

Application technology
Materials testing
Quality assurance

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Test report

Report no. 14-210-00754-PB

Material examination in accordance with ASTM F 1216

manufacturer: KOB Karl Otto Braun GmbH & Co. KG
sample designation: pipe section DN 150:
synthetic fiber hose with epoxy resin
sample no.: 1453003
resin ID: Brawo I
client: KOB Karl Otto Braun GmbH & Co. KG
Lauterstraße 50
67752 Wolfstein

This report includes 5 pages (incl. cover page).
It may only be handed over to third parties with the approval of SIEBERT+KNIPSCCHILD GmbH and in unabbreviated form.

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1 Determination of material properties according to ASTM F1216-09

1.1 Determination of tensile properties in accordance with ASTM D638-10

Acc. to ASTM F1216-09, Table 1, the tensile strength of the material is only required for applications in pressurized pipes.

It is not intended to use the CIPP-system "Brawo-Liner" for the repair of pressure pipes.

1.2 Determination of bending stress and bending Young's modulus in accordance with ASTM D790-10

The specimens were taken from the cured CIPP in accordance with ASTM F1216-09, Section 8.1.1. The specimens were taken in the longitudinal direction.

Table: Summary of test results (mean values):

sample number	test date	wall thickness e_m [in (mm)]	flexural strength σ_{fb} [psi (MPa)]	flexural modulus E_f [psi (MPa)]
1453003	19.05.2014	1.26 (3.20)	11269.4 (77.7)	443235 (3056)

The individual test log is enclosed as Annex.

1.3 Test of the resistance of the cured CIPP to chemical attack acc. to ASTM F1216, Table X2.1

For the test of the resistance of the cured CIPP to chemical attack acc. to ASTM F1216, Table X2.1 the test specimens were stored in the test media for **one month** at 23°C. The test media included:

- 100% tap water
- 5% nitric acid
- 10% phosphoric acid
- 10% sulfuric acid
- 100% gasoline
- 100% vegetable oil
- 0.1% detergent
- 0.1% soap

After the storage time the flexural properties were determined acc. to ASTM D790 – 10.

During the storage time the CIPP test specimens should lose no more than 20% of their initial flexural strength and flexural modulus.

1.3.1 Determination of the change of flexural properties

5 test specimens were used to determine the change of the flexural properties, i. e. flexural strength and flexural modulus, after one month of storage at 23°C in the test media listed in section 1.4.

The change of flexural strength and flexural modulus in per cent was determined after removal from the test media and conditioning (24 hours in standard climate conditions).

Table: Summary of test results (mean values):

test specimen designation	medium	flexural strength σ_{fb} [psi (MPa)]	flexural modulus E_f [psi (MPa)]
1453003	100% tap water	12067.1 (83.2)	470502 (3244)
	5% nitric acid	11617.5 (80.1)	477319 (3291)
	10% phosphoric acid	10950.3 (75.5)	408716 (2818)
	10% sulfuric acid	11066.4 (76.3)	385655 (2659)
	100% gasoline	10355.7 (71.4)	468907 (3233)
	100% vegetable oil	11588.5 (79.9)	498060 (3434)
	0.1% detergent	11719.0 (80.8)	462090 (3186)
	0.1% soap	11530.5 (79.5)	479205 (3304)

The measurement and test logs are enclosed as Annexes.

Table: Summary of test results (mean values):

test specimen designation	medium	change of flexural strength σ_{fb} [%]	change of flexural modulus E_f [%]
1453003	100% tap water	7.1	6.2
	5% nitric acid	3.1	7.7
	10% phosphoric acid	-2.8	-7.8
	10% sulfuric acid	-1.8	13.0
	100% gasoline	-8.1	5.8
	100% vegetable oil	2.8	12.4
	0.1% detergent	4.0	4.3
	0.1% soap	2.3	8.1

The measurement and test logs are enclosed as Annexes.


2 Result

The CIPP-system "Brawoliner", consistent of the epoxy-based resin "Brawo I", shows no loss of 20 % or more of its initial flexural modulus and its flexural strength after the storage in media according to ASTM F1216, X2.1. The CIPP-System "Brawoliner" with the epoxy-resin "Brawo I" fulfils the requirements of ASTM F 1216, X2.1.

Oststeinbek, june 23, 2014


 Technical Director
 Dipl.-Ing. A. Haacker




 Tester in charge
 B.Eng. Stefan Schwarzer

Annex:
 individual test logs

test data :

construction project: Material examination in acc. to ASTM- Standards
 client: Karl Otto Braun GmbH & Co. KG
 manufacturer: Karl Otto Braun GmbH & Co. KG
 material: EP - Syntesefaser
 Material-ID: 1201400860804

date of order: 12.05.2014
 pipe geometry: DN 150
 line name: BRAWO I
 date of manufacturing: 14.04.2014

test parameters :

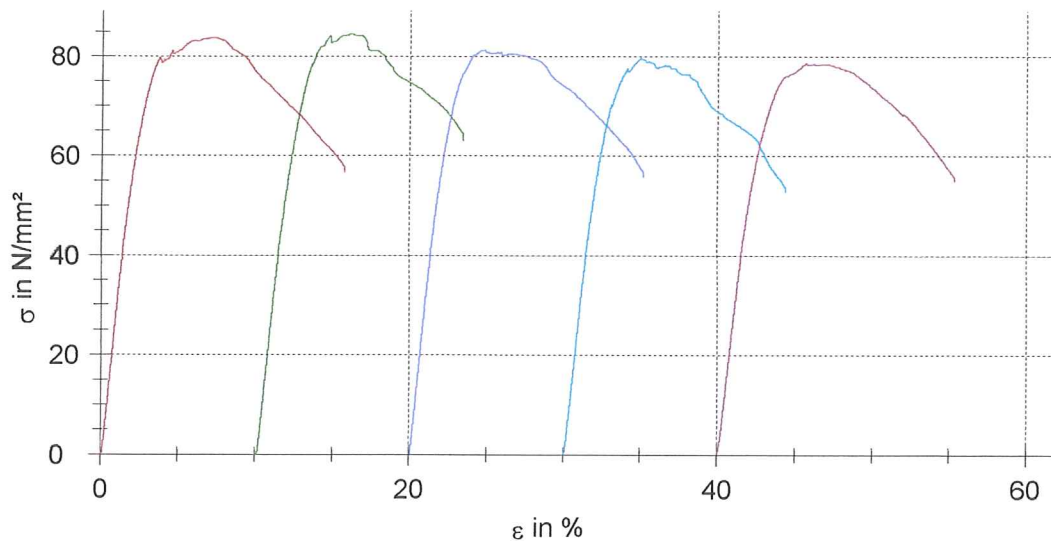
test date : 19.05.2014
 direction of testing : logitudinal direction
 machine data : 1445 WN:117562
 Traversenwegaufnehmer WN:117562
 Kraftsensor ID:0 WN:117563 10 kN

rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,16	14,25	3224	79,7	3,74	83,7	7,04	10	20	50
2	3,05	14,15	3078	78,4	3,60	84,4	6,01	10	20	50
3	3,23	13,68	3111	81,2	4,78	81,2	4,72	10	20	50
4	3,23	14,27	3005	70,4	3,08	79,8	4,92	10	20	50
5	3,31	13,77	2861	78,7	5,68	78,7	5,59	10	20	50

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
x̄	3,20	14,02	3056	77,7	4,18	81,5	5,66	10	20	50
min	3,05	13,68	2861	70,4	3,08	78,7	4,72	10	20	50
max	3,31	14,27	3224	81,2	5,68	84,4	7,04	10	20	50
R	0,26	0,59	364	10,8	2,60	5,8	2,32	0	0	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



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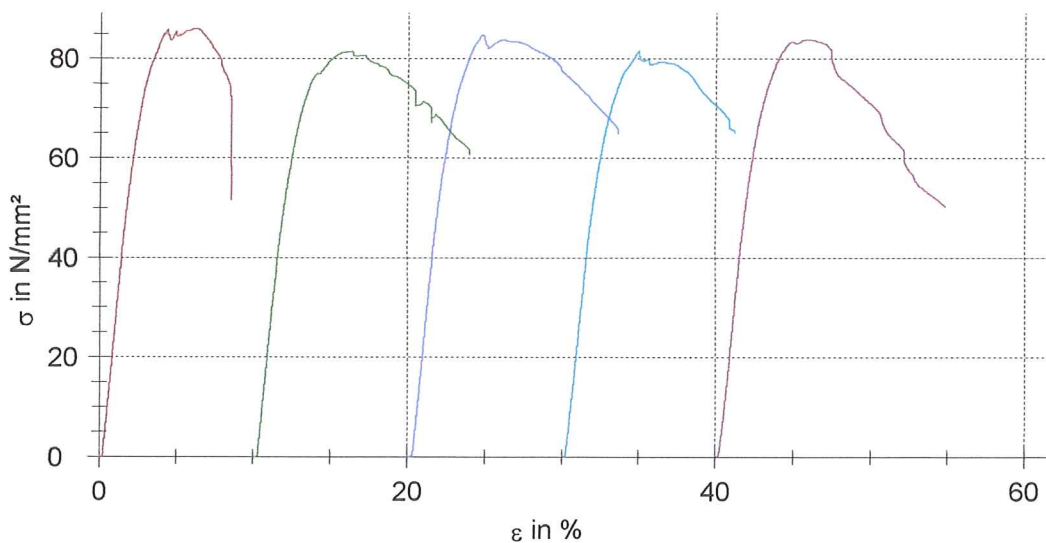
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 Traversenwegaufnehmer WN:117562
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test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,26	14,09	3369	85,2	4,14	86,0	5,99	10	20	50
2	3,21	14,31	3217	81,4	6,35	81,4	6,04	10	20	50
3	3,13	13,97	3230	84,7	4,78	84,7	4,44	10	20	50
4	3,26	13,74	3129	81,6	4,98	81,6	4,68	20	30	50
5	3,00	14,09	3273	83,3	4,81	83,8	5,61	20	30	50

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,17	14,04	3244	83,2	5,01	83,5	5,35	14	24	50
min	3,00	13,74	3129	81,4	4,14	81,4	4,44	10	20	50
max	3,26	14,31	3369	85,2	6,35	86,0	6,04	20	30	50
R	0,26	0,57	240	3,8	2,21	4,6	1,59	10	10	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



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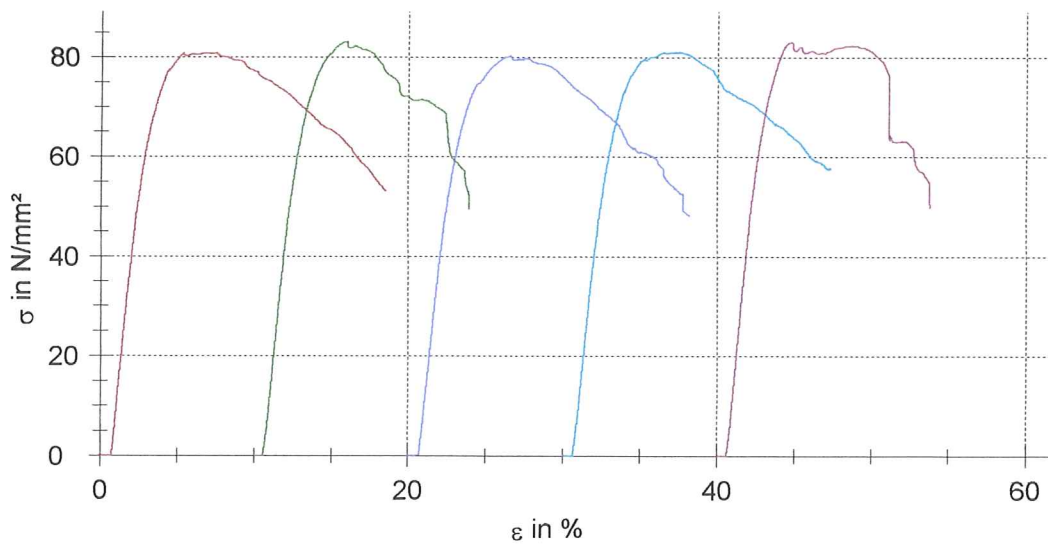
test date : 19.06.2014
 direction of testing : longitudinal direction
 machine data : 1435 WN:116255
 Traversenwegaufnehmer WN:116255
 Mitutoyo Messschieber
 Kraftsensor ID:0 WN:811555 10 kN

rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,30	14,14	3326	80,8	5,34	80,8	4,58	15	20	52
2	3,25	14,31	3331	83,1	5,94	83,1	5,28	15	20	52
3	3,39	13,90	3131	80,4	6,59	80,4	5,85	15	20	52
4	3,14	14,14	3226	73,3	3,92	81,0	6,50	15	20	52
5	3,40	14,17	3442	83,0	4,73	83,0	4,05	20	25	52

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,30	14,13	3291	80,1	5,30	81,7	5,25	16	21	52
min	3,14	13,90	3131	73,3	3,92	80,4	4,05	15	20	52
max	3,40	14,31	3442	83,1	6,59	83,1	6,50	20	25	52
R	0,26	0,41	311	9,9	2,66	2,8	2,45	5	5	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



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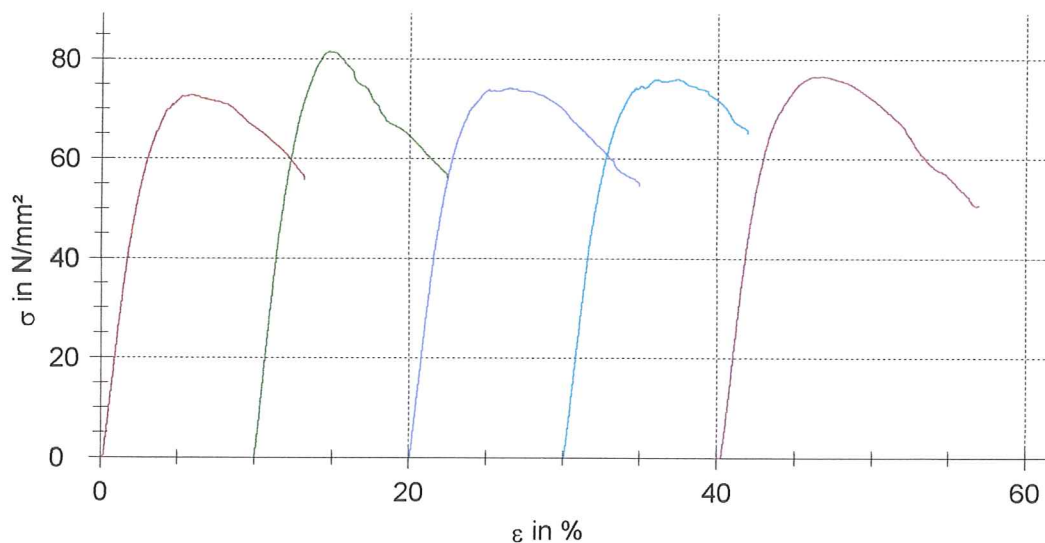
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 Traversenwegaufnehmer WN:117562
 Kraftsensor ID:0 WN:117563 10 kN

rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,25	14,13	2737	71,0	4,63	72,7	5,66	10	15	52
2	2,98	14,13	3056	81,5	4,75	81,5	4,72	10	20	52
3	3,23	14,21	2753	73,9	5,13	74,2	6,41	10	20	52
4	3,57	14,02	2780	74,3	4,68	76,0	7,29	10	20	52
5	3,19	13,75	2763	76,6	6,79	76,6	6,48	10	15	52

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
x̄	3,24	14,05	2818	75,5	5,20	76,2	6,12	10	18	52
min	2,98	13,75	2737	71,0	4,63	72,7	4,72	10	15	52
max	3,57	14,21	3056	81,5	6,79	81,5	7,29	10	20	52
R	0,59	0,46	320	10,5	2,16	8,8	2,57	0	5	0

symbols pursuant to ASTM D790

- d : depth of beam
- L : support span
- σ_{f1} : initial stress of modulus identification
- b : sample width
- ε_{fb} : flexural strain at first break
- ε_{fM} : flexural strain
- σ_{f2} : end stress of modulus identification
- E_f : flexural modulus
- σ_{fb} : flexural stress at first break
- σ_{fM} : flexural strength



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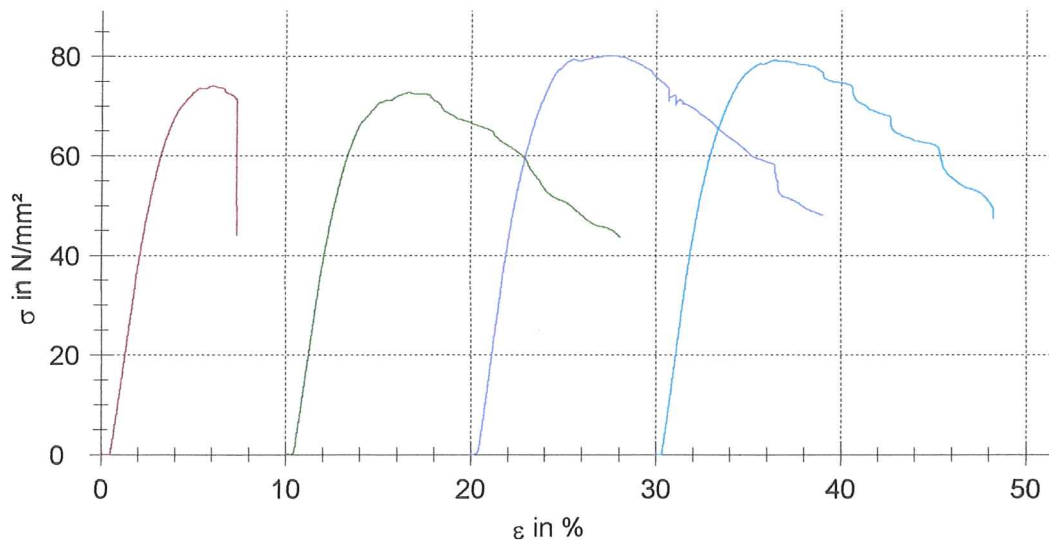
test date : 19.06.2014
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 Traversenwegaufnehmer WN:117562
 Kraftsensor ID:0 WN:117563 10 kN

rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,01	14,90	2606	74,1	6,05	74,1	5,49	20	30	48
2	2,99	14,00	2502	72,7	6,64	72,7	6,19	20	30	48
3	3,01	14,17	2767	79,4	5,57	80,1	6,94	10	20	48
4	3,09	14,31	2761	79,2	6,48	79,2	6,10	10	20	48

diagram :



statistic :

Serie n = 4	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,02	14,35	2659	76,3	6,18	76,5	6,18	15	25	48
min	2,99	14,00	2502	72,7	5,57	72,7	5,49	10	20	48
max	3,09	14,90	2767	79,4	6,64	80,1	6,94	20	30	48
R	0,10	0,90	264	6,7	1,07	7,4	1,44	10	10	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



test data :

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 client: Karl Otto Braun GmbH & Co. KG
 manufacturer: Karl Otto Braun GmbH & Co. KG
 material: EP - Syntesefaser
 Material-ID: 1201400860804

date of order: 12.05.2014
 pipe geometry: DN 150
 line name: BRAWO I
 date of manufacturing: 14.04.2014

test parameters :

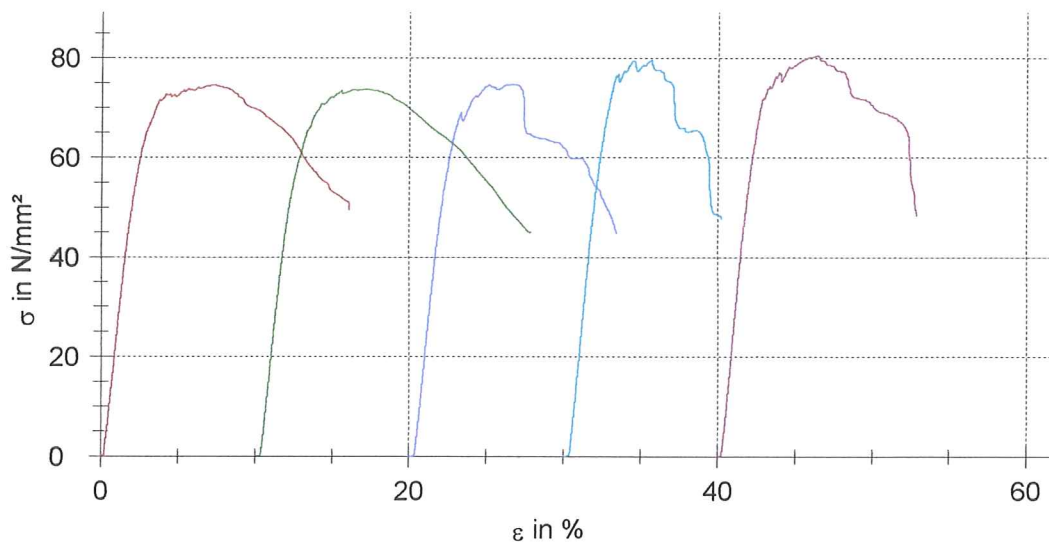
test date : 19.06.2014
 direction of testing : longitudinal direction
 machine data : 10TN2S WN:143493
 Traversenwegaufnehmer WN:143493
 Kraftsensor ID:0 WN:143494 10 kN

rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,32	14,01	3102	67,0	3,13	74,6	6,99	10	15	50
2	3,04	13,95	3103	72,3	4,93	73,8	6,71	10	15	50
3	3,21	13,85	3134	69,1	3,37	74,7	6,46	10	15	50
4	2,93	14,07	3401	76,7	3,39	79,6	5,23	20	30	50
5	3,24	14,24	3427	71,9	2,88	80,5	6,12	20	30	50

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,15	14,02	3233	71,4	3,54	76,6	6,30	14	21	50
min	2,93	13,85	3102	67,0	2,88	73,8	5,23	10	15	50
max	3,32	14,24	3427	76,7	4,93	80,5	6,99	20	30	50
R	0,39	0,39	324	9,6	2,04	6,7	1,76	10	15	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



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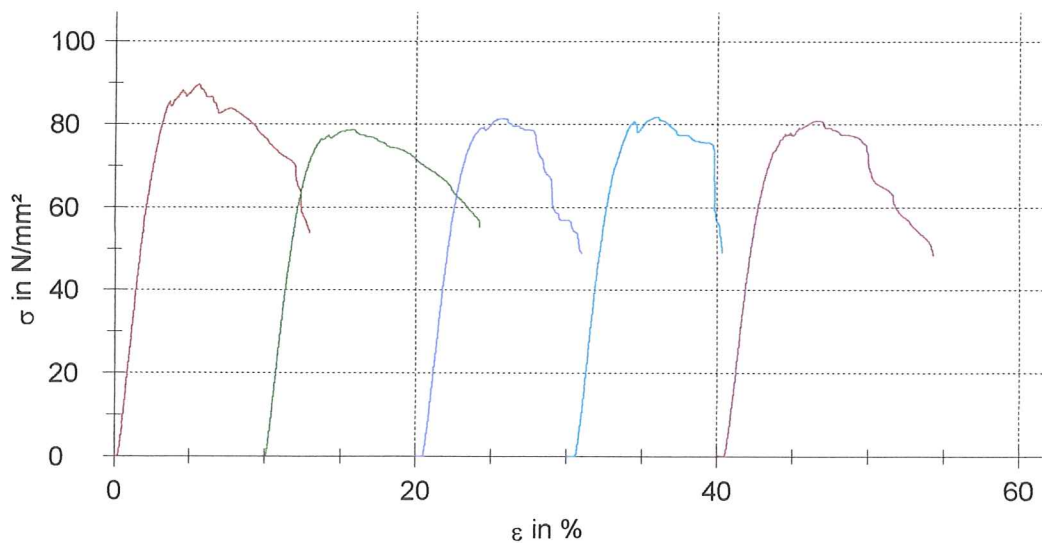
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rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,22	14,17	3576	85,1	3,57	89,6	5,31	10	20	52
2	3,27	14,30	3431	76,6	3,71	78,6	5,64	20	25	52
3	3,48	14,35	3402	79,3	4,54	81,4	5,13	20	25	52
4	3,31	13,98	3443	80,7	4,47	81,8	5,24	20	25	52
5	3,26	13,90	3316	77,7	4,52	80,9	6,08	20	25	52

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,31	14,14	3434	79,9	4,16	82,5	5,48	18	24	52
min	3,22	13,90	3316	76,6	3,57	78,6	5,13	10	20	52
max	3,48	14,35	3576	85,1	4,54	89,6	6,08	20	25	52
R	0,26	0,45	261	8,5	0,97	11,0	0,95	10	5	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



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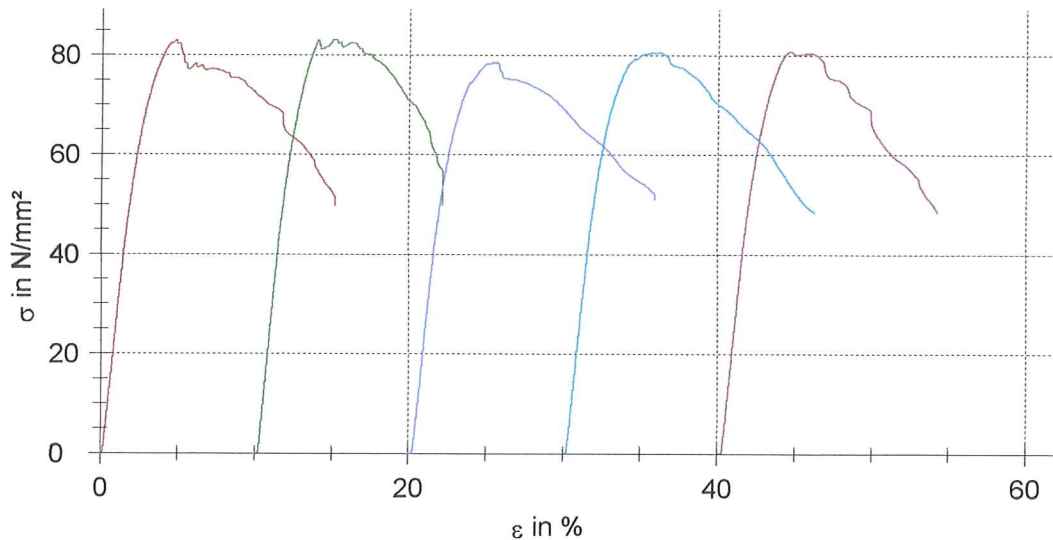
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rate of crosshead motion : 1,3 mm/min
 tester : T. Benner

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,31	13,98	3160	82,5	4,48	83,0	4,68	10	20	52
2	3,26	14,23	3346	83,0	4,09	83,1	4,78	10	20	52
3	3,24	14,13	3089	78,4	5,07	78,6	5,13	10	20	52
4	3,22	14,17	3185	79,3	4,57	80,6	5,46	10	20	52
5	3,08	14,18	3151	80,8	4,66	80,8	4,36	10	20	52

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,22	14,14	3186	80,8	4,58	81,2	4,88	10	20	52
min	3,08	13,98	3089	78,4	4,09	78,6	4,36	10	20	52
max	3,31	14,23	3346	83,0	5,07	83,1	5,46	10	20	52
R	0,23	0,25	257	4,6	0,98	4,5	1,10	0	0	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification

b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification

E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength



test data :

construction project: Material examination in acc. to ASTM- Standards
 date of order: 12.05.2014
 client: Karl Otto Braun GmbH & Co. KG pipe geometry: DN 150
 manufacturer: Karl Otto Braun GmbH & Co. KG line name: BRAWO I
 material: EP - Syntesefaser date of manufacturing: 14.04.2014
 Material-ID: 1201400860804

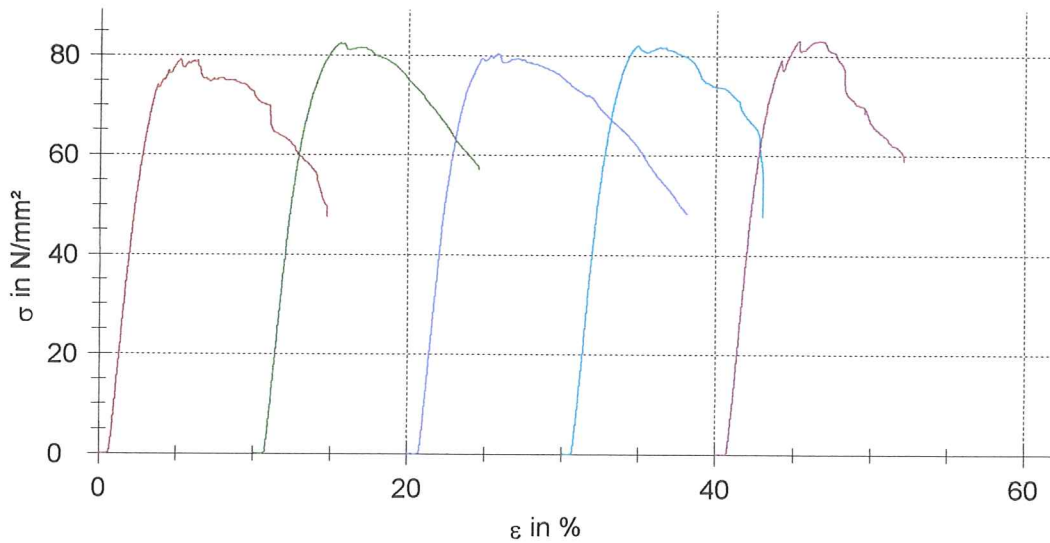
test parameters :

test date : 19.06.2014 rate of crosshead motion : 1,3 mm/min
 direction of testing : logitudinal direction tester : T. Benner
 machine data : 1435 WN:116255
 Traversenwegaufnehmer WN:116255
 Mitutoyo Messschieber
 Kraftsensor ID:0 WN:811555 10 kN

test results :

Nr	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
1	3,39	13,98	3297	74,1	3,75	79,3	4,53	20	25	50
2	3,06	14,23	3224	82,5	5,56	82,5	4,77	20	25	50
3	3,16	14,13	3278	79,5	4,76	80,4	4,99	20	25	50
4	3,22	14,17	3396	82,1	4,81	82,1	4,06	20	25	50
5	3,22	14,18	3325	79,2	4,17	83,2	4,52	20	25	50

diagram :



statistic :

Serie n = 5	d mm	b mm	E _f N/mm ²	σ _{fb} N/mm ²	ε _{fb} %	σ _{fM} N/mm ²	ε _{fM} %	σ _{f1} N/mm ²	σ _{f2} N/mm ²	L mm
\bar{x}	3,21	14,14	3304	79,5	4,61	81,5	4,57	20	25	50
min	3,06	13,98	3224	74,1	3,75	79,3	4,06	20	25	50
max	3,39	14,23	3396	82,5	5,56	83,2	4,99	20	25	50
R	0,33	0,25	173	8,4	1,81	4,0	0,94	0	0	0

symbols pursuant to ASTM D790

d : depth of beam
 L : support span
 σ_{f1} : initial stress of modulus identification
 b : sample width
 ε_{fb} : flexural strain at first break
 ε_{fM} : flexural strain
 σ_{f2} : end stress of modulus identification
 E_f : flexural modulus
 σ_{fb} : flexural stress at first break
 σ_{fM} : flexural strength

