Static Tests of OPTIMAT MD and UD coupons

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TG 1

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Change record

Issue/revision	date	Pages	Summary of changes
0	16.06.2003	all	new document

Table of contents

1 Introduction

This work was carried out according to the test plan in DPA [1] and the Test Plan Report of TG1 [2]. In total, 10 MD and 10 UD specimens were tested under static loading. Five coupons each were tested in tension and five in compression.

2 Test coupons

For all tests Standard Optimat UD and MD Coupons were used. The nominal dimension of the test coupons are shown in Figure 1 and Figure 2.

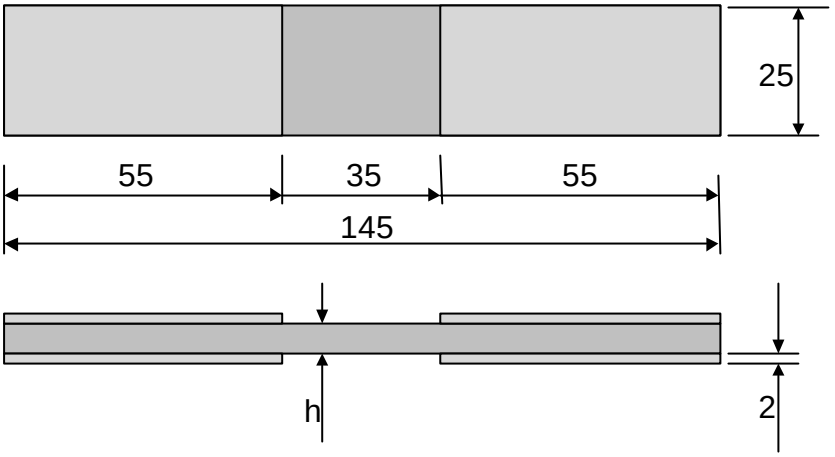

Figure 1: Geometry of Optimat UD test coupon

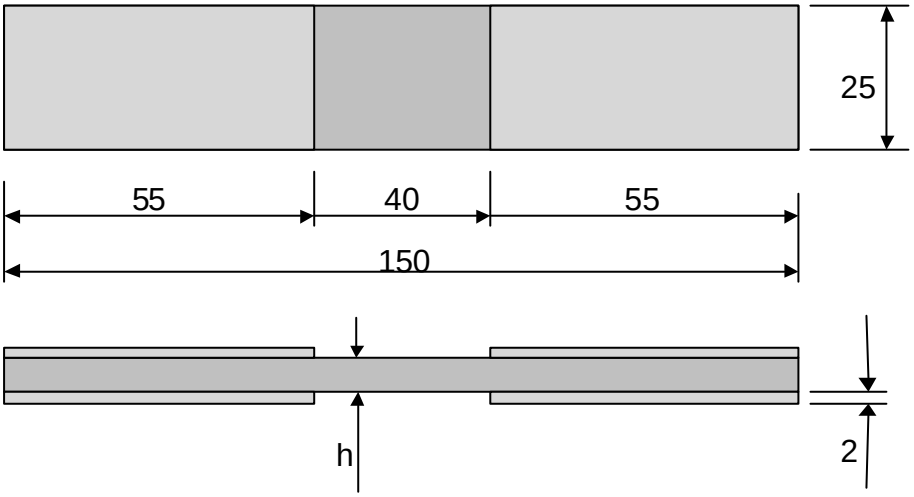

Figure 2: Geometry of Optimat MD test coupon

3 Experimental

3.1 Static tensile tests

Tests were carried out on a Zwick 200 kN test machine equipped with hydraulic grips of 100 kN capacity. Strain was measured using 2 TML gauges (one on each side of the specimen) with a gauge length of 6 mm and nominal electrical resistance of 120 Ohms, type FLA-6-11-1L. Load was applied displacement-controlled with nominal speed of 0.25 mm/min.
All tests were carried out at ambient room conditions.

3.2 Static compression tests

Tests were carried out on a Mohr und Federhaff 250 kN servo-hydraulic test machine equipped with mechanical grips using a Roell Amsler K7500 control-unit. Strain was measured using 2 TML gauges (one on each side of the specimen) with a gauge length of 6 mm and nominal electrical resistance of 120 Ohms, type FLA-6-11-1L. Strain gauge measurements were aquired using an HBM UPM100 acquisition system. Load was applied displacement-controlled with nominal speed of 1 mm/min.
All tests were carried out at ambient room conditions.

4 Test Results

4.1 Static tensile tests

Elastic modulus was determined for axial strains between 500 and 2500 µstrain, according to EN ISO 527-1 [3]. Values were calculated using the average of the two strain gauge measurements. Experimental results are summarized in Table 1 and Table 2.

Material property	Unit	Measurement	COV [%]
Elastic modulus	MPa	27678	0,59
Tensile strength	MPa	532,97	1,00
Tensile strain to failure	%	2,26	2,87

Table 1: Results from static tensile tests for MD coupons

Material property	Unit	Measurement	COV [%]
Elastic modulus	MPa	39019	0,46
Tensile strength	MPa	838,50	3,07
Tensile strain to failure	%	2,29	2,45

Table 2: Results from static tensile tests for UD coupons

4.2 Static compression tests

Elastic modulus was determined for axial strains between 500 and 2500 µstrain, according to EN ISO 14126 [4]. Values were calculated using the average of the two strain gauge measurements. Experimental results are summarized in Table 3 and Table 4.

Material property	Unit	Measurement	COV [%]
Elastic modulus	MPa	28178	1,15
Compression strength	MPa	485,80	3,99
Compression strain to failure	%	1,99	4,29

Table 3: Results from static compression tests for MD coupons

Material property	Unit	Measurement	COV [%]
Elastic modulus	MPa	38928	1,56
Compression strength	MPa	588,04	4,88
Compression strain to failure	%	1,51	4,87

Table 4: Results from static compression tests for UD coupons

5 Conclusions

Static tensile and compression tests were performed using the Optimat MD and UD specimens. All tests showed acceptable failure modes. For the UD coupons severe bending could be observed in the compression tests, if stress exceeds 400 MPa.
Scatter was very low for both test types.

6 References

[1] Ch.W. Kensche et al., *Detailed plan of action Task Group 1*, DLR, doc. OB_TG1_O002 rev. 4, 17.02.2003

[2] O. Krause, Test plan report, DLR, doc. OB_TG1_R003 rev. 0, 24.02.2003

[3] EN ISO 527:1996, *Plastics - Determination of tensile properties*, European Committee for Standardization

[4] ISO 14126:1999, *Fibre reinforced plastics composites – Determination of compressive properties in the in-plane direction*, European Committee for Standardization

7 Appendix

7.1 Results

Coupon Name	Width [mm]	Thickness [mm]	Modulus [MPa]	Fracture strength [MPa]	Fracture strain [%]
GEV207-RO400-0134	25,30	6,60	27697	528,71	2,26
GEV207-RO400-0135	25,37	6,65	27807	534,99	2,30
GEV207-RO400-0136	25,00	6,58	27441	538,90	2,35
GEV207-RO400-0137	25,25	6,58	27842	536,09	2,20
GEV207-RO400-0138	25,21	6,63	27602	526,16	2,20
Mean Value	**25,23**	**6,61**	**27678**	**532,97**	**2,26**
COV [%]	0,55	0,47	0,59	1,00	2,87

Table 5: Static tensile test results of MD coupons

Coupon Name	Width [mm]	Thickness [mm]	Modulus [MPa]	Fracture strength [MPa]	Fracture strain [%]
GEV206-RO300-0025	25,05	3,70	39156	862,02	2,35
GEV206-RO300-0026	25,00	3,65	38882	865,04	2,27
GEV206-RO300-0027	25,10	3,70	38778	840,78	2,32
GEV206-RO300-0028	25,25	3,70	39185	814,95	2,33
GEV206-RO300-0029	25,00	3,75	39094	809,73	2,21
Mean Value	**25,08**	**3,70**	**39019**	**838,50**	**2,29**
COV [%]	0,41	0,96	0,46	3,07	2,45

Table 6: Static tensile test results of UD coupons

Coupon Name	Width [mm]	Thickness [mm]	Modulus [MPa]	Fracture strength [MPa]	Fracture strain [%]
GEV207-R0400-0098	25,30	6,65	28061	457,06	1,91
GEV207-R0400-0099	25,18	6,61	28497	498,65	1,99
GEV207-R0400-0100	25,26	6,60	27982	500,10	2,06
GEV207-R0400-0101	25,16	6,60	28540	500,92	2,08
GEV207-R0400-0102	25,21	6,63	27810	474,27	1,89
Mean Value	**25,22**	**6,62**	**28178**	**486,20**	**1,99**
COV [%]	0,23	0,33	1,15	4,06	4,29

Table 7: Static compressive test results of MD coupons

Coupon Name	Width [mm]	Thickness [mm]	Modulus [MPa]	Fracture strength [MPa]	Fracture strain [%]
GEV206-R0300-0030	25,15	3,70	38666	599,65	1,56
GEV206-R0300-0031	25,05	3,70	38496	553,11	1,43
GEV206-R0300-0032	25,15	3,70	38334	590,54	1,56
GEV206-R0300-0033	25,10	3,65	39435	627,74	1,58
GEV206-R0300-0034	25,20	3,70	39708	569,15	1,43
Mean Value	**25,13**	**3,69**	**38928**	**588,04**	**1,51**
COV [%]	0,23	0,61	1,56	4,88	4,87

Table 8: Static compressive test results of UD coupons

7.2 Figures

7.2.1 Tensile test MD coupons

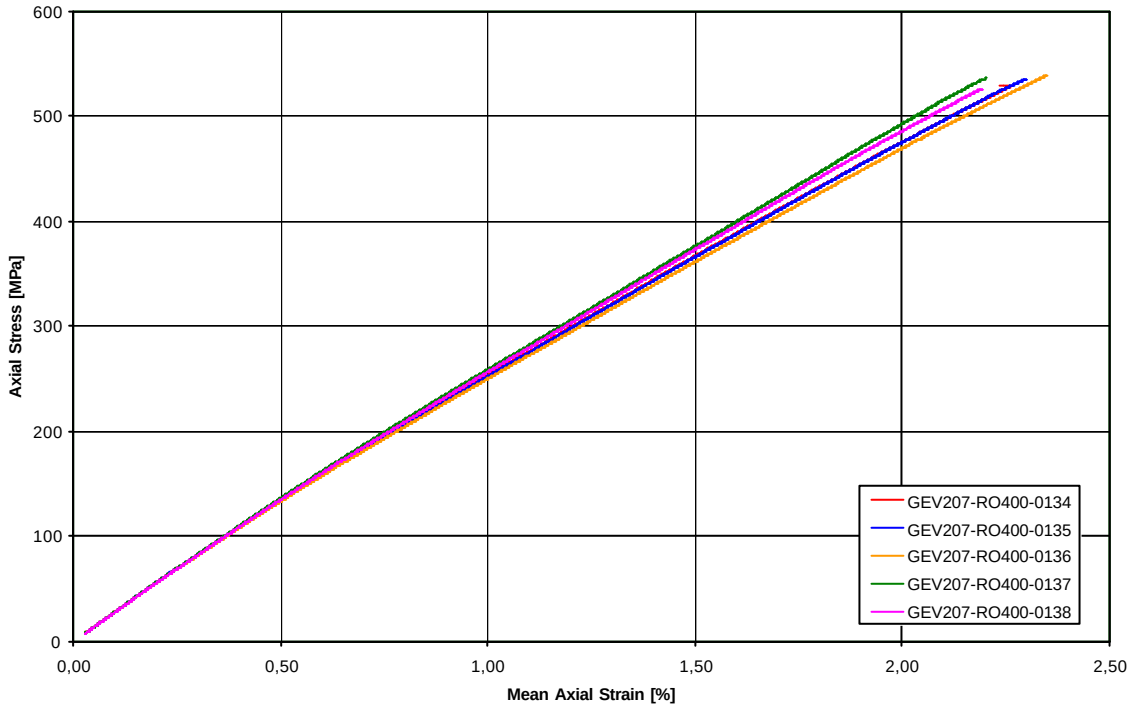

Figure 3: Axial stress vs. mean axial strain

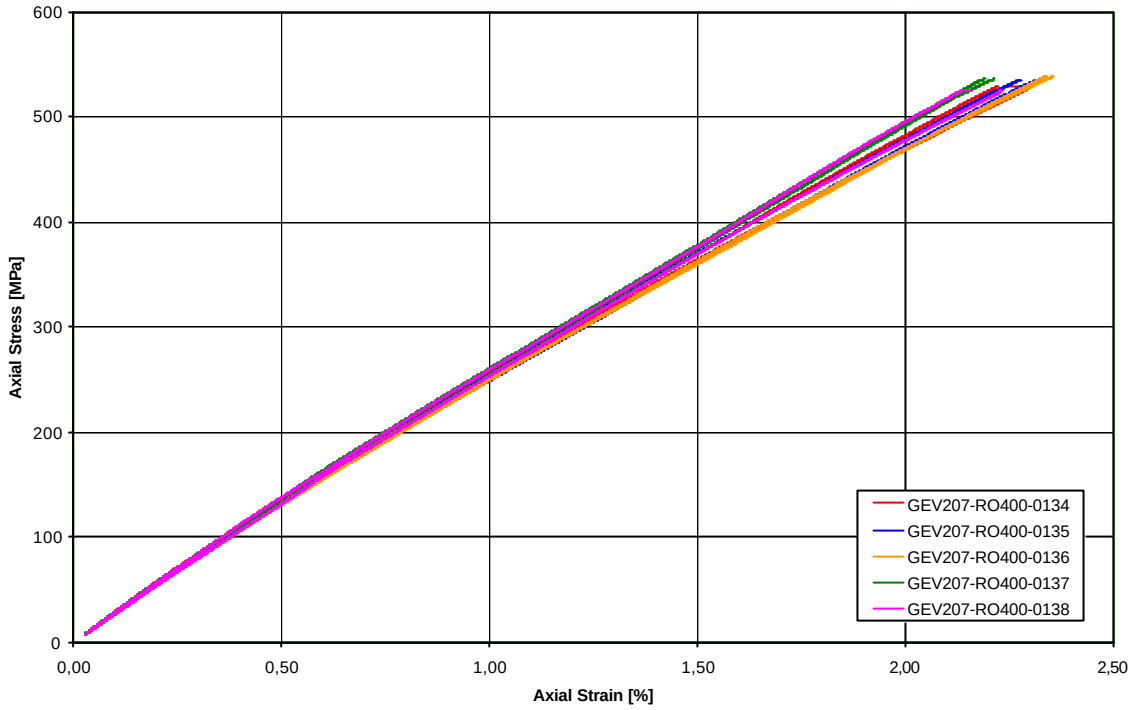

Figure 4: Axial stress vs. axial strain, both strain gauges presented

7.2.2 Tensile test UD coupons

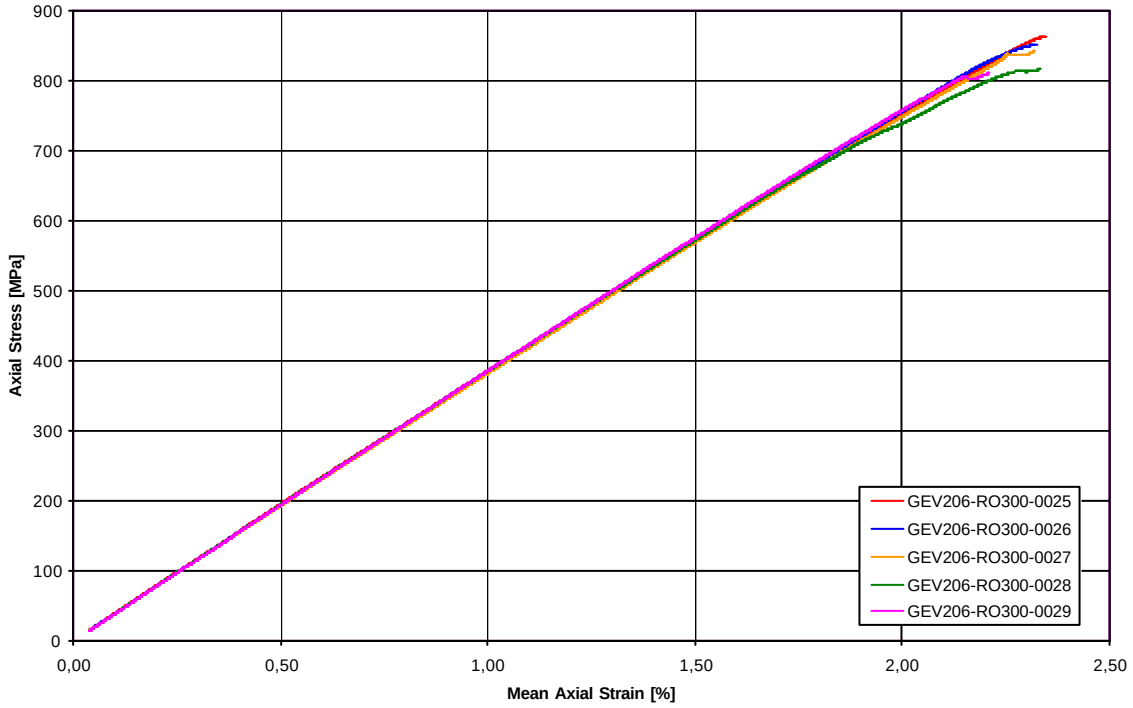

Figure 5: Axial stress vs. mean axial strain

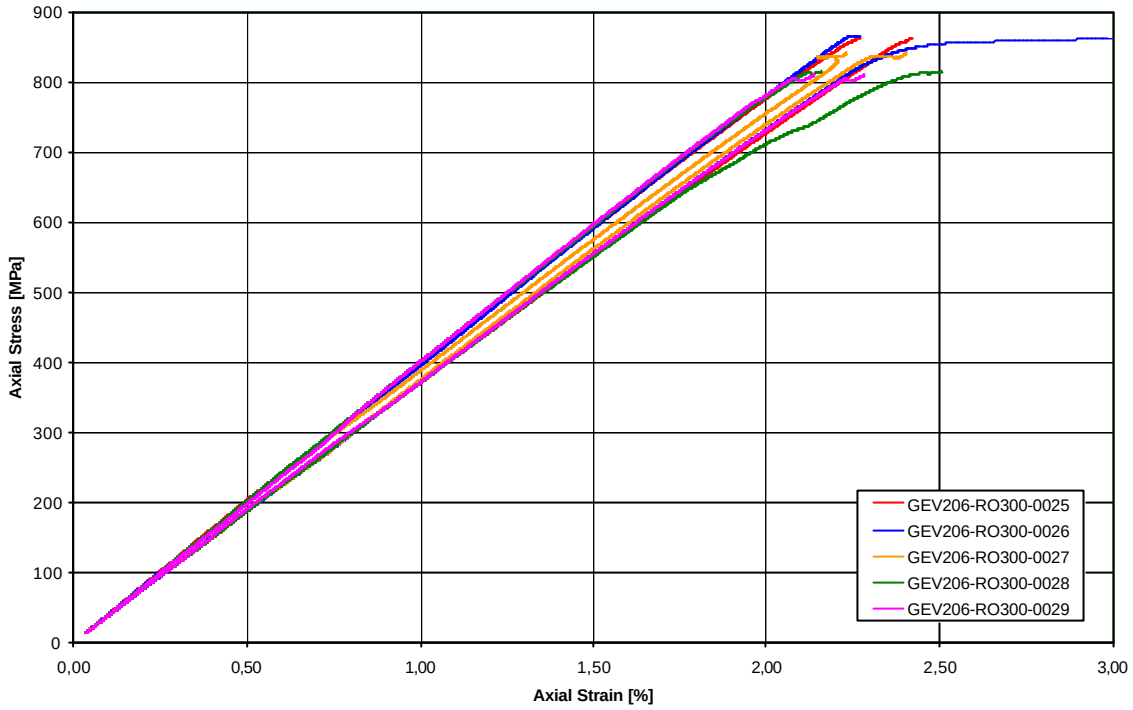

Figure 6: Axial stress vs. axial strain, both strain gauges presented

7.2.3 Compressive test MD coupons

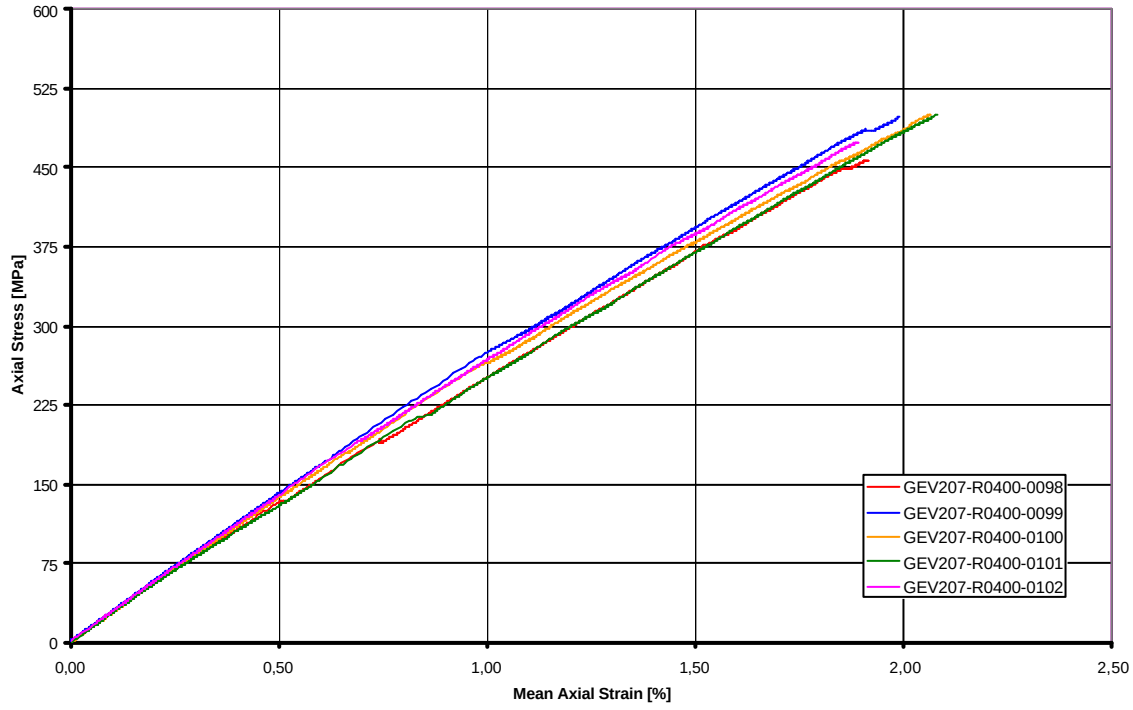

Figure 7: Axial stress vs. mean axial strain

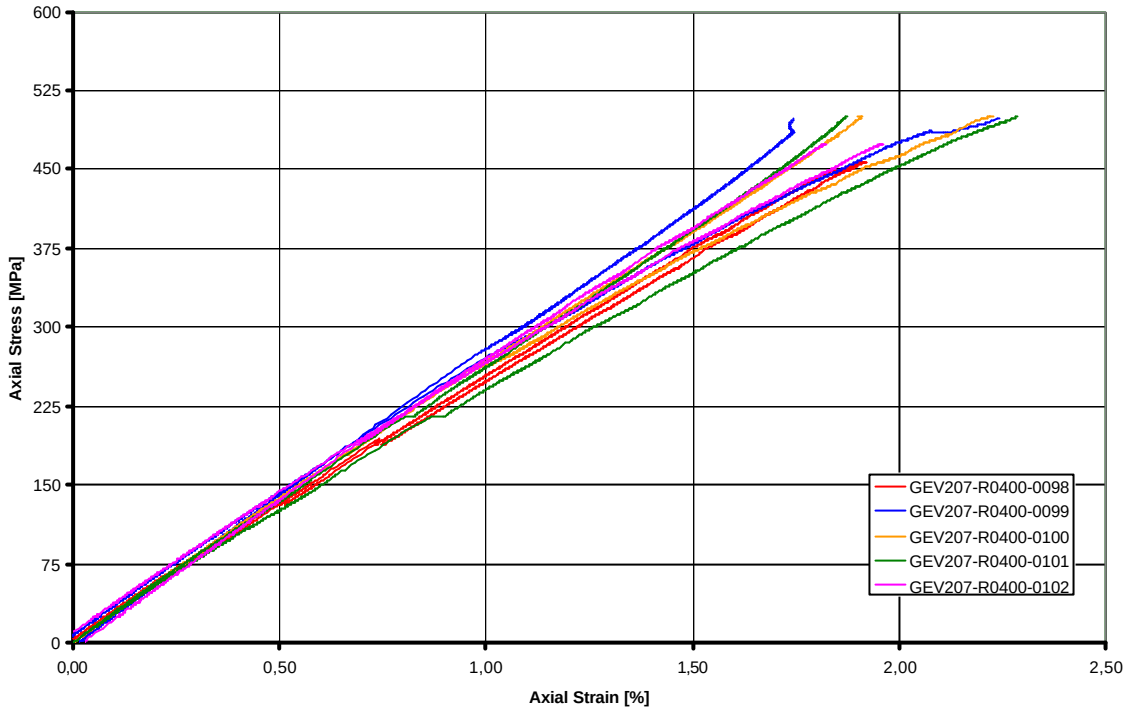

Figure 8: Axial stress vs. axial strain, both strain gauges presented

7.2.4 Compressive test UD coupons

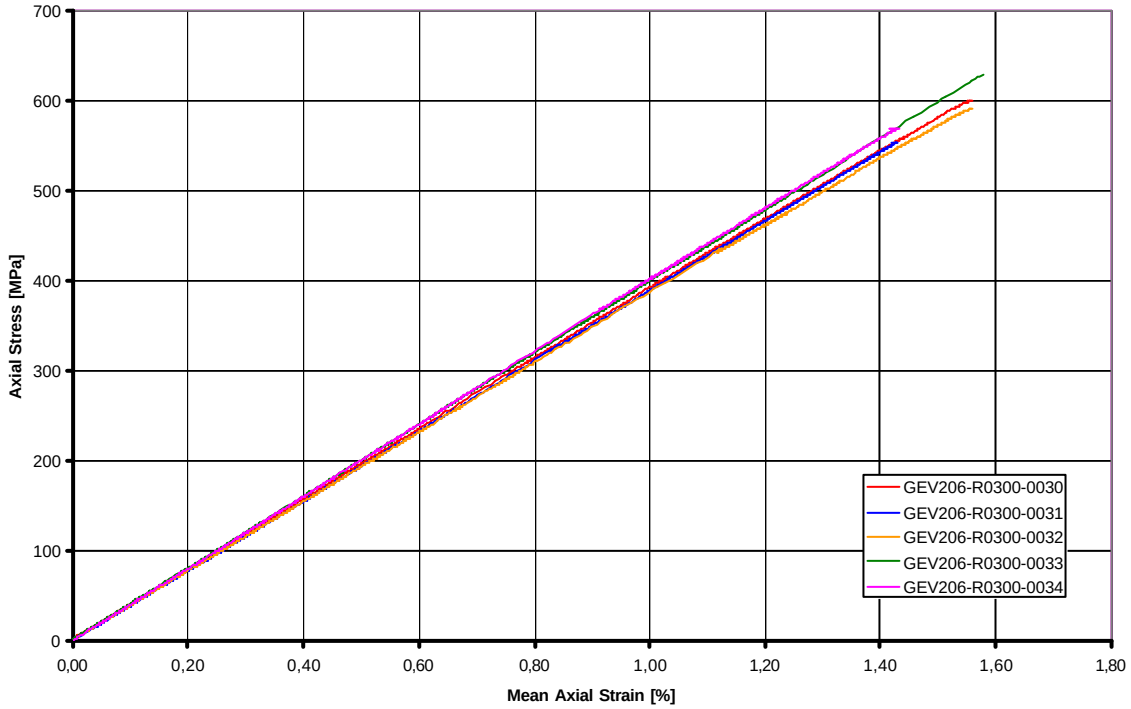

Figure 9: Axial stress vs. mean axial strain

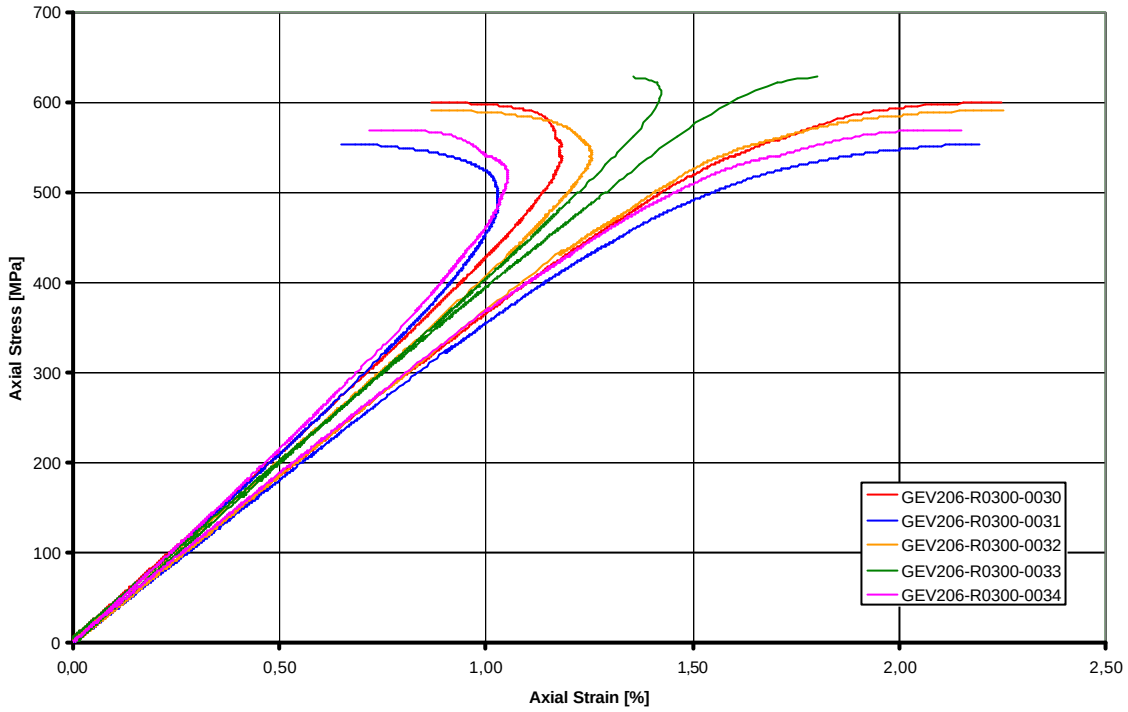

Figure 10: Axial stress vs. axial strain, both strain gauges presented