Fatigue/lifetime Testing of T and Y Composite Profiles

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Abstract: Presented paper describes fatigue/lifetime testing of two composite profiles designed primarily for the joining of aircraft structures. The selected loading levels were derived from the limit load. Once the sample was subjected to 1 000 000 cycles without failure, the experiment was stopped, and the sample was inspected by means of the ultrasonic testing method. The sample was then put aside for subsequent static testing aimed at proving whether a change had occurred in terms of the strength and stiffness compared to the "virgin" samples that had been statically tested previously.

Keywords: fatigue; lifetime; thermoplastic composite.

1 Introduction

The T profile, which is frequently used in the structural assembly of aircraft in the form of clips, brackets, and stringers [1], is manufactured via the application of various methods and using various types of composite materials. However, whichever method is applied, it is necessary to address the problem of the structure and the production of the intersection between the flange and the web [2–4]. This problem was eliminated in our case because of novel shapes of profiles. In previous works [5,6] two novel composite profiles (T and Y), manufactured by thermoforming process from C/PPS 5H satin fabric with $[[(0,90)/(\pm45)]_2]_s$ lay-up, were tested statically in pull of direction and these experiments were simulated by FEM. The main aim of presented work was to determine the fatigue/lifetime limits of these joining components and compare them with prescribed load.

2 Materials and methods

The fatigue/lifetime tests were conducted in the laboratory on three T profiles and three Y profiles. The R value (stress ratio – minimum peak stress divided by the maximum peak stress) was 0.1 and the frequency of the load was 5 Hz except for sample Y_03 with a frequency of 4 Hz. Sinusoidal type of signal and load control was used. The experiment was performed using the Instron 40 kN hydraulic testing system (the assembly of the fatigue test is shown in Fig. 1). From the prescribed limit load (5 910 N) the selected loading levels were derived – 100% meant loading up to the limit load level, 153% loading up to the ultimate load level, 200% loading up to twice the limit load level and 306% loading up to twice the ultimate load level. Once the sample was subjected to 1 000 000 cycles without failure, the experiment was stopped, and the sample was inspected by means of the ultrasonic testing method.

The sample was then put aside for subsequent static testing aimed at proving whether a change had occurred in terms of the strength compared to the "virgin" samples that had been statically tested previously (see [1,2]). The static experiment was conducted using a TIRA 2300 universal testing machine with a crosshead speed of 2 mm/min. Displacement was measured directly from the displacement of the machine's crosshead and the load cell used during the testing has 100 kN capacity. Tensile loading was applied through the screws in the web of the profile jointed with the jaws of the machine. Fig. 2 illustrates the fixing of the sample in the machine.

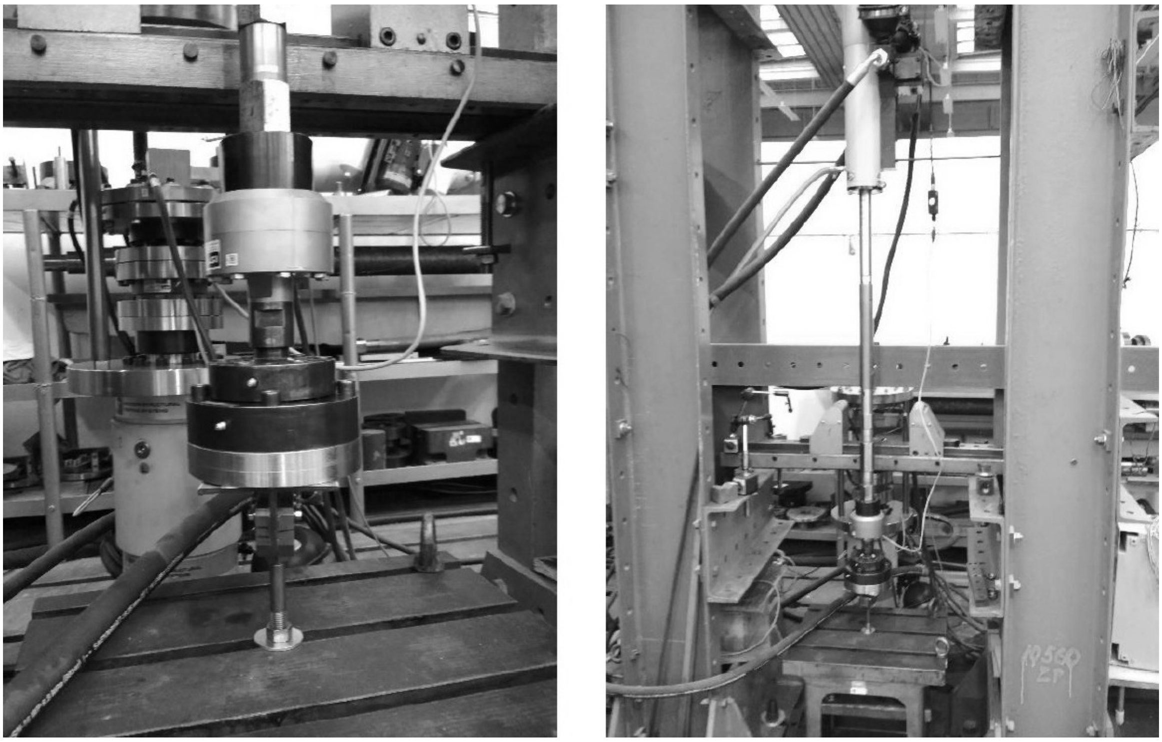

Fig. 1: Assembly of the fatigue test.

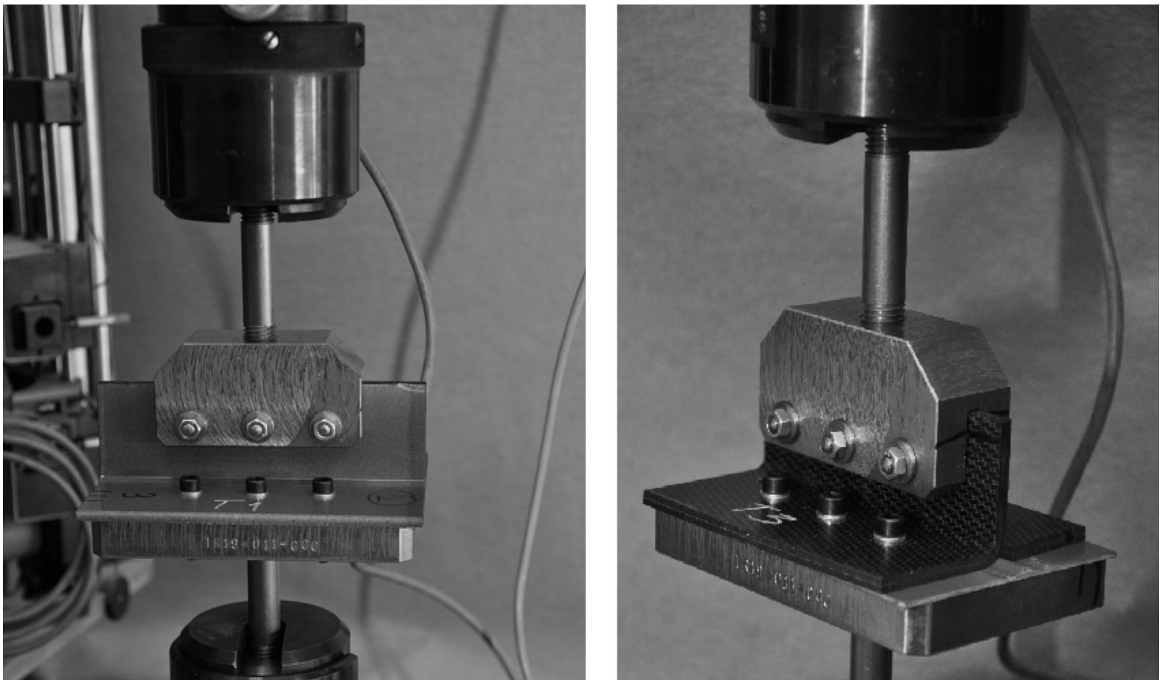

Fig. 2: T profile in the testing machine.

3 Results and discussions

The results and a description of the fatigue/lifetime test are provided in Tab. 1. Sample Y_03 was destroyed after 122 396 cycles following the destruction of the screws (after 83 407 cycles and 108 876 cycles) – see Fig. 3, which were replaced both times. Moreover, the final failure was also accompanied by the destruction of some of the screws. The T-shaped samples and samples Y_01 and Y_02 survived the fatigue testing process (the limit and ultimate upper loads for T-profiles and the ultimate load and twice the limit load for Y-profiles), thus presenting the opportunity to perform static testing aimed at proving whether there had been a change in their behavior. The comparison of tested samples after 1 000 000 cycles and "virgin" samples (see Fig. 4 and 5) shows that stiffness and strenght were not significantly affected by the fatigue effect.

Tab. 1: Lifetime results for the tested profiles.

Sample	Load level	F [N]	Number of cycles N [-]	Result
T_01	100%	5 910	1 000 000	no failure
T_02	100%	5 910	1 000 000	no failure
T_03	153%	9 042	1 000 000	no failure
Y_01	153%	9 042	1 000 000	no failure
Y_02	200%	11 820	1 000 000	no failure
Y_03	306%	18 085	122 396	failure

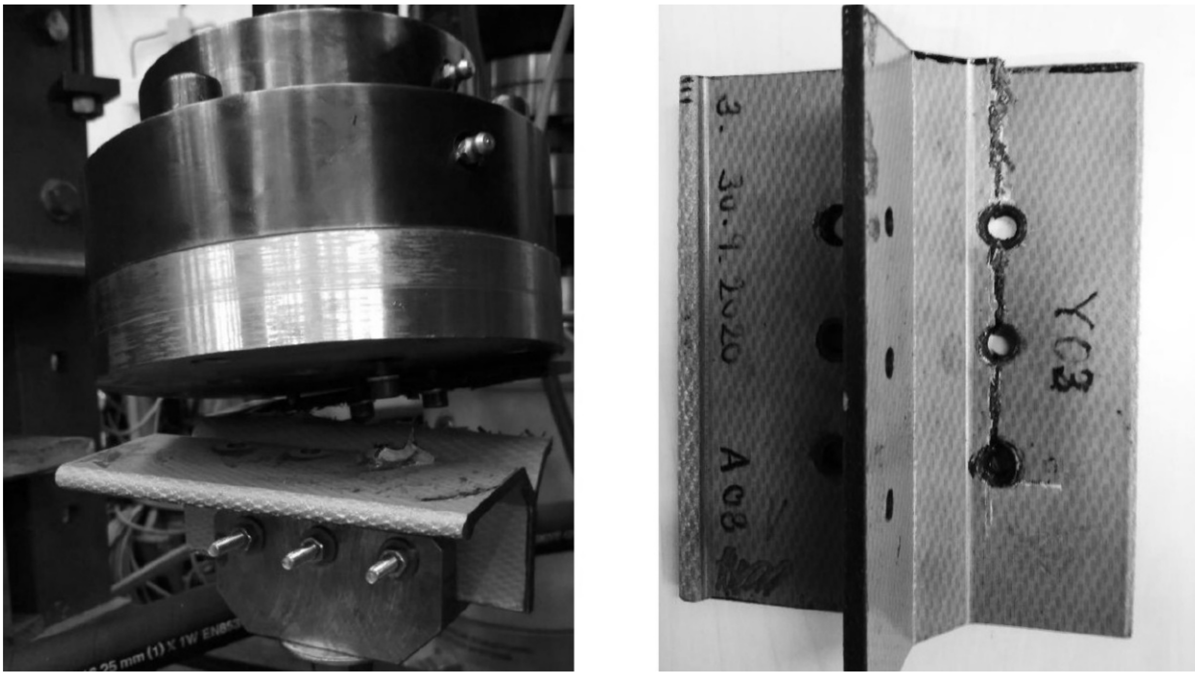

Fig. 3: Destroyed sample Y_03 after 122 396 cycles.

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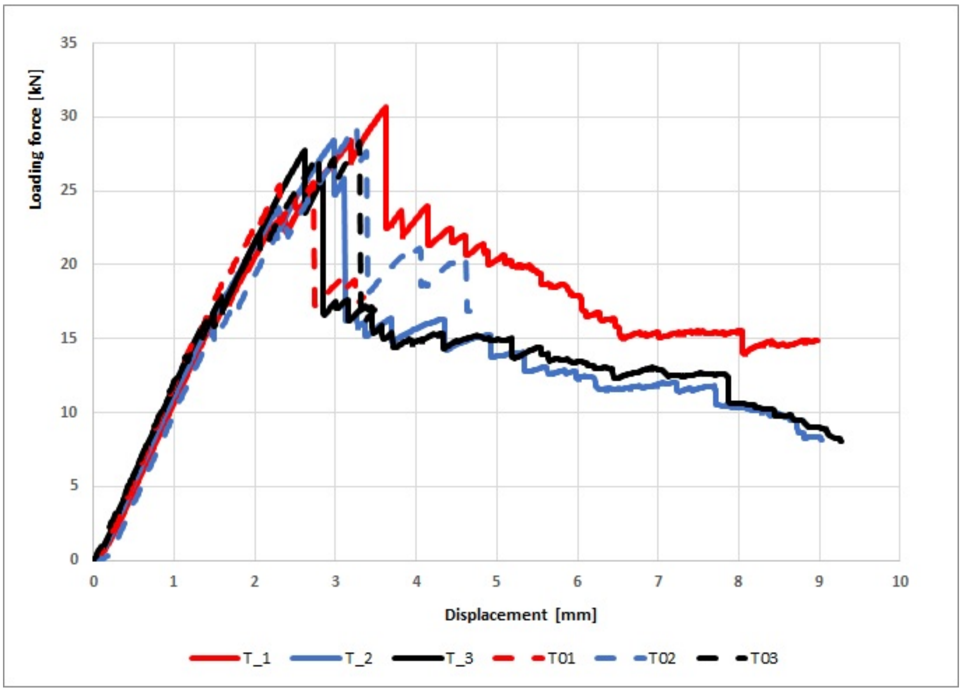

Fig. 4: Relationship between the loading force and the displacement for the tested T profiles (“virgin” and after 1 000 000 cycles).

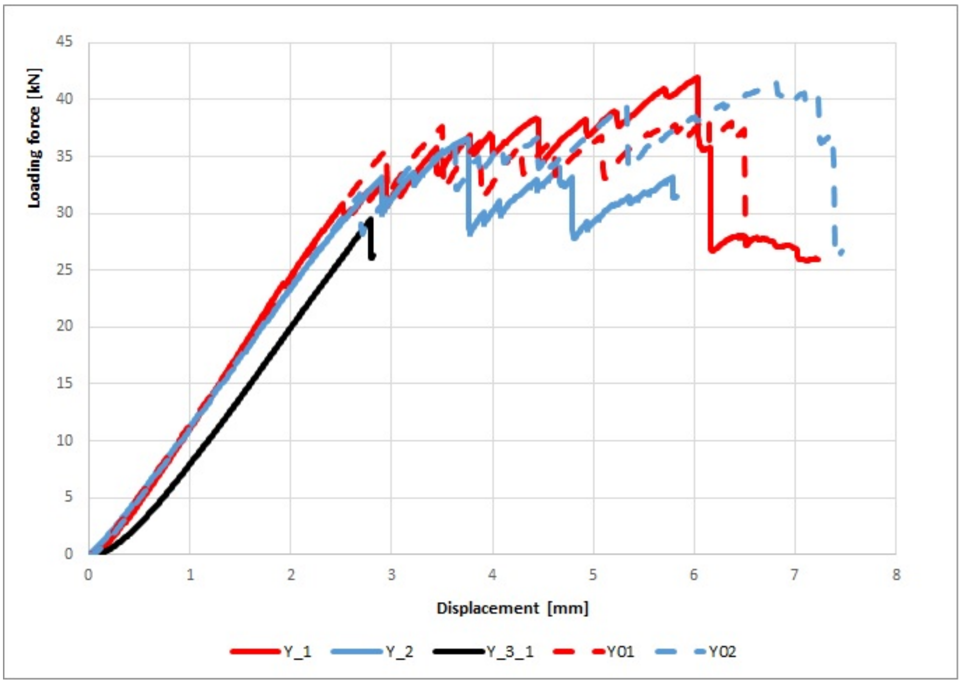

Fig. 5: Relationship between the loading force and the displacement for the tested Y profiles (“virgin” and after 1 000 000 cycles).

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