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Comparison of Hybrid Metal-Composite Micropin Joints with Conventional Ones in Terms of Fatigue Life

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Abstract: The current research deals with special hybrid metal-composite joints which use thin sheet-metal reinforcement with small die-fixed pins (2-3 mm) imbedded into the composite part of the joint. This technological trick significantly and positively influences strength of the metal-composite bolted joints loaded in out-of-plane direction. This fact was proved by comparison of pull-off fatigue tests results of metal-composite joints with and without reinforcement.

Introduction

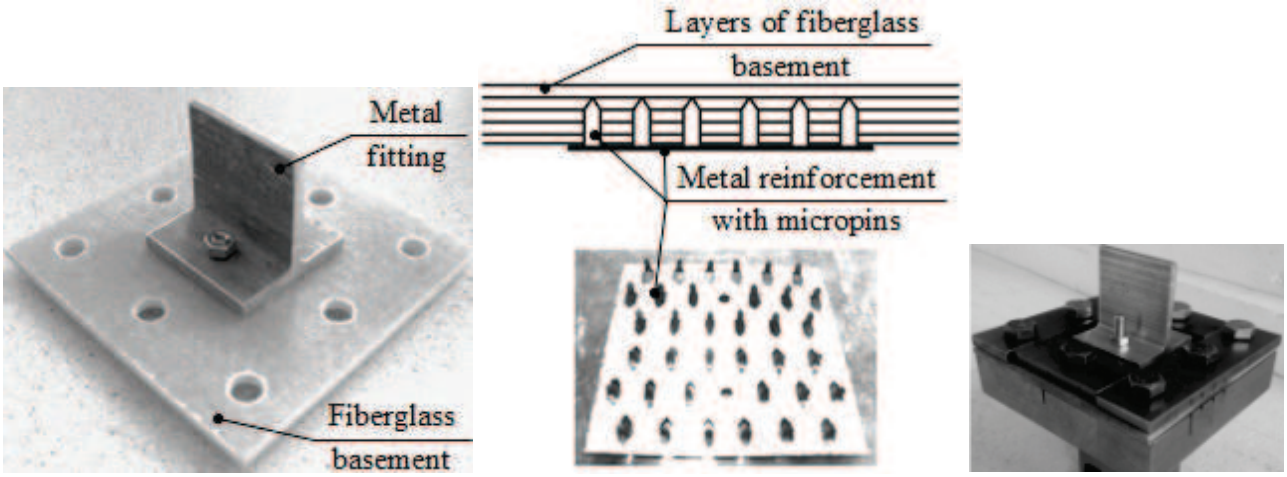
The conventional laminates based on polymer matrixes show low delamination resistance in consequence of very weak interlaminar strength. In order to increase the efficiency of composite structures and prevent the crack propagation in interlaminar and intralaminar directions, micro-pin elements are imbedded into laminates in out-of-plane direction (hereafter z-direction). Investigations of static and fatigue strength of composite specimens reinforced with thin metal pins [1-3] showed up prospects for implementation of such reinforcements to composite structures.

Very wide and longstanding experience in theoretical investigations and implementation of mechanical (bolted, riveted, etc.) joints showed up not enough efficiency for thin-walled composite structures. Therefore, the described hybridization of composite structures could be a good solution for increasing the efficiency of composite-composite and metal-composite joints. The hybridization and modification of the joints area is usually done by through-thickness cross-stitching elements (different kinds of clamps, wires, welded, pressed-in or milled metal micropin elements) [4-6].

The current research is devoted to fatigue life definition of a hybrid metal-composite joint (hereafter MCJ) loaded in z-direction. The fatigue life of the investigated joint is compared to the fatigue life of the same joint without hybridization.

Description of specimens and experiment set-up

The specimens consist of a composite basement and a metal fitting joined to the basement by 2 steel bolts 5 mm in diameter (see Fig. 1). The composite basement of the specimens was made of fiberglass twill-woven fabric 03BG225LD (the producer is Lange-Ritter, Germany) and epoxy resin LH-275 cured at 3.5 atm. pressure and 50°C temperature. Two types (type I and type II) of specimens were tested. The type I specimens (see Fig. 1a) represent the conventional bolted MCJ loaded in z-direction without any modifications. The type II specimens represent hybrid MCJ. The hybridization is provided by 0.5 mm thick metal reinforcement with die-fixed micropin elements imbedded into the lower side of the composite basement before curing (see Fig. 1b). Both the surface of the reinforcement facing the composite and micropins were covered with gluing compound VK-25. The fatigue tests were performed on a hydraulic test machine with asymmetrical loading cycle (R = 0.1) at 5 Hz frequency. The specimens were fixed in the machine grips with help of a special jig. The jig assembled with a specimen is shown in the Fig. 1c.



a) b) c)

Fig. 1: Tested specimens: a) conventional, b) reinforced, c) the test jig assembled with a specimen

Tests results

The results of the tests were analyzed according to ASTM E739 and are summarized in the linearized fatigue life curves shown in Fig. 2.

It can be seen from the curves the implementation of thin metal reinforcement with micropins is very efficient and allow increasing the load carrying capacity of such joints more than 1.5 times without remarkable weight increasing.

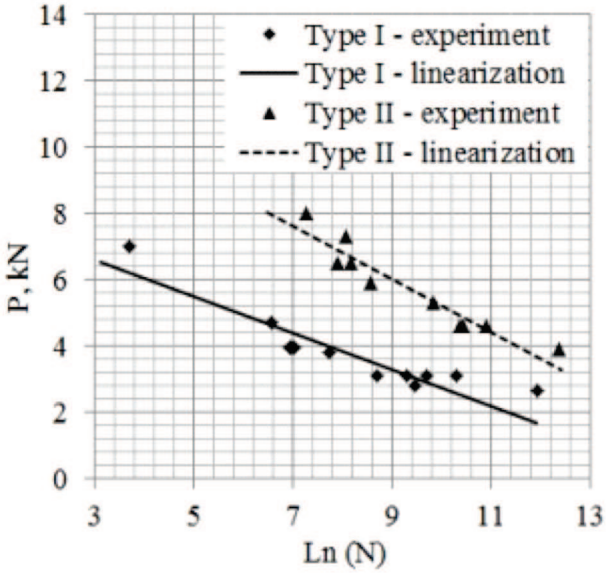


Fig. 2: Tests results

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