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ADAPTED BUCKLING SUPPORT TO INVESTIGATE THE COMPRESSIVE PROPERTIES OF LONG AND THIN SPECIMENS

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ABSTRACT

When fibre reinforced polymers (FRPs) are used as load-bearing structural materials, the designer cannot always prevent compressive stresses from occurring in the material. If compressive loads occur, these often determine the dimensioning of the component, since the compressive strength of FRP is significantly lower than the tensile strength. This circumstance makes it particularly important to know the compressive strength of FRP exactly and to determine it experimentally as precisely as possible. The work carried out here has investigated a relatively new test device with combined load application for the failure of FRP under compressive load. For tensile-compressive tests (R=-0.5), the Instron 8800H2470 under stress control mode at 5 Hz with a maximum force of 100 kN and the Instron 8802L2741 under stress control mode at 3 Hz with a maximum force of 250 kN were used. For fixing servo-hydraulic clamps with a hydraulic pressure of 120 bar clamped the specimens. Anti-buckling supports were employed during the tests to prevent buckling of the samples and premature failure (Figure 1). The anti-buckling support designed for fatigue after impact tests was used. This design is similar to the device used in the open hole compressive tests (ASTM D6484-04 [3]), with the difference that the load is applied via shear forces. The advantage of the anti-buckling support is that the specimen is supported along its entire length, reducing the probability of local buckling. The samples are not restrained laterally, so transverse contraction is not restricted. This design can reduce or avoid stress concentrations at the edges of the specimen.

The materials investigated were prepregs from NTPT Switzerland, consisting of the toughened matrix TP402 [1] and T700S [2] standard modulus fibres from Torayca. The different composite layups are summarized in Table 1.

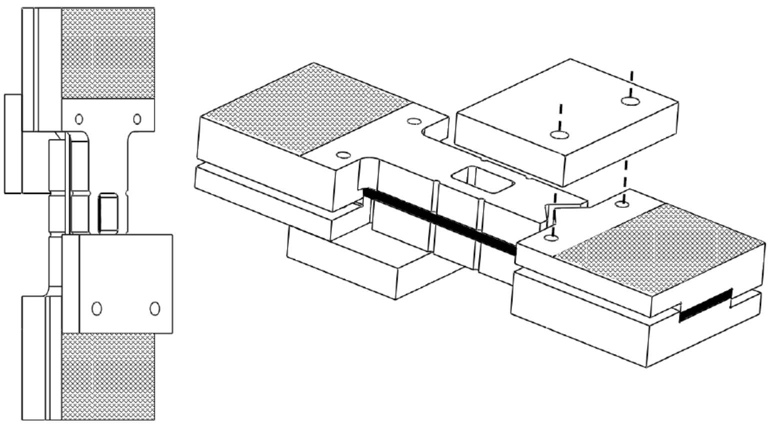

Figure 1: Illustration of the anti-buckling support used for the fatigue tests supports the specimen along its entire length and clamps the specimen.

The fatigue tests results with a load ratio of R=-0.5 show improved properties with decreasing layer thickness. In case of the 60, 120 and 360 gsm samples, no change in the slope of the S-N curves is apparent (Fig. 2). Stress concentrations at thin layer thicknesses will lead to premature failure at higher stresses in the load introduction area (30 gsm). Nevertheless, thinner layers display superior fatigue behavior at higher load cycles, as they occur in industrial applications.

Using the anti-buckling support for fatigue after impact tests with a stress ratio of R=-0.5, the impact damage growth could be observed for all samples resulting in more realistic results. Results with a restricted transverse contraction exhibit a fast growth of edge delamination for all layer thicknesses, which does not reflect the behavior of larger structures.

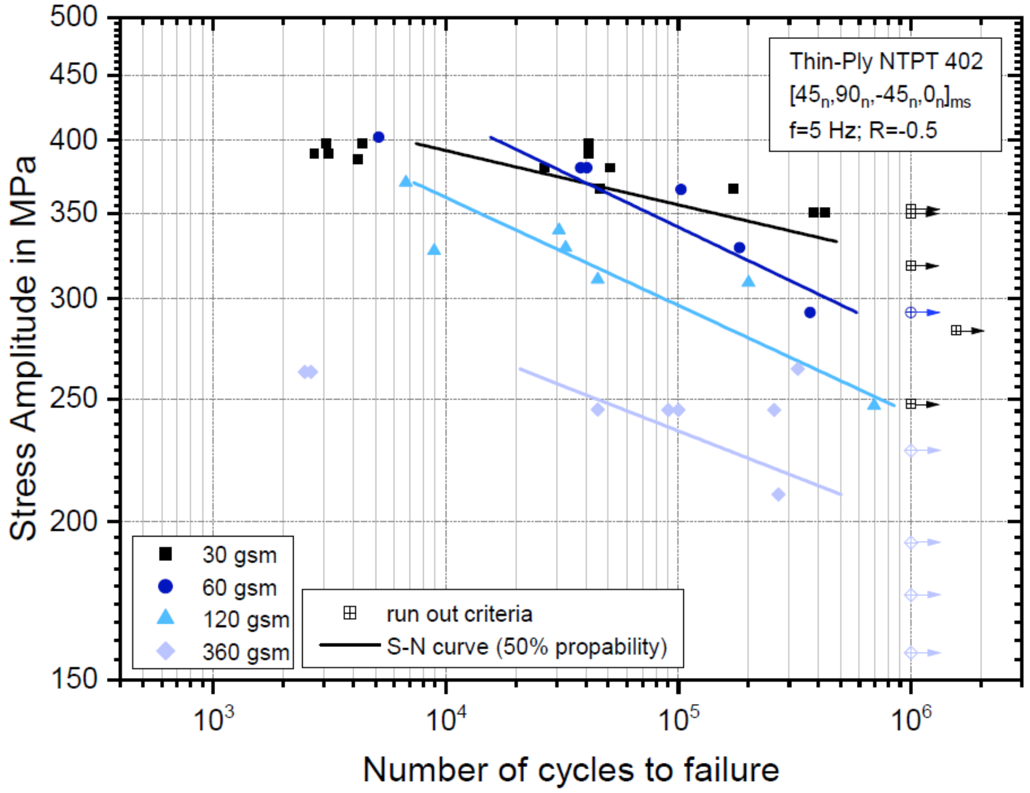

Figure 2: Results of the tensile-compressive fatigue tests with a stress ratio of R=-0.5 [4]

Table 1 Laminate layups of the static tensile and compressive, as well as fatigue and fatigue after impact (FAI) tests.

	Fibre areal weight in gsm				
Test Method	30	60	120	240 (2x120)	360 (3x120)
Tension	$[45/90/-45/0]_{12s}$	$[45/90/-45/0]_{6s}$	$[45/90/-45/0]_{3s}$	$[45_2/-45_2/90_2/0_2]_s$	$[45_3/90_3/-45_3/0_3]_s$
Compression	$[45/90/-45/0]_{22s}$	$[45/90/-45/0]_{11s}$	$[45/90/-45/0]_{6s}$	$[45_2/90_2/-45_2/0_2]_{3s}$	$[45_3/90_3/-45_3/0_3]_{2s}$
Fatigue	$[45/90/-45/0]_{12s}$	$[45/90/-45/0]_{6s}$	$[45/90/-45/0]_{3s}$	–	$[45_3/90_3/-45_3/0_3]_s$
FAI	$[45/90/-45/0]_{12s}$	$[45/90/-45/0]_{6s}$	$[45/90/-45/0]_{3s}$	–	$[45_3/90_3/-45_3/0_3]_s$

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