STUDY ON TEST METHOD FOR SHEAR PROPERTIES OF MINISIZE ROD－Z-PIN

N.Li, J.Xiao
Nanjing University of Aeronautics and Astronautics, Nanjing, China
kadianzimo@163.com

Keywords: *z-pin， shear test*

1 Introduction

Manufacturing the high quality z-pin which is used to reinforce composite laminate is the key to z-pined composite laminate. The shear properties of z-pin have a direct influence on the bridge mechanisms of the z-pin reinforced laminates, which will have a further influence on the delimitation toughness and impact the resistance for the laminate although the in-plane properties of the laminate will have a certain decrease while the delimitation toughness increases by inserting z-pins into the laminate. Therefore, a small dimension z-pin (generally the diameter of z-pin is less than 1 mm) is needed to decrease the loss on the in-plane properties. However, there is no standard testing method for such minisize sample to evaluate the shear properties of z-pin. Aiming at the problem, this paper proposes a modified standard method to test the shear properties of z-pin. Firstly, z-pin's failure mode should be confirmed, then the testing parameters are derived for the test based on the failure mode analyzing above. At last, the load-displacement curve graphic of the new method should be compared with typical shear failure graphic to verify the validity and availability of this method.

2 Experiment Design

2.1 Method Select

Four kinds of methods are usually used for interlaminate shear test for composite materials. They are three-point bend short beam shear test, double-notched tension (compression) method; compression-shear method and Iosipescu shear test method. The sharp and dimension of z-pin are not up to the standard of the last three methods. And the short beam shear test during modify can be used to this kind of minisize rod — z-pin. So, the short beam shear test is selected to evaluate z-pin's shear properties.

2.2 Analyze and Modify

First, make sure z-pin's failure mode is shear failure. Tension stress and shear stress are both exist when three-points bending load on z-pin. That the basic theory of beam bending specifies the biggest transverse shear stress of any rectangular beam is:

$$\tau_{13}^{\max} = VQ / Ib = 3P / 4A \qquad (1)$$

V-shear force, Q-area moment, I-moment of inertia,

b-beam width, P-load value, A-beam cross-sectional area

It can be detected that the shear stress is unrelated with the span form the formula (1). The bending moment is proportional with the span. So, shorten the span can decrease the bending stress, to make the shear stress at a dominant position when loading. So， the key of this method is to calculate the span that the shear failure happened first.

For round cross rod, tension stress is

$$\sigma = M_{\max} / W \qquad (2)$$

and the shear stress is

$$\tau = 4F_s / 3\pi R^2 \qquad (3)$$

F_S-shear force, R - radius of z-pin, the same below.

If the shear failure happened first, the formula below should establish

$$\tau = [\tau] \qquad (4)$$

And at the same time the tension stress should not exceed the failure tolerance:

$$\sigma \le [\sigma] \qquad (5)$$

So, according to formula (1) to (5), the span should be

$$L \le 4[\sigma] / 3[\tau] \qquad (6)$$

2.3 Parameter Identify

For the high performance fiber composite materials in common use, the strength of fiber at least exceeded 3000MPa. Suppose the fiber volume content of z-pin is 60%, then the tension strength of z-pin [σ]should be more than 1800MPa. Interlaminar shear strength of the fiber composite materials is deeply influenced by the resin and the interface between the fibers and matrix resin. Its value is usually between 20MPa and 100MPa. Choose the biggest value 100MPa as the shear stress [τ].

Base on above all,

$$L \leq 20R \qquad (7)$$

3 Experiment Validate

3.1 Primary materials and equipments

Z-pins used for the verification experiment are T300/resin A (EP) and T300/resin B (EP) composite pultrusion rods, about Φ 0.5 in diameter.Z-pins see in Fig 1.

The test fixture was designed independently see in Fig 2.

Experiments were conducted with the electronic universal testing machine produced by Shenzhen Sans Testing Machine CO. LTD.

3.2 Results and discussion

According to the above analysis and discussion, set the span 3mm to carry on the experiment. Shear test results of z-pins are shown in Table.1 which were tested at room temperature and under dry condition.

The Load-displacement curve of this test see in Fig. 3 conform the features of typical shear failure which verify the validity and availability of this method. The shear properties of z-pins made by different materials were clearly compared by the modified standard method in Table 1.

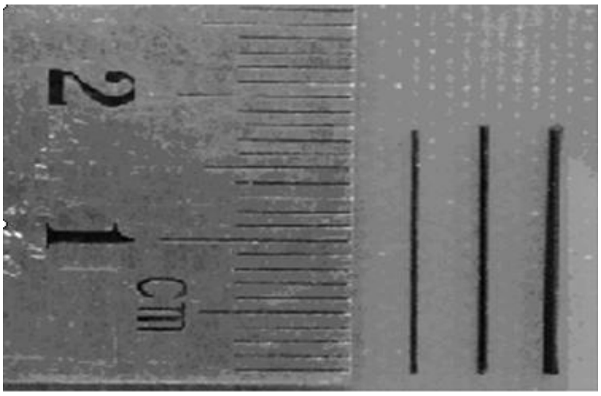

Fig 1. Z-pins

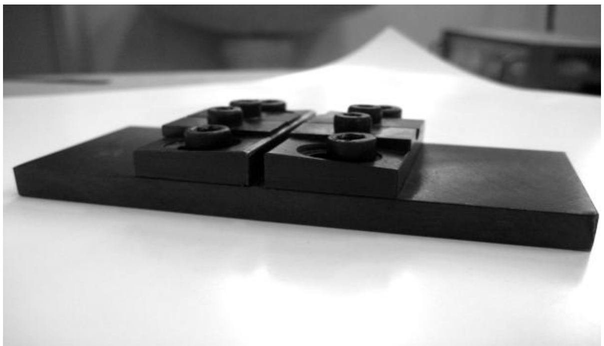

Fig 2. Self-developed fixture

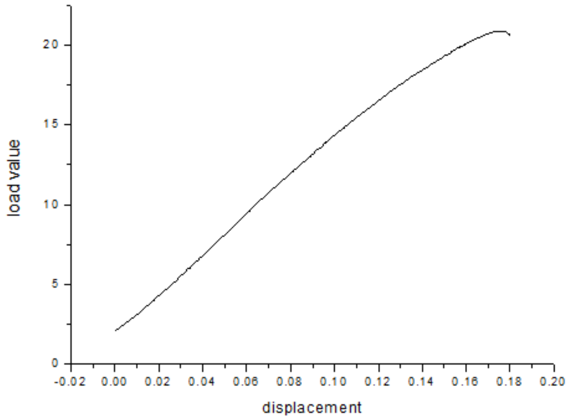

Fig 3. The load-displacement curve

Table 1. Shear test results

	A	B
Radius /mm	0.49	0.49
Load value/ N	17.94	9.60
Shear strength/MPa	63.97	34.31
Standard deviation	2.94	3.03
Coefficient of dispersion	4.59%	8.82%

A represents T300/Resin A composite pultrusion z-pin, same to B.