

RĪGAS TEHNISKĀ UNIVERSITĀTE

MATERIĀLU UN KONSTRUKCIJU INSTITŪTS

Āzenes iela 16/20

Rīga, LV-1048, Latvija.

Tel./fax (+371) 7089248

E-mail: Olgerts.Ozolins@rtu.lv

Characterization of the material properties of particle filled resin composite plate

Report Nr. /2014

Customer: Amfi-Top Ltd.

Adress: Riga, LV-1011

Rīga 2014

RTU
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Test report Nr. /2014

Customer:

Amfi-Top Ltd.

Test article:

Flat particle fillet resin plate

Test task:

Characterization of mechanical properties (tensile, compression, flexure)

Test article
recieved:

15.07.2014

Tested:

22.07.2014

Test site:

RTU Institute of materials and structures, Test laboratory

Test article:

Flat plate of 11.6 mm thickness recieved.

Test equipment and conditions:

Tests were carried out on universal testing machine INSTRON 8002.

Specification:

INSTRON servo-hydraulic test frame 8002.

- Max. displacement – 150 mm;
- Max. load – 250 kN;
- INSTRON Fast Track 8800 controller;
- INSTRON Bluehill2 test software;
- INSTRON 2620 series clip-on extensometer;



INSTRON 8002 servo-hydraulic test system

Conditions:

T = 23°C, RH = 60-70%

Reports:

Test results characterize only properties obtained for test article and can't be transferred to the similar products, even on those sharing the same technological process.

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Test carried out by: O.Ozoliņš

Supervised by: Aleksandrs Korjamins

CHARACTERIZATION OF MATERIAL PROPERTIES BY COUPON TESTS

The material characterization of the particle reinforced/filled resin composite is performed according to the following standards: ISO 527-1:1993 Plastics - Determination of tensile properties, ASTM D 695-02a Standard test method for compressive properties of rigid plastics, ISO 14125:1998 Fibre reinforced plastic composites – Determination of flexural properties.

Samples were manufactured as a batch of 6 specimens for each test type with total number of 24 specimens for 4 types of tests. Some custom specimen size approach used due to available raw material format, specimen thickness about 11.65 mm. Nominal specimen dimensions: for tensile tests were chosen as 25 mm width and 300 mm long, for compression (in-plane) prismatic shape with cross section of 15 mm x 11.65 mm and anvil height of 25 mm, for compression (out-of-plane, thickness direction) prismatic shape with cross section of 15 mm x 15 mm and anvil height 11.65 mm (actual plate thickness).

Coupon test specimens were cut from flat plate by diamond blade dry saw. The final shape of the specimens was obtained by precision grinding on 120 grain sandpaper machine. In total four material constants were obtained: E^t , E_0^c , E_{90}^c , E_{flex} . Additionally four corresponding strength constants obtained: R^t , R_0^c , R_{90}^c , R_{flex} .

Clip-on extensometer with 50 mm gauge length was used for tensile tests. Strain measurements for compressive and flexural tests were calculated as elongation/shortening of the specimen gauge length (anvil height) or axial translation of the loading support in the case of bending (3-point bending test).

Mean values, as well as max and min and standard deviation were calculated for each test series for comparison reasons and series quality estimation. Some specimen data were excluded (indicated by (excl.) at the corresponding series number), from mean value calculation to improve standard deviation of the series, which in most cases maintained to be no much higher than 5%.

Tension test

Tension tests were performed on INSTRON 8802 (250 kN) universal testing machine. Total specimen length was 300 mm with free section of 100 mm, nominal width 25 mm, Figure . Data processing for modulus calculation based on clip-on extensometer, Fig. 2 was carried out on INSTRON Bluehill2 software. Tested specimens are shown in Fig. 3. The material properties are calculated based on ISO 527-1:1993 Plastics - Determination of tensile properties standard.

Results for tension tests were gathered in Table 1.

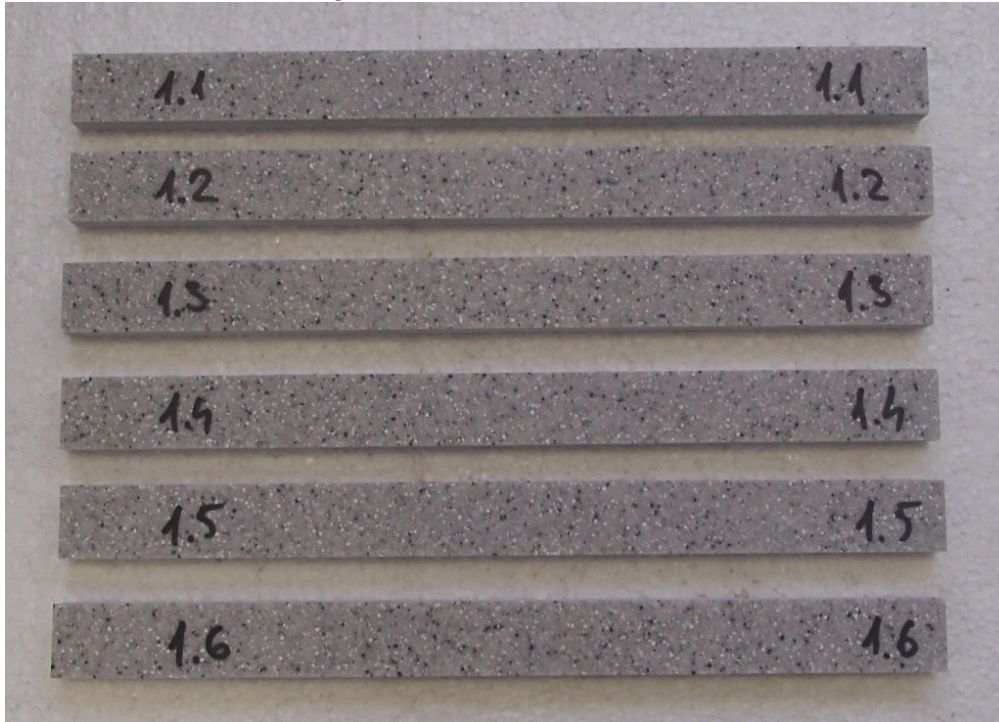


Figure 1. Specimens for tension test.

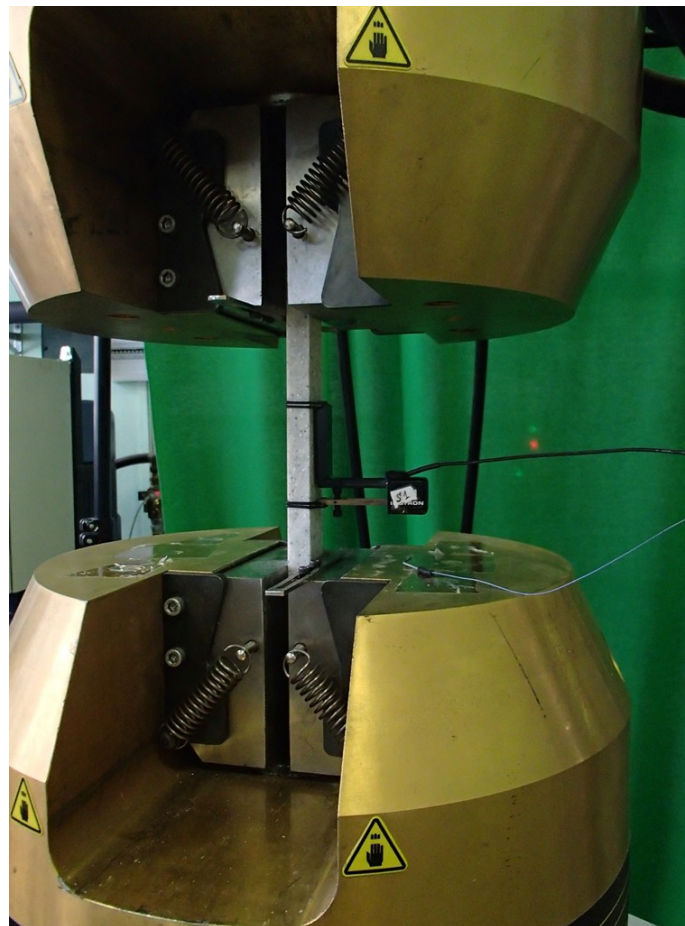


Figure 2. Location of clip-on extensometer for tension test.

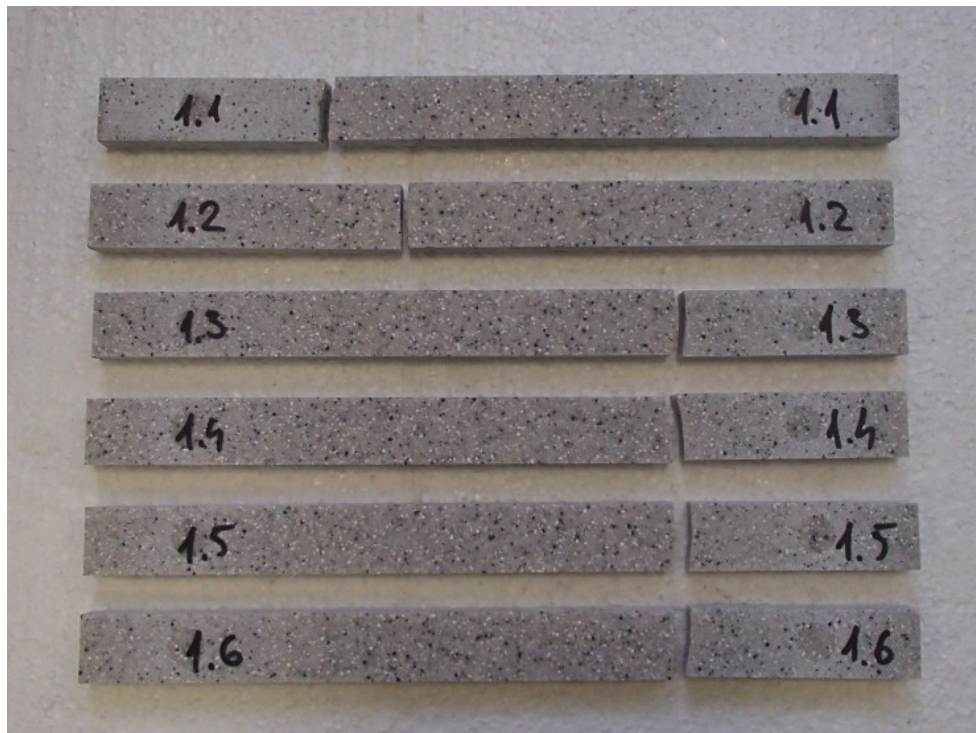


Figure 3. Tensile specimens after test.

Table 1. E^t modulus (Stress range 5 - 20 MPa)

		Specimen number	Thickness	Width	Tensile strength	Elongation at break	E - modulus (tensile)
			(mm)	(mm)	(MPa)	mm/mm	(GPa)
1(excl.)		1.1	11.62	24.65	13	0.00153	8.31
	2	1.2	11.66	24.87	27	0.00356	8.56
	3	1.3	11.66	24.72	27	0.00362	8.21
	4	1.4	11.65	24.62	30	0.00393	8.25
	5	1.5	11.62	24.86	26	0.00348	8.48
	6	1.6	11.64	24.58	28	0.00384	8.22
Mean					27	0.00369	8.27
Maximum					30	0.00393	8.56
Minimum					26	0.00348	8.21
Standard Deviation					1.43363	0.00019	0.14716
Standard Deviation (%)					5.3	5.1	1.8

Compression test

Compression tests (in-plane and out-of-plane) were performed on INSTRON 8802 (250 kN) universal testing machine. Specimen anvil height was used according to standard 25 mm (in-plane) and 11.65 mm (real plate thickness) for (out-of-plane), Figure . Samples were tested up to visible failure. Specimens were tested employing flat circular compression platens with spherical seat on one end for better alignment,

Fig. 5, 6. Strain calculation was carried out based on machine displacement and actual specimen anvil height. Tested specimens are shown in Fig. 7. The material properties are calculated based on ASTM D 695-02a Standard test method for compressive properties of rigid plastics standard.

Results for (in-plane) compression tests were gathered in Table 2 and (out-of-plane) in Table 3. Compressive strength indicated in Table 2 and Table 3 corresponds to the maximum stress, which in this case was observed higher than maximum elastic limit (proportionality limit). Practical compression strength (within proportionality limit can be 82 MPa (in-plane) and 87 MPa (out-of-plane), calculation based on proportionality limit load 14 kN (in-plane) Fig. 8 and 20 kN (out-of-plane) Fig. 9 and average specimen series cross section.

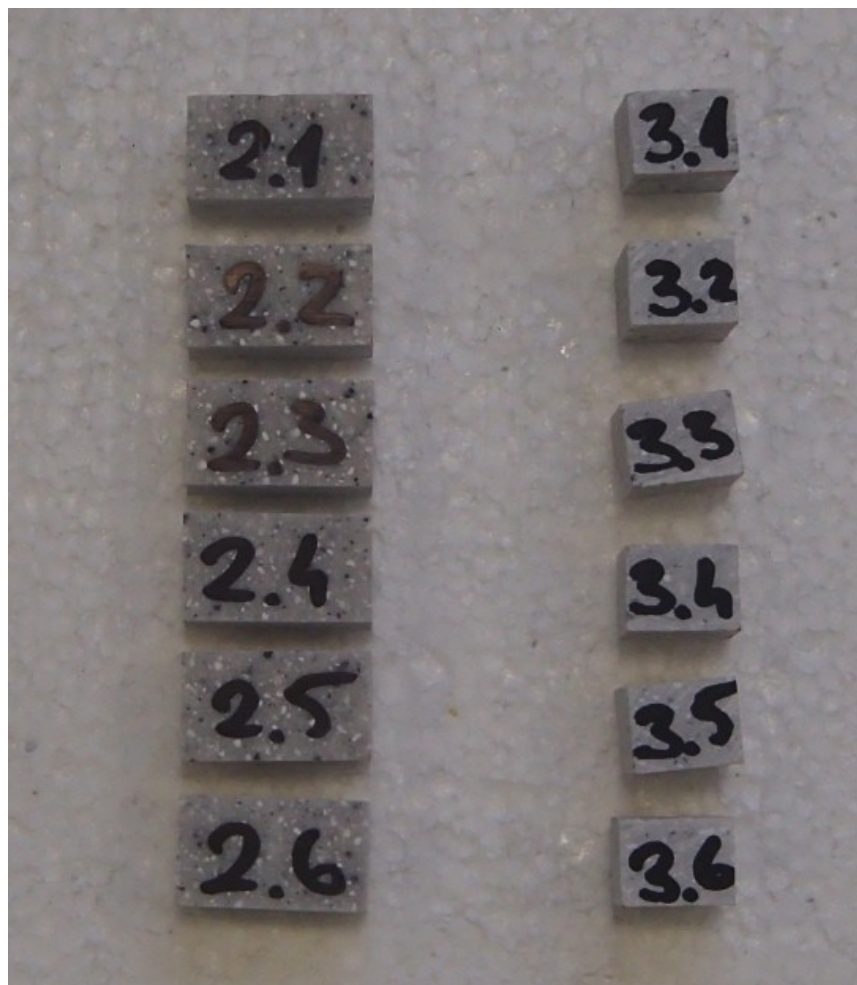


Figure 4. Test specimens for compression tests.

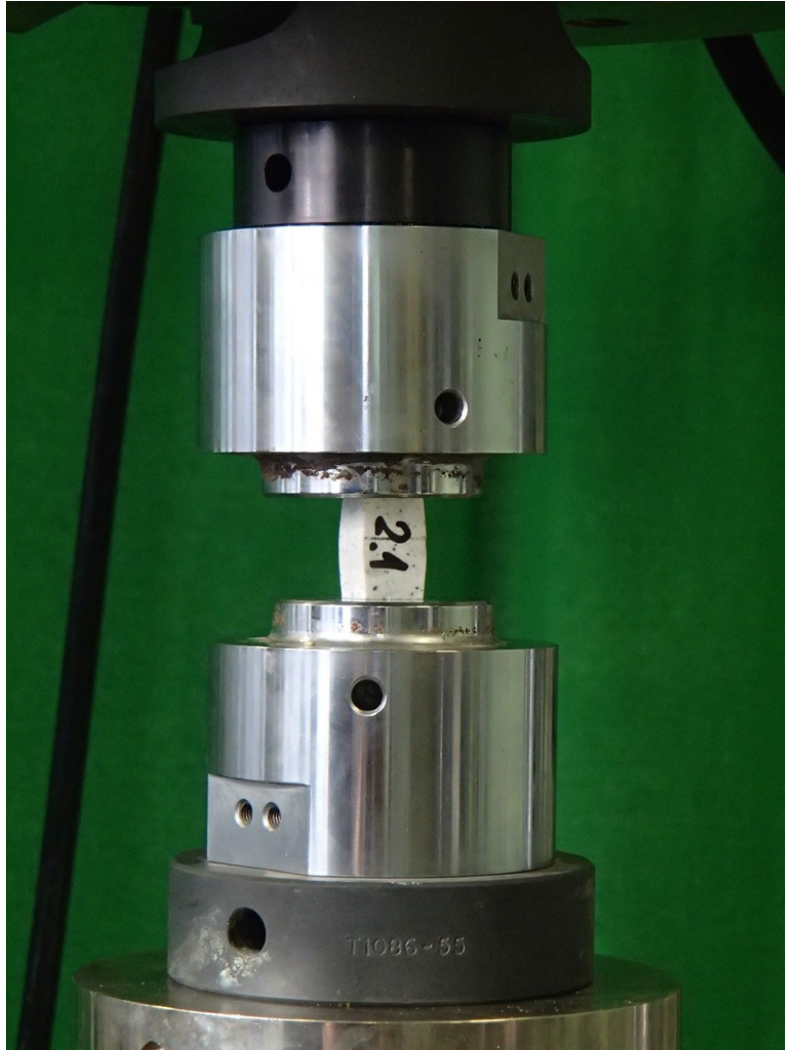


Figure 5. Compression specimen (in-plane) installed in compression platens during testing.

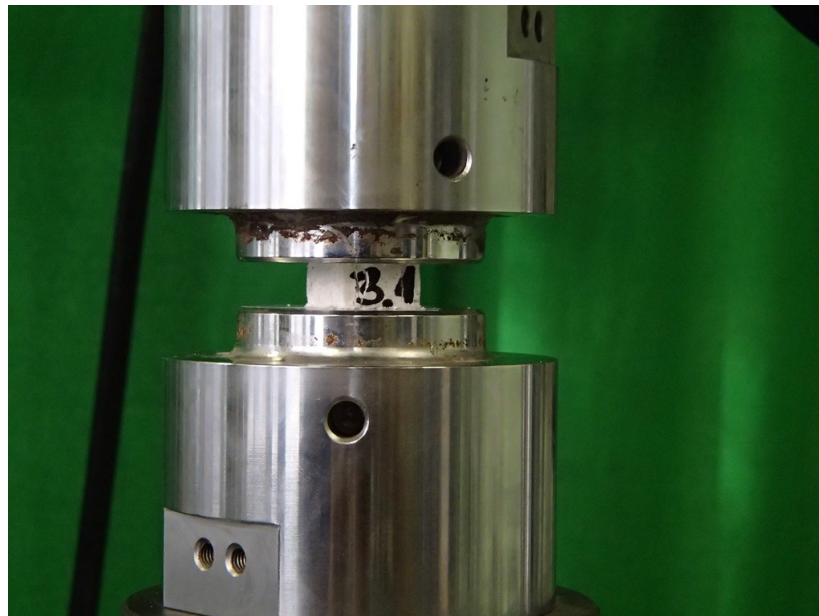


Figure 6. Compression specimen (out-of-plane) installed in compression platens during testing.



Figure 7. Compression specimens after testing.

Table 2. E_o^c (in-plane) modulus (Stress range 10 - 50 MPa)

		Specimen label	Width	Thickness	Anvil height	Compressive strength	Compressive strain at max. Compressive strength	E - modulus (compressive)
			(mm)	(mm)	(mm)	(MPa)	mm/mm	(GPa)
1		2.1	14.76	11.61	25.87	97	0.13878	4.97
2	(excl.)	2.2	14.42	11.63	25.80	97	0.12877	4.77
3		2.3	14.77	11.65	25.83	100	0.13272	4.83
4		2.4	14.67	11.65	25.83	100	0.1319	4.56
5		2.5	14.70	11.62	25.72	99	0.13276	4.34
6		2.6	14.86	11.63	25.91	98	0.12031	5.06
Mean						98	0.13129	4.76
Maximum						100	0.13878	5.06
Minimum						97	0.12031	4.34

Standard Deviation	1.28749	0.00673	0.26404
Standard Deviation (%)	1.3	5.1	5.6

Table 3. E_{90}^c (out-of-plane) modulus (Stress range 10 - 50 MPa)

		Specimen label	Width	Thickness	Anvil height	Compressive strength	Compressive strain at max. Compressive strength	E - modulus (compressive)
			(mm)	(mm)	(mm)	(MPa)	mm/mm	(GPa)
	1	3.1	14.86	15.40	11.60	131	0.16737	4.68
	2	3.2	14.85	15.49	11.68	150	0.16235	4.77
	3	3.3	14.84	15.45	11.60	133	0.17123	4.67
	4	3.4	14.85	15.47	11.60	145	0.13441	4.95
	5 (excl.)	3.5	14.90	15.42	11.66	130	0.15938	5.27
	6 (excl.)	3.6	14.70	15.43	11.61	135	0.26176	4.90
Mean						137	0.15895	4.79
Maximum						150	0.17123	4.95
Minimum						130	0.13441	4.67
Standard Deviation						8.08634	0.01445	0.12834
Standard Deviation (%)						5.9	9.1	2.7

Graph 1

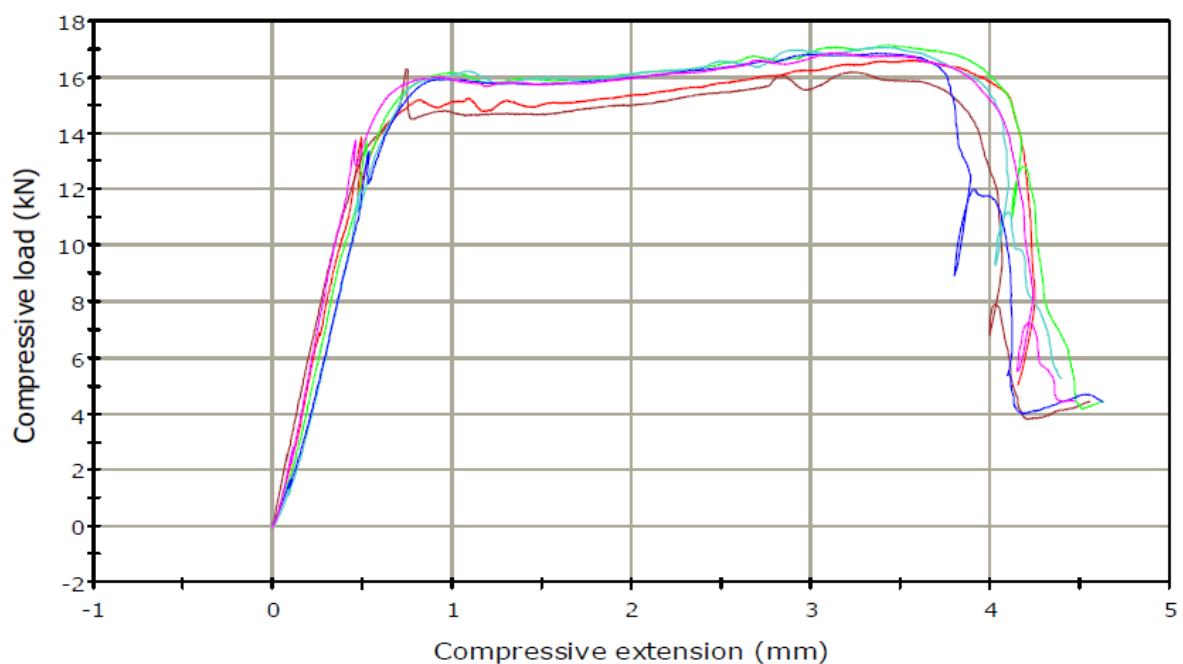


Figure 8. Test curves of compression (in-plane).

Graph 1

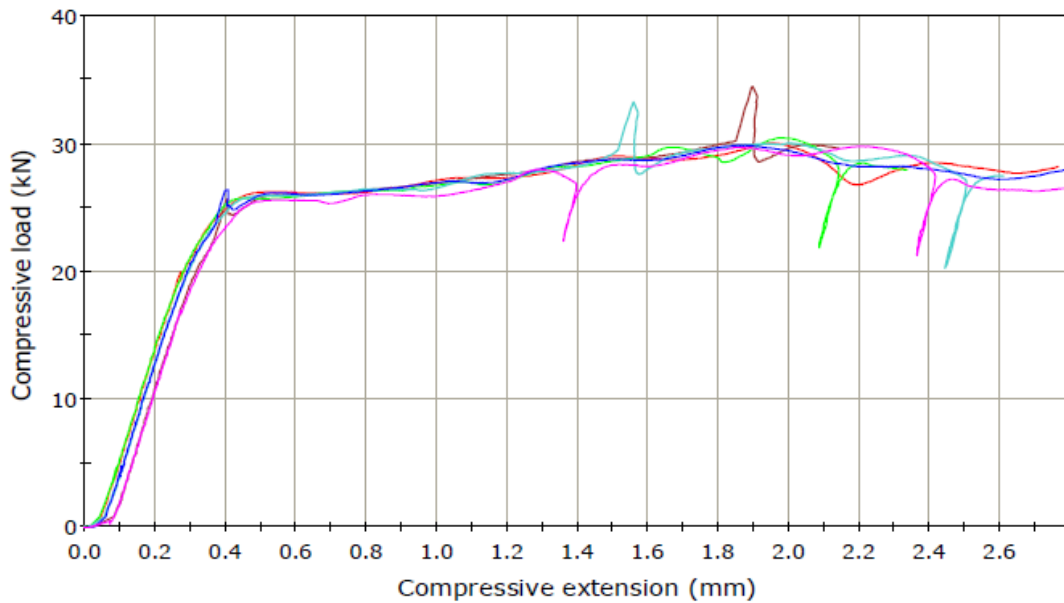


Figure 9. Test curves of compression (out-of-plane).

Flexural test

3-point flexure tests were performed on INSTRON 8802 (250 kN) universal testing machine, employing 3-point bending fixture. Total specimen length was 235 mm (20 x h) with support span of 186 mm (16 x h), nominal width 15 mm, Figure . Samples were tested up to failure. Specimens were tested employing 3-point bending fixture, rested on fixed spherical seat. Bending translation was measured by machine translation. The material properties are calculated based on ISO 14125:1998 Fibre reinforced plastic composites – Determination of flexural properties standard. Obtained test results were gathered in Table 4.



Figure 10. Test specimens for flexure tests.

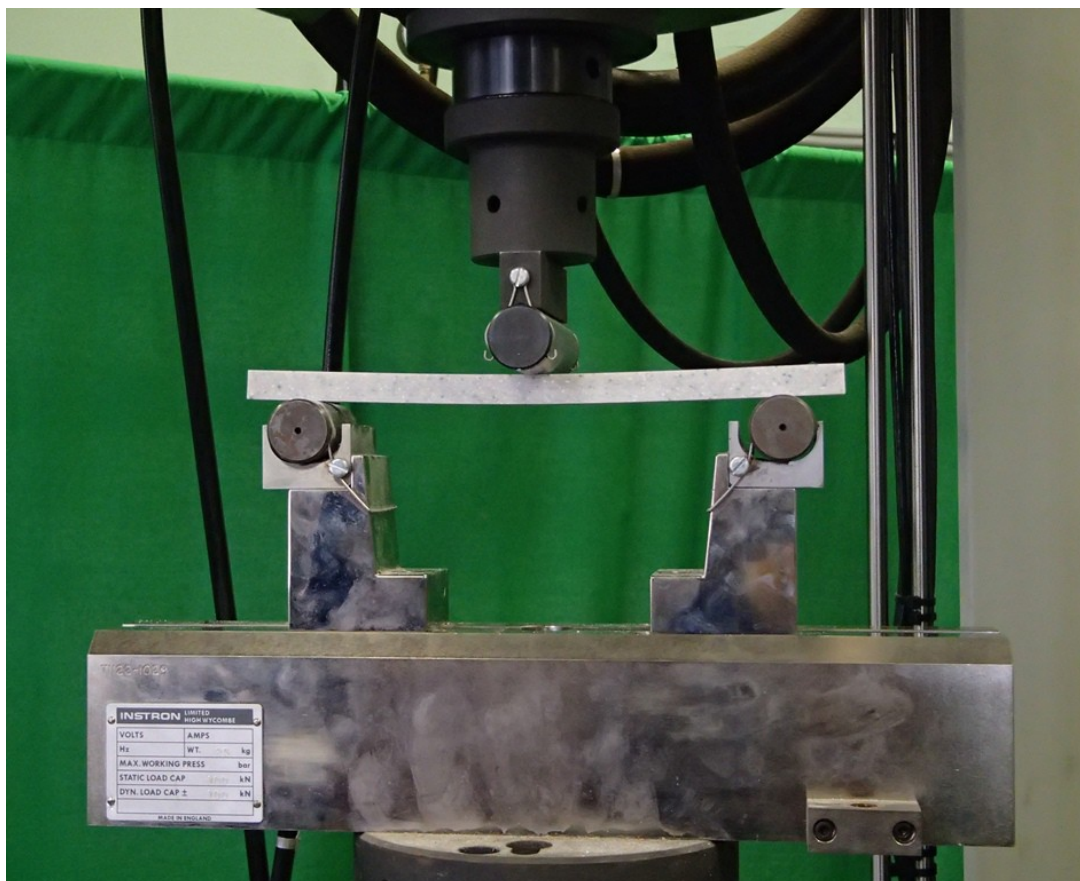


Figure 11. Test specimens for flexure tests.

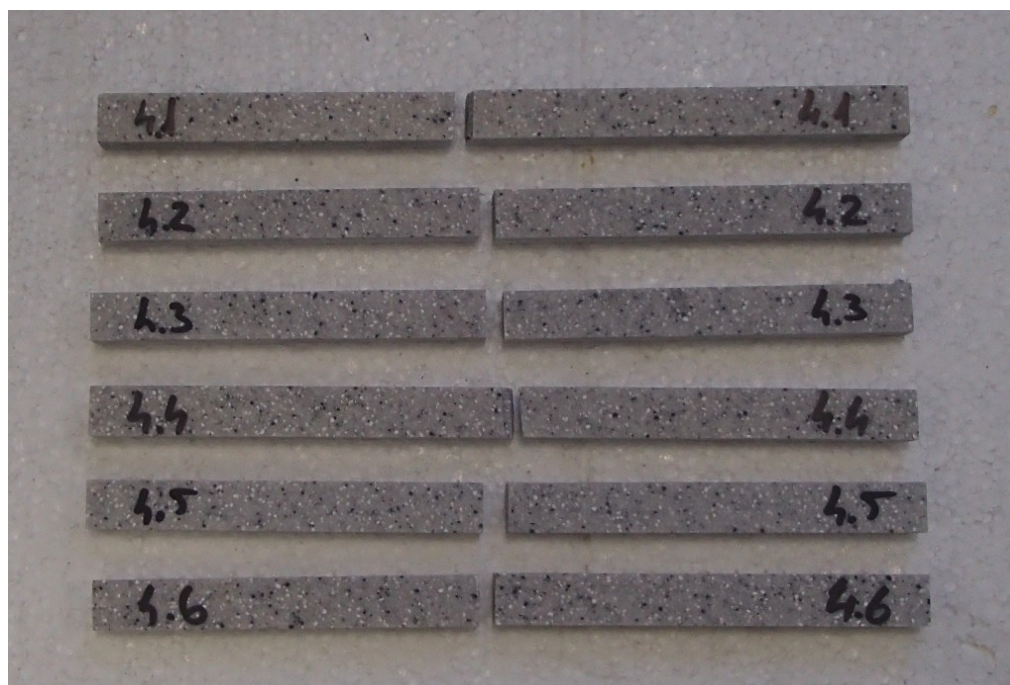


Figure 12. Test specimens after flexure tests.

Table 4. E_{flex} modulus (Stress range 5 - 20 MPa)

	Specimen label	Width	Thickness	Flexure strength	E - modulus (flexural)
		(mm)	(mm)	(MPa)	(GPa)
1 (excl.)	4.1	14.7	11.62	37	6.70
2	4.2	14.6	11.56	39	8.95
3	4.3	14.3	11.68	34	8.77
4	4.4	14.7	11.66	42	7.47
5	4.5	14.7	11.63	40	7.07
6	4.6	14.7	11.59	36	7.50
Mean				38	7.95
Maximum				42	8.95
Minimum				34	7.07
Standard Deviation				2.77894	0.91498
Standard Deviation (%)				7.3	11.5

CONCLUSIONS

Specimen failure observed in coupon tests was within test zone for all specimens, except tension specimens, where failure was observed near grip interface which is acceptable for the un-tabbed specimens. Tabbed specimens most likely can slightly improve strength at break, but this is only assumption (not confirmed). All obtained results gathered in Table 5. Red marked compression strength values are calculated according to proportionality limit load values assuming that exploitation up-to this load level will not introduce permanent damage to the structure.

Experimental testing

	Mean value	Standard deviation
Stiffness	(GPa)	(%)
E_t	8.27	1.8
$E_c(0)$	4.76	5.6
$E_c(90)$	4.79	2.6
E_{flex}	7.95	11.5
Strength	(MPa)	(%)
R_t	27	5.3

Rc (0)	82	1.3
Rc (90)	87	5.9
Rflex	38	7.3

Appendix A (test protocols)

