…-14**

Table 4: Flatwise Tensile Test after 56 d of conditioning (DUR2); test series B097.21-56d-08...14

Specimen-no.	a (mm)	b (mm)	F_{max} (N)	$f_{Ct, RT}$ (MPa)	$E_{Ct, RT}$ (MPa)	$\varepsilon_{Ct, RT}$ (%)	s(F=200N) (mm)	s(F=400N) (mm)
B097.21-56d-08	99,9	100,2	952	0,095	19,45	0,56	0,052	0,115
B097.21-56d-09	100,7	100,1	531	0,053	16,52	0,38	0,053	0,127
B097.21-56d-10	99,9	100,1	640	0,064	21,86	0,32	0,024	0,080
B097.21-56d-11	100,3	100,1	737	0,073	20,81	0,37	0,058	0,118
B097.21-56d-12	100,7	100,1	582	0,058	14,44	0,58	0,121	0,206
B097.21-56d-13	100,3	99,9	366	0,037	-	0,47	0,114	-
B097.21-56d-14	100,2	99,9	395	0,040	-	0,69	0,164	-
Average value:				**0,060**	**18,62**	**0,48**		
Standard deviation:				**0,020**	**3,08**	**0,13**		
Coefficient of variation:				**33,3%**	**16,5%**	**27,1%**		
Max:				**0,095**	**21,86**	**0,69**		
Min:				**0,037**	**14,44**	**0,32**		
5%-fractile (n = 7; k = 2,25; w = 75%):				**0,027**	**12,06**	**-**		

Due to the low maximum loads of specimens B097.21-56d-13 and -14 the evaluation of the tensile modulus was not possible. Thus, no tensile modulus values could be considered in the statistical evaluation. The fractile value of the tensile modulus was therefore only calculated with 5 values (k=2,46).

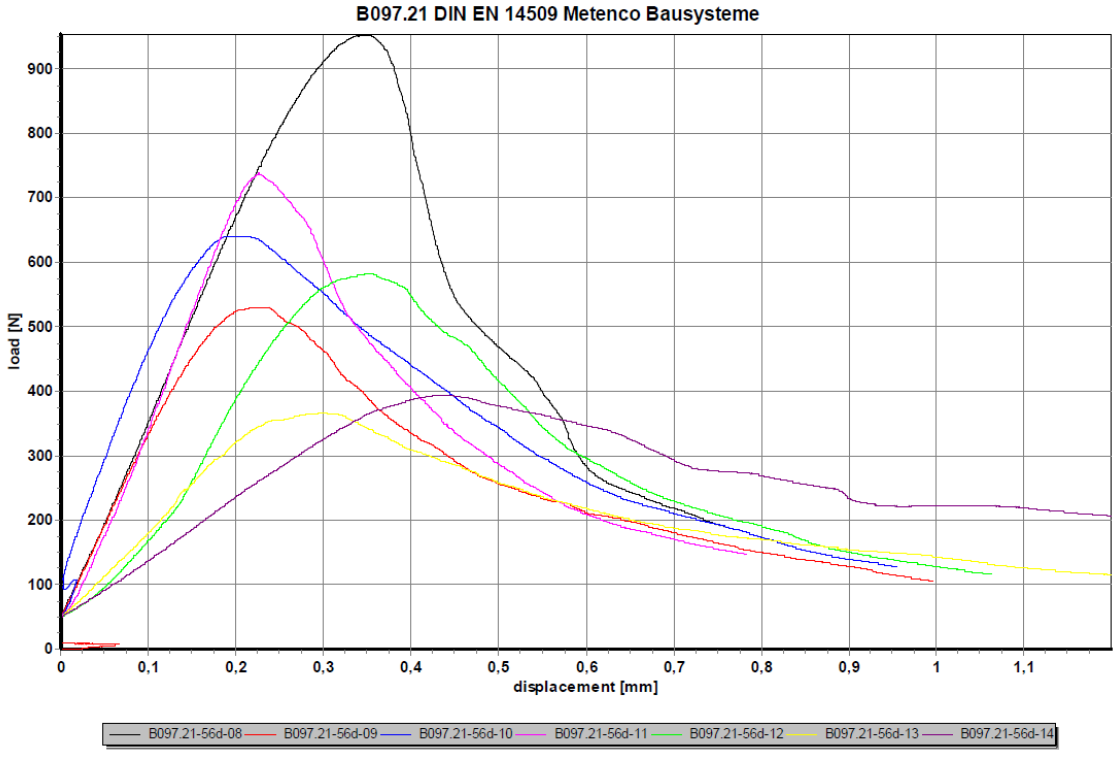

Figure 11: Load – displacement curves of flatwise tensile test after 56 d of conditioning (DUR2); test series B097.21-56d-08…14

Figure 12: Failure figures of flatwise tensile test after 56 d of conditioning (DUR2); test series B097.21-56d-08…14, specimens -08…-11

Figure 13: Failure figures of flatwise tensile test after 56 d of conditioning (DUR2); test series B097.21-56d-08…14, specimens -12…-14

Table 5: Results of Durability-Test (DUR2)

Result flatwise tensile strength			Durability criteria is fulfilled, if				Result flatwise tensile strength	Acceptance criteria is fulfilled, if			
			$f_{ct7} - f_{ct28}$	3 x ($f_{ct0} - f_{ct7}$)	f_{ct28}	0,4 x f_{ct0}		$f_{ct28} - f_{ct56}$	$f_{ct7} - f_{ct28}$	f_{ct56}	0,4 x f_{ct0}
f_{ct0} [MPa]	f_{ct7} [MPa]	f_{ct28} [MPa]	≤		≥		f_{ct56} [MPa]	<		≥	
0,132	0,113	0,082	0,031	0,059	0,082	0,053	0,060	0,022	0,031	0,060	0,053

The cutting edges and the top layers showed no signs of corrosion after conditioning.

Table 6: Results of moisture absorption due to conditioning (DUR2):
7 d: test series B097.21-7d-08…14,
28 d: test series B097.21-28d-08…14,
56 d: test series B097.21-56d-08…14

Specimen-no.	**m_0 (g)**	**m_1 (g)**	**Δm (g)**	**Δm**
B097.21-7d-08	144,472	145,0	0,528	0,37%
B097.21-7d-09	143,331	143,7	0,369	0,26%
B097.21-7d-10	204,449	205,1	0,651	0,32%
B097.21-7d-11	145,073	145,3	0,227	0,16%
B097.21-7d-12	142,228	142,4	0,172	0,12%
B097.21-7d-13	143,619	144,0	0,381	0,27%
B097.21-7d-14	144,564	144,8	0,236	0,16%
Average value:	**152,534**	**152,9**	**0,366**	**0,24%**
B097.21-28d-08	146,285	146,513	0,228	0,16%
B097.21-28d-09	139,743	139,998	0,255	0,18%
B097.21-28d-10	143,011	143,369	0,358	0,25%
B097.21-28d-11	141,559	141,788	0,229	0,16%
B097.21-28d-12	141,093	141,451	0,358	0,25%
B097.21-28d-13	143,981	144,302	0,320	0,22%
B097.21-28d-14	143,446	143,778	0,332	0,23%
Average value:	**142,731**	**143,028**	**0,297**	**0,21%**
B097.21-56d-08	142,222	142,675	0,452	0,32%
B097.21-56d-09	142,586	143,044	0,457	0,32%
B097.21-56d-10	143,347	143,787	0,440	0,31%
B097.21-56d-11	143,917	144,320	0,403	0,28%
B097.21-56d-12	140,937	141,369	0,431	0,31%
B097.21-56d-13	139,891	140,239	0,349	0,25%
B097.21-56d-14	145,509	145,950	0,440	0,30%
Average value:	**142,630**	**143,055**	**0,425**	**0,30%**

The mass of specimen B097.21-7d-10 differs significantly from the results of the test series. The test specimen showed no external abnormalities. Thus, this result was considered in the statistical evaluation of the test series.

Figure 14: Perforated top layer after DUR2-conditioning (28 d), test series B097.21-28d-08…14

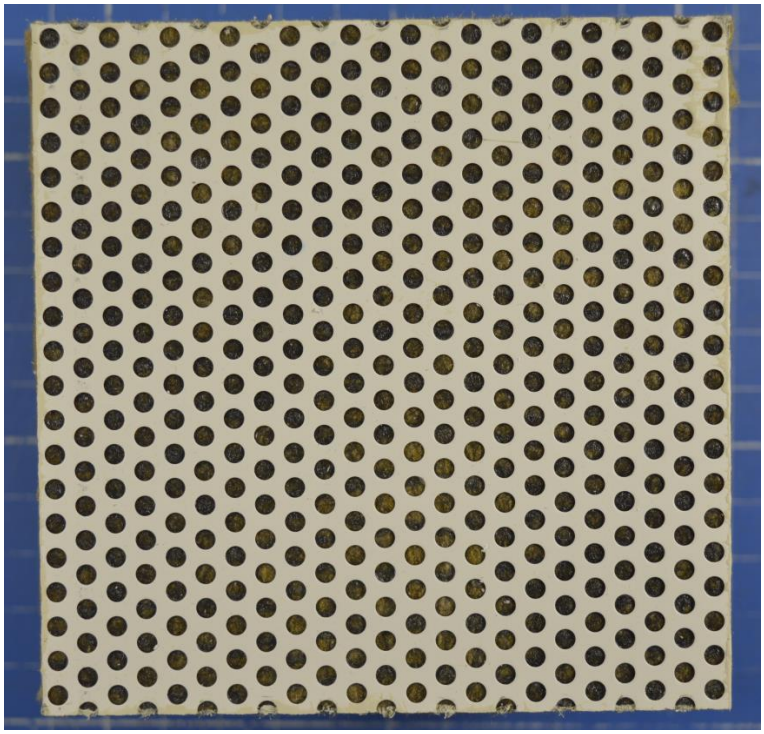

Figure 15: Perforated top layer after DUR2-conditioning (56 d), test series B097.21-56d-08…14

Reviewed	Created
Dipl.-Ing. Karl Scheffler	Dipl.-Ing. Jörg Finnberg