TEAR AND PUNCTURE BEHAVIORS OF FLEXIBLE COMPOSITES

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1 Introduction

Woven fabrics are the most commonly used textile system for flexible composite applications. During their service life, tear and puncture are general damage modes. Several references have reported the tear and puncture behaviors of coated woven fabrics. For example, Zhong et al. [1] used the Ising model combined with the Monte Carlo simulation to study the phenomenon of single tongue tear failure for coated fabric. Maekawa et al. [2] established the relationship between tear strength and actual tear propagation characteristics of an airship envelope material which is layered based on Zylon fabrics. Mayo et al. [3] investigated the quasi-static and dynamic puncture behaviors of thermoplastic (TP) impregnated aramid fabric. The results revealed that the TP-laminated fabrics showed an increased cut resistance and reduced windowing comparing with neat fabric. Wilson-Fahmy and his co-workers [4-6] provided a theoretical approach to design the inclusion of geomembrane protection materials with high puncture resistance.

However, the trapezoid tearing and puncture behaviors of uncoated and Thermoplastic Urethane (TPU)-coated woven fabrics have not reported in above-mentioned references.

2 Materials

The specifications of the uncoated woven fabric tested in this paper are shown in Table 1. The warp and weft yarns are made of Polyethylene Terephthalate (PET) filaments. The linear density of warp yarns is 454×2 tex two-ply filaments and the linear density of weft yarns is 700×2 tex two-ply filaments.

The coating material in the coated woven fabric is Thermoplastic Urethane (TPU). The thickness of coating on the upper and lower surfaces of woven fabric is about 2.5 mm. The coating is produced by extrusion process while the woven fabric is woven. Fig.1 shows surface and cross-section photographs of neat and coated woven fabrics.

3 Tearing strength test and damage mechanism

The tearing strength tests were all operated on the Material Test System (MTS 810.23) along the weft direction adopting trapezoid-shaped specimen. Fig. 2 shows photographs of specimens of the uncoated and coated woven fabrics. The tearing strength of uncoated and coated fabrics was compared in Fig.3. It can be seen from the load-displacement curve that the coating doesn't cause evident tearing strength loss. This is mainly due to the coating material. On the one hand, it prevent the relative movement of the warp and weft yarns which results in a smaller tearing region; on the other hand, coating itself contributes to the tearing also.

Fig. 4 displays the tearing damage morphologies of uncoated and coated woven fabrics. It can be concluded that the pre-slit propagated along a straight line across the width direction in the case of the coated sample. While in the damage photograph of the uncoated sample, the failures of weft yarns were comparatively irregular.

4 Quasi-static puncture test and damage mechanism

The uncoated and coated woven fabric samples of quasi-static puncture test in this paper were circle with a radius of 60mm which is shown in Fig. 5. The stabber in the puncture tests was a cylinder with a flat end. Fig. 5 (c) gives the detailed geometric size

of the stabber. The photographs of inner surfaces of the clamper are shown in Fig. 6. The interface of the upper and lower circular rings was designed as concave-convex grooves which will prevent the tested sample from slipping during the puncture test.

The results of the puncture test which are shown in Fig. 7 reveal the coating significantly improved the puncture resistance of woven fabric. This is mainly due to protection effect of coating on the reinforcement. Fig. 8 gives the puncture failure morphologies of the uncoated and coated woven fabrics. It can be seen from Fig. 8 that the damage area on the surface and back of coated sample is evidently smaller that on the uncoated sample.

5 Summary and conclusions

Coated fabric is a common kind of flexible composite. The tearing and puncture behaviors of neat and coated woven fabrics are investigated in this paper. The results reveal that the tearing strength of coated fabric is comparatively the same with neat woven fabric while the coating fabric improves the puncture resistance of woven fabric significantly.

6 Acknowledgement

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Table 1 specifications of neat 2/1 twill woven fabric

Fabric	Material	Thickness (mm)	Areal density (g/m^2)	Warp density (ends/10cm)	Weft density (ends/10cm)
2/1 twill	PET	2.19	520	28	19

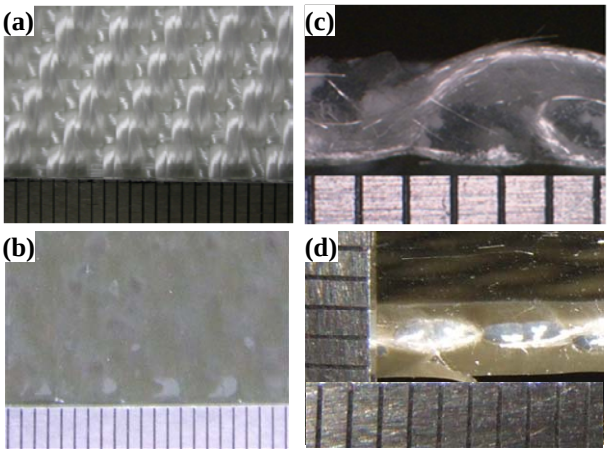
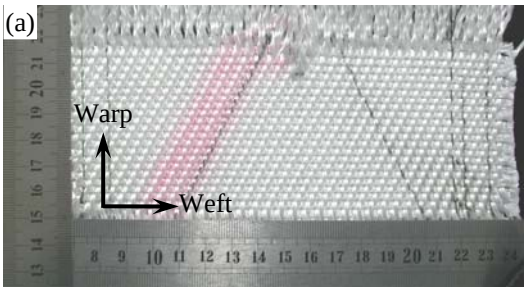
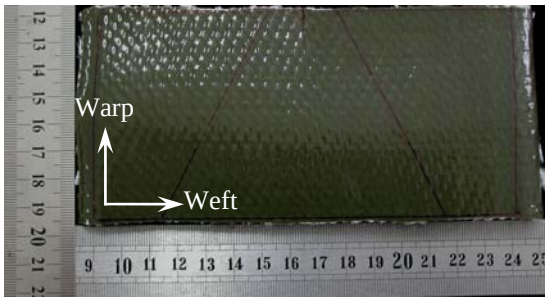


Fig.1 (a) Surface photograph of neat twill woven; (b) Surface photograph of coated woven fabric; (c) Cross-section photograph of neat twill woven fabric; (d) Cross-section photograph of coated woven fabric.



(b)



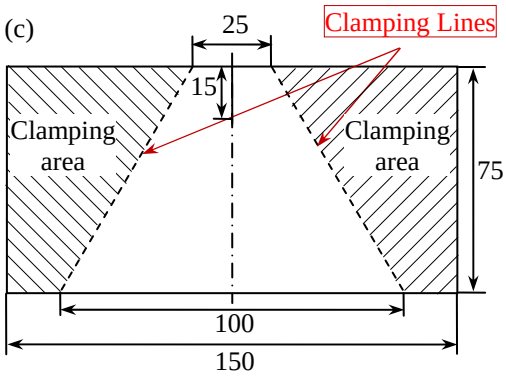


Fig.2 (a) photograph of uncoated sample; (b) photograph of coated sample; (c) geometric size of the trapezoid-shaped specimen

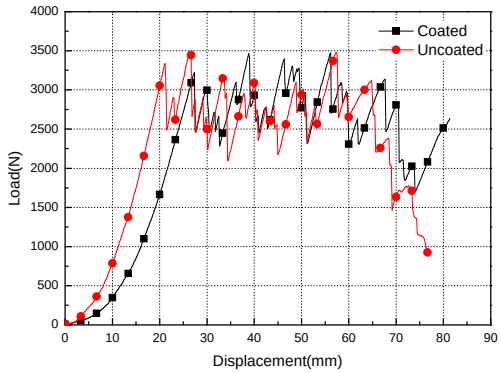


Fig.3 Tearing strength of uncoated and coated fabrics

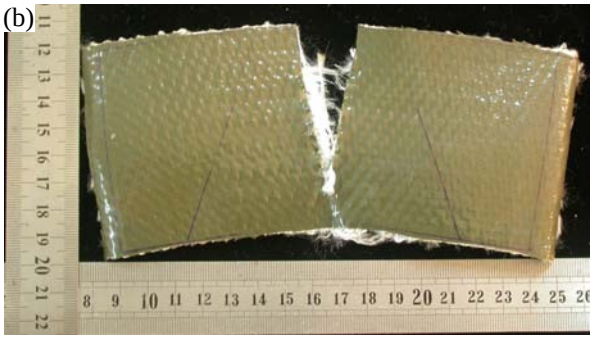


Fig. 4 Tearing damage morphologies of (a) uncoated woven fabric; (b) coated woven fabric

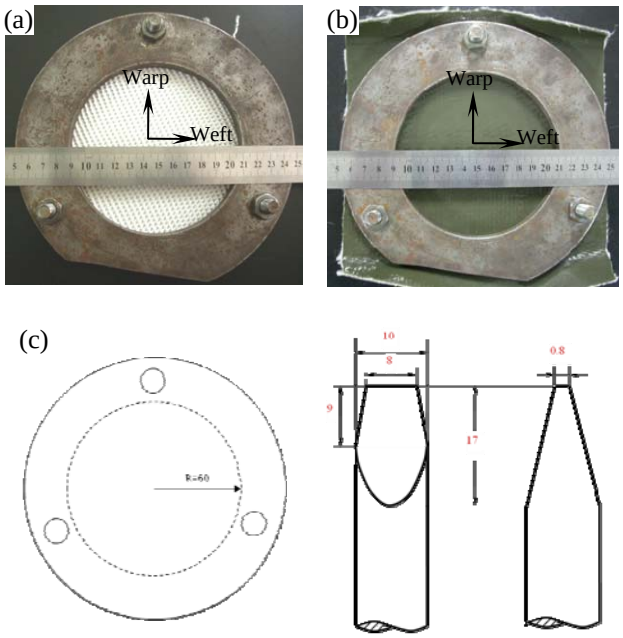


Fig.5. (a) photograph of uncoated sample; (b) photograph of coated sample; (c) geometric size of fabric and puncture used in quasi-static puncture testing

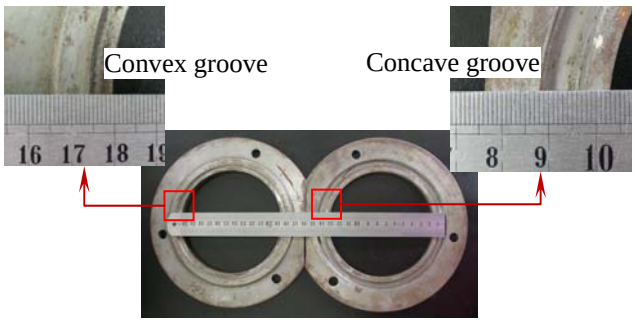


Fig. 6 Inner surfaces of the clamper in the puncture test

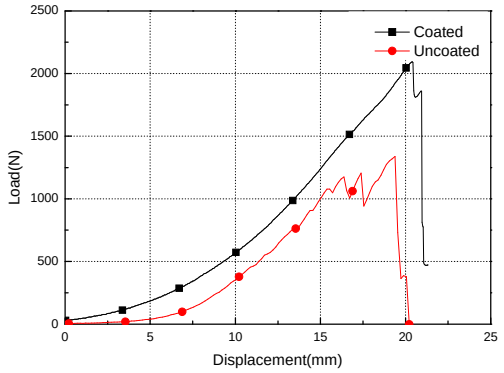


Fig.7 Puncture strength of neat and coated woven fabrics

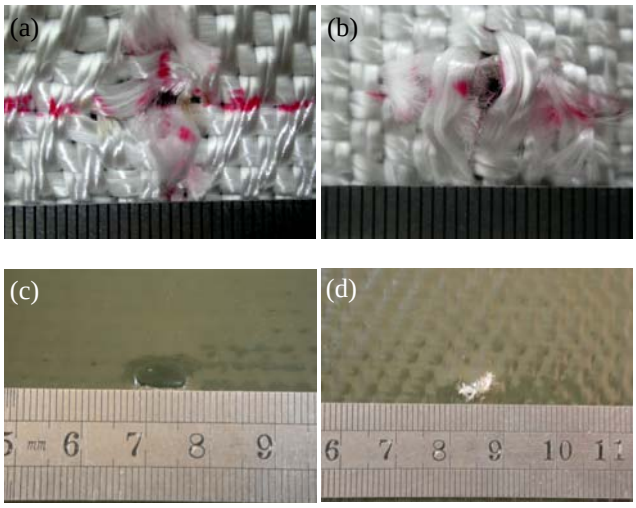


Fig. 8 Puncture damage morphologies of (a) surface of the uncoated sample; (b) back of the uncoated sample; (c) surface of the coated sample; (d) back of the coated sample

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