Preliminary tests -2

(Compression of UD specimens)

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1. Introduction

Three UD specimens will be tested in compression within this test series to find out the best suited specimen geometry. Specimens of same width and thickness but different gauge length will be tested using mechanical grips. For each type of specimen fatigue tests will be performed to verify the requested strain rate (10%/s) proposed by the Technical Committee.

2. Specimens

Compression test specimens with lay up [UD]4 and gauge length, GL30, GL35, GL40 are manufactured and provided by LM Glasfiber A/S. The clamping area (TABs) are kept the same length for all specimens, therefore specimens with different gauge length (GL30, GL35, GL40) have different total length, named A, B and C respectively. The length of the specimens, corresponding gauge length (GL) and numbering of the specimens are given in Table 1. The generalized drawing of the specimen is given in Figure 1. Two strain gauges, one on each side, are glued on the specimen to measure strain and control alignment during the test.

Figure 1. Specimen geometry for compression test.

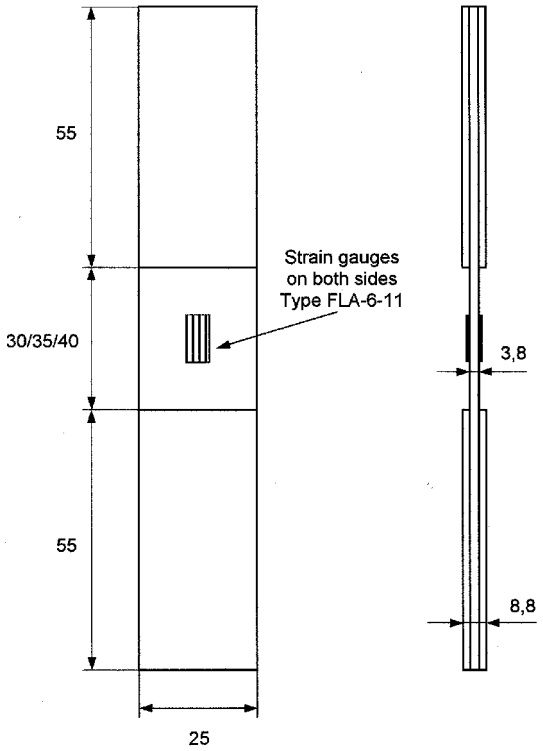


Table 1. Length of the specimens.

Specimen length		Gauge length (GL)		Specimen Nr.
ID	Length (mm)	ID	Length (mm)	
A	140	GL30	30	S02, S07, S12, S17
B	145	GL35	35	S32, S37, S42, S47
C	150	GL40	40	S62, S67, S72, S77

3. Testing

For each type of specimen one static test is performed using an servo-hydraulic test-stand. The same machine is used for fatigue tests. Static tests can not be performed in a specialized static testing machine, because grips for high-loaded compression tests are currently not available at DLR. Static tests have to be performed force-controlled because low displacement rates can not be generated with the existing control unit. This leads to difficulties with specimens having short gauge lengths because the grips can crash together immediately after failure of the specimen. Therefore the static tests of specimen types GL30 and GL35 have to be performed by "hand" to prevent damage from the test-stand.

DLR sees big difficulties to find out the most optimal specimen geometry and testing conditions for fatigue tests. For these reasons three specimens of each type are tested in tension-compression at R=-1. During the first load cycle frequency is reduced to 0,05 Hz (quasistatic) to determine strain and control bending of the specimen. Different strain rates are used within this test program. Surface temperature of the specimen is measured within gauge length and clamping area.

4. Results

The results of static compression tests are given in Table 2. Contrary to all expectations compression strength is not increasing as shorter gauge length is used. But since only one specimen of each type is tested this can be a coincidence and indicates experimental scatter. The significant low value for UCS in case of specimen S32_B_GL35 is almost certainly consequence of different failure mode in comparison to the other two specimens.

Table 2. Results of static compression tests.

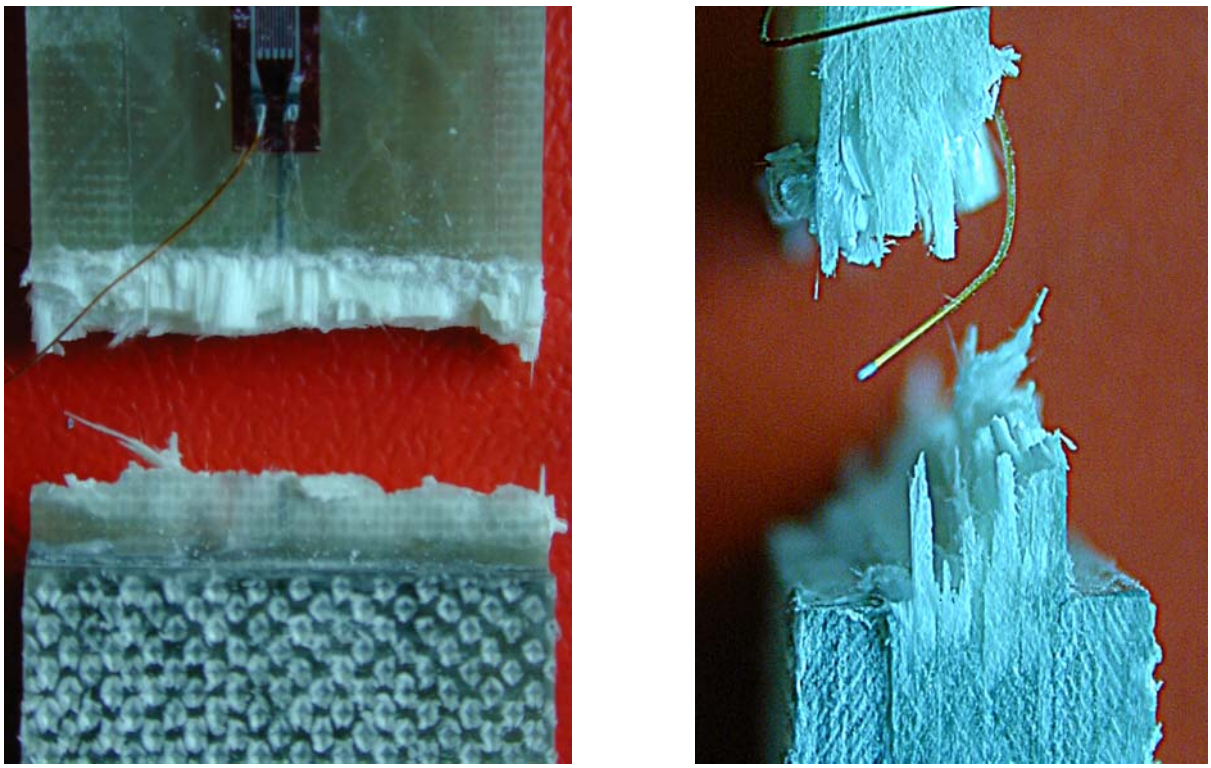
	S02_A_GL30	**S32_B_GL35**	**S62_C_GL40**
UCS (MPa)	523,7	451,2	519,2
Ultimate Strain (%)	1,20	1,23	1,35
Bending strain (%)	0,11	0,08	0,02
Modulus (GPa)	35,4	36,0	38,2
Averaged displacement rate (mm/min)	1,57	1,05	2,55
Failure location	gauge length	nearby tabs	gauge length
Remarks	displacement-controlled (hand)	displacement-controlled (hand)	force-controlled

The results of fatigue tests in tension-compression are given in Table 3. All specimen fail nearby the tabs what is basically an unacceptable failure mode (Figure 2). Surface temperature rises rapidly although a small fan is used for cooling (ambient air, no pre-cooling). Fatigue results show no significant difference between the three types of specimen regarding achieved lifetime at the same stress level and same strain rate. Tests with specimens of type GL35 indicate increasing lifetime as using a lower strain rate. This may be a consequence of reduced temperature increase during the test. Debonding of tabs occurs later when using lower strain rates. In addition the amount of frictional heat resulting of the relative movement between debonded tab and specimen is reduced due to the lower frequency.

Table 3. Results of fatigue tests.

Specimen	Stress level (% UCS) UCS=520 MPa	Strain rate (%/s)	Cycles	Temperature (°C)	Failure
S67_C_GL40	75	10,0	139	>50 (tabs)	nearby tabs
S72_C_GL40	Problems with testing machine				
S77_C_GL40	50	10,0	1811	>43 (tabs)	nearby tabs
S42_B_GL35	50	10,0	1375	41 (tabs)	nearby tabs
S37_B_GL35	50	8,5	2313	38 (tabs)	nearby tabs
S47_B_GL35	50	7,0	11627	39 (tabs)	nearby tabs
S12_A_GL30	50	10,0	3700	41,1 (tabs)	nearby tabs
S17_A_GL30	50	7,0	7732	42,5 (tabs)	nearby tabs
S07_A_GL30	40	10,0	190082	35 (tabs, 11500 cycles)	nearby tabs

Figure 2. Typical failure (S42_B_GL35).



Probably lifetime increases due to less temperature influence when reducing strain rate. But with these few specimens a statistical based statement is not possible. On the other hand will use of pre-cooled air reduce temperature rise, but I doubt that this will be possible at each test-stand the institutes will use within this program.