In Application

High Strain Rate Behaviour of Composite Materials using Digital Image Correlation

Faculty of Engineering and the Environment, University of Southampton, UK

Introduction

Composite materials are used in land, sea and air vehicles in high performance applications, particularly where speed and manoevrability are primary considerations. Full-field data-rich imaging techniques are used to provide a better understanding of the behaviour of composite materials subjected to high strain rate loading, such as those experienced during shock and blast loading. The project has particular application to protection of personnel and equipment helping to reduce serious injuries and damage to costly equipment.

Experimental Setup

To achieve the high strain rates a specific test facility is required. Testing was conducted on an Instron VHS (high strain rate) test machine capable of speeds up to 20 m/s and loads of 80 kN. Normally in testing on these machines the specimen is tested to failure (such as shown in figure 1) but in this case the rig was specially adapted to (a) limit the loads imparted on the specimen and (b) prevent springback which might introduce further damage.

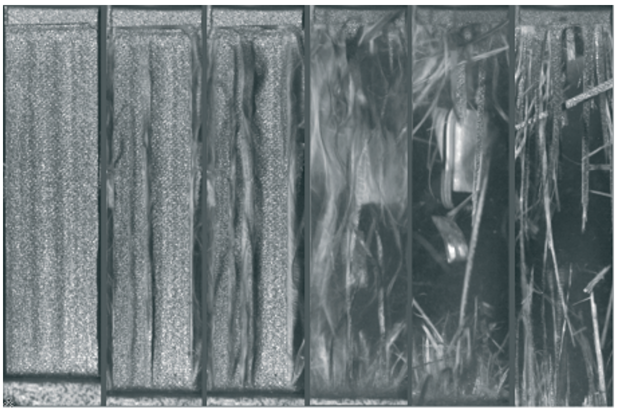

Figure 1: Sample - tested to failure

Digital Image Correlation (and Infra-Red Thermography [IRT]) was employed to analyze the response of composite materials with a focus on the onset of damage and strain localization. To image the specimen deforming at high-speed, sufficient camera frame rates are required. Two high-speed cameras were utilized allowing frame rates up to 5.4 kHz with maximum resolution, and in the tests were driven with 512 x 512 pixels @ 20 kHz. Having the two cameras in a stereoscopic setup (see Figure 2) allows 3D DIC calculations via LaVision's StrainMaster software.

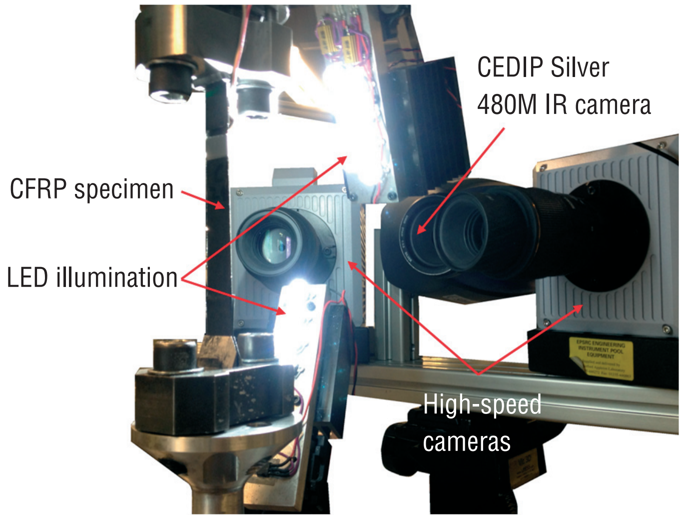

Figure 2: Instron VHS test machine with stereoscopic high-speed camera setup and test specimen instrumented with a strain gauge

LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
D-37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
211 W. Michigan Ave. / Suite 100
Ypsilanti, MI 48197 / USA
E-mail: sales@lavisioninc.com / www.lavisioninc.com
Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306

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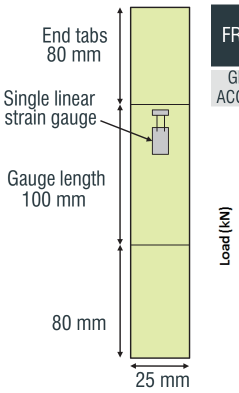
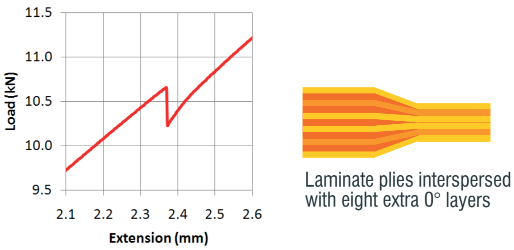
Results



FRP material	Stacking Sequence	Quasi-static properties	
		Young's Modulus	UTS
Glass-Epoxy ACG MTM 28-1	$[90,0,90,0]_S$	21.22 ± 0.72GPa	513± 40 MPa



Specimen thickness: 1.20 mm

Figure 3: Specimen design

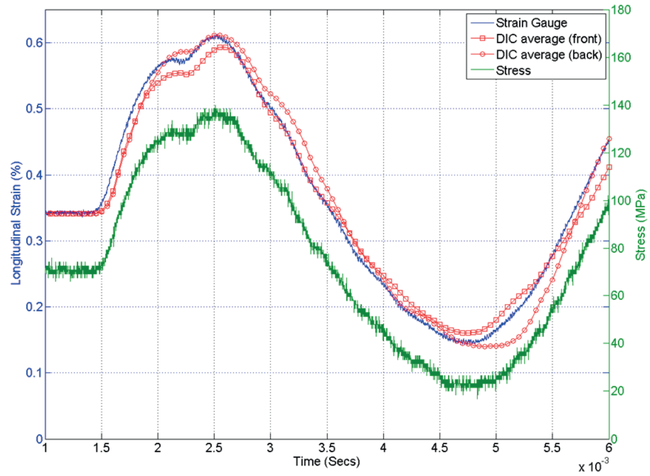


Figure 4: Results from images correlated with DaVis software

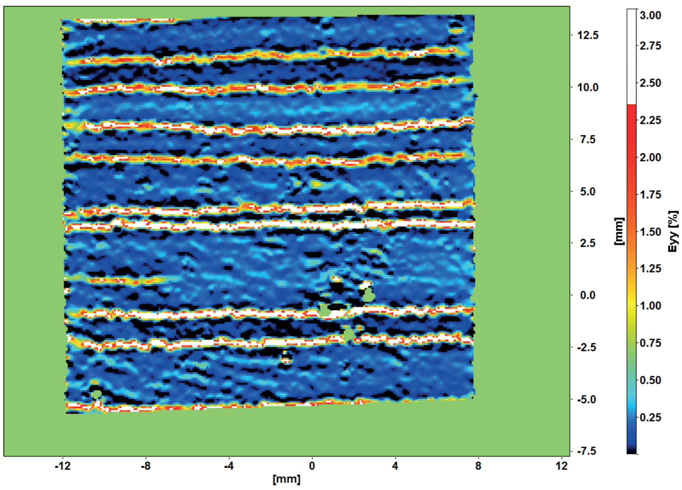


Figure 5: Longitudinal (vertical) strain map showing the development of surface transverse cracks occurring in a quasi-statically loaded crossply [90,0]s carbon-epoxy specimen

The specimen design is shown in Figure 3 and the whole setup was validated by imaging a specimen also instrumented with a strain gauge. Figure 4 shows the good agreement between gauge and DIC results (from the front and rear of the specimen).The full field DIC results show the typical development of transverse cracks for this kind of test as shown in Figure 5.

The testing showed the ability to make high strain rate tests, and study strain rate effects in composite materials using Digital Image Correlation. The test methodology was subsequently used to gather data synchronous with Infra-Red imaging techniques, and utilize Thermoelastic Stress Analysis (TSA) to make further calculations. This kind of data is invaluable in validating and optimizing computational simulations.

The damage tolerance project is jointly funded by the EPSRC and DSTL. The project team is led by Professor Janice Barton. DSTL are playing a major role in the research which is lead on their behalf by Laura Jones. Further details can be found at http://www.southampton.ac.uk/damtol/

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LaVisionUK Ltd
2 Minton Place / Victoria Road
Bicester, Oxon / OX26 6QB / United Kingdom
E-Mail: sales@lavision.com / www.lavisionuk.com
Phone: +44-(0)-870-997-6532 / Fax: +44-(0)-870-762-6252

LaVision GmbH
Anna-Vandenhoeck-Ring 19
D-37081 Göttingen / Germany
E-Mail: info@lavision.com / www.lavision.com
Tel. +49-(0)551-9004-0 / Fax +49-(0)551-9004-100

LaVision Inc.
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Ypsilanti, MI 48197 / USA
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Phone: (734) 485 - 0913 / Fax: (240) 465 - 4306