Natural Fibre Reinforced Composites

Strong But Not Tough

Callum Hill, JCH Industrial Ecology Limited

JCH

AERO RESEARCH TECHNICAL NOTES

From –The Director of Research and Development, Aero Research Limited

Duxford, Cambridge
Telephone: Sawston 167-8

BULLETIN No. 34
October 1945

A FIGHTER FUSELAGE IN SYNTHETIC MATERIAL

Introduction

The state of emergency which existed in Britain during the later months of 1940 demanded an all-embracing review of the country's resources of material supply. The fall of France eliminated as a source of supply (and placed at the disposal of the enemy) some of the largest bauxite deposits in the world and among the measures considered at the time was the possibility of building aircraft from materials, other than light alloys, which could be produced in the British Isles. In August of that year, Aero Research Ltd., were asked, as a result of a proposal put forward by themselves, to build an experimental Spitfire fighter fuselage in order to determine whether synthetic material could be used satisfactorily for such a purpose.

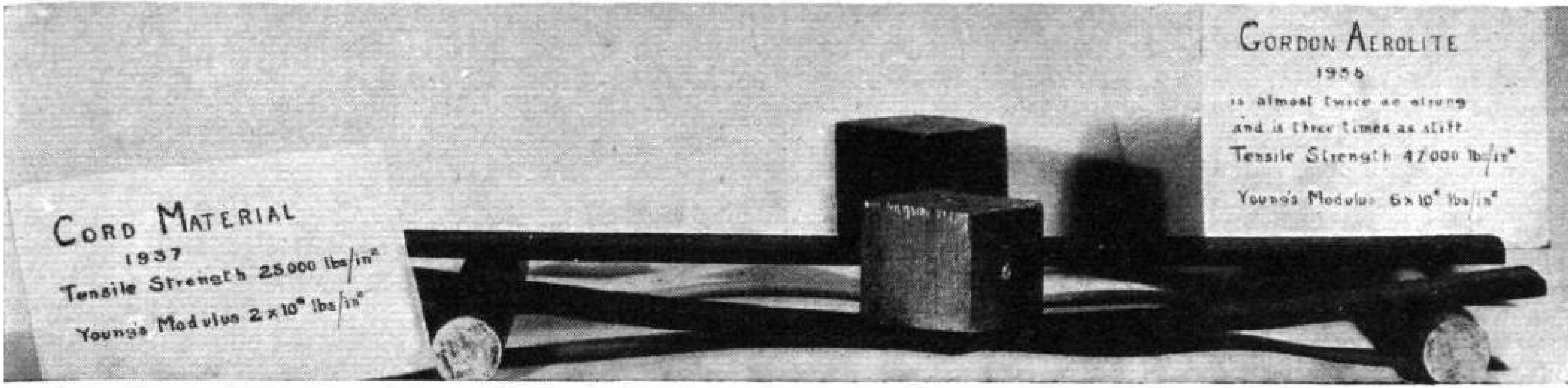


Fig. 1. "Cord" material of two years ago compared with modern "Gordon Aerolite," which is almost twice as strong and three times as stiff.

PLASTIC PROGRESS

Some Further Developments in the Manufacture and Use of Synthetic Materials for Aircraft Construction

By N. A. de BRUYNE, M.A., Ph.D

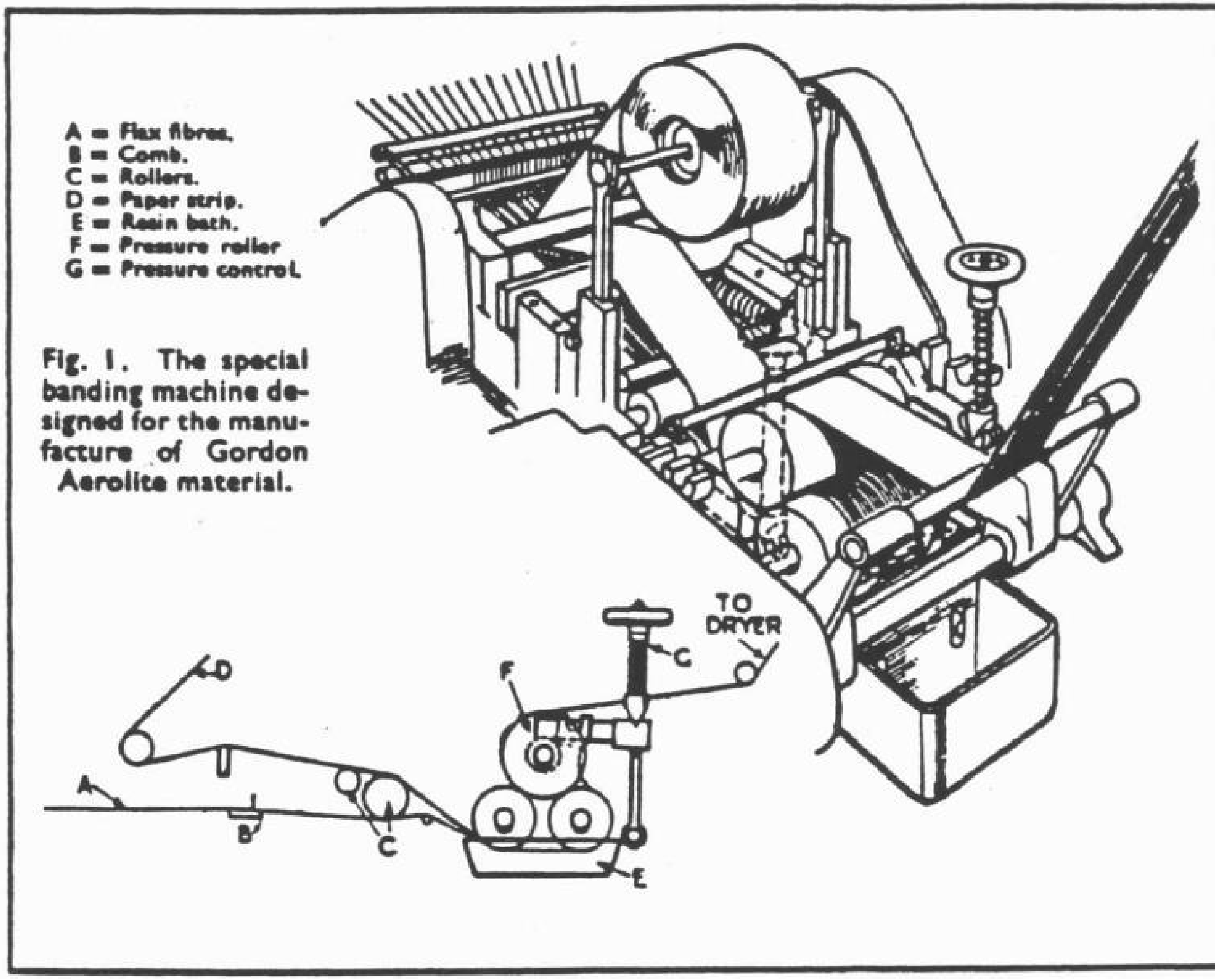


Fig. 1. The special banding machine designed for the manufacture of Gordon Aerolite material.

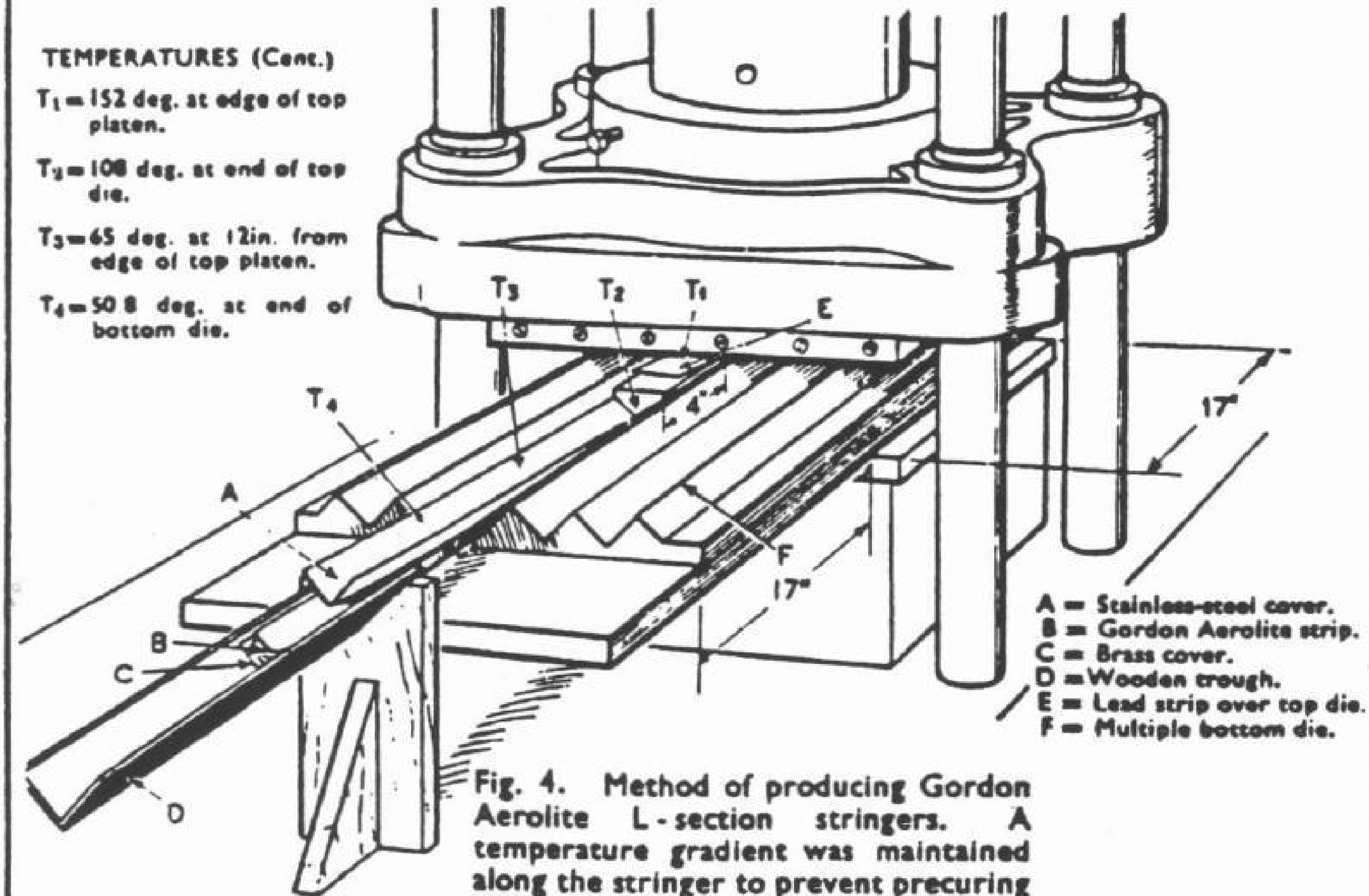


Fig. 4. Method of producing Gordon Aerolite L-section stringers. A temperature gradient was maintained along the stringer to prevent precuring of the material before it reached the press.

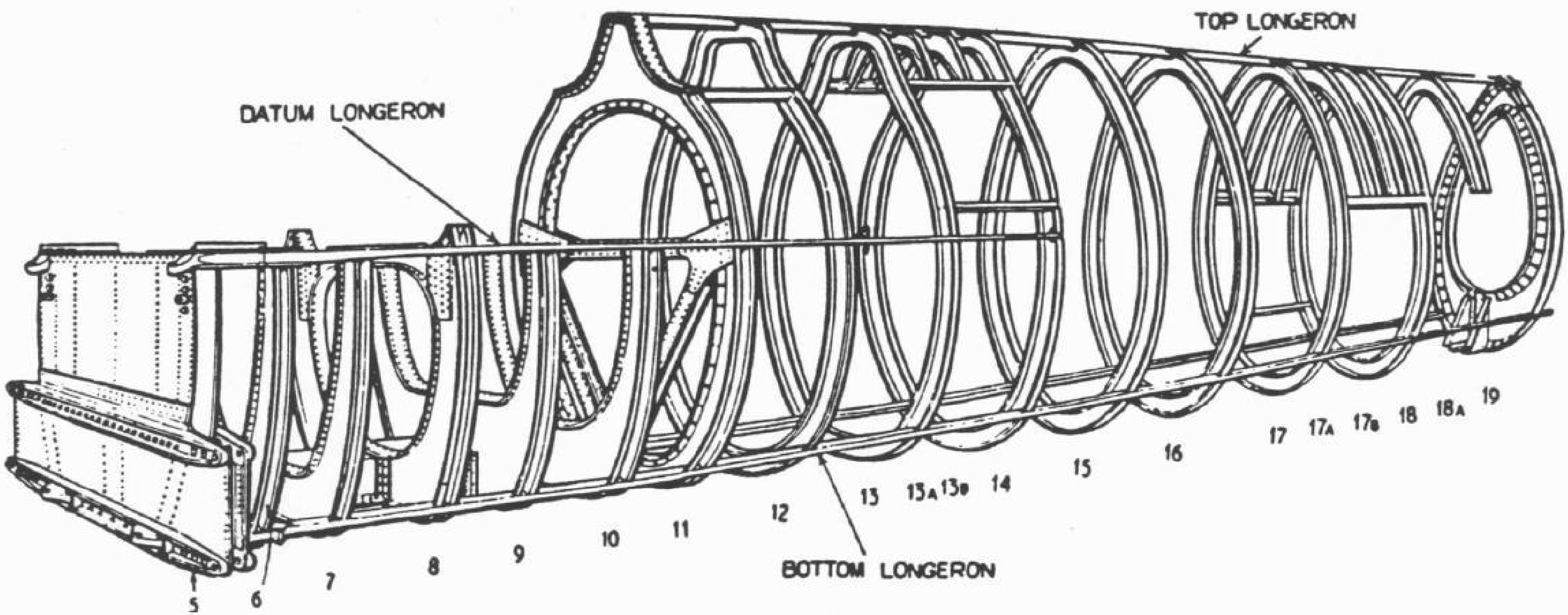


Fig. 6. Structure of the fuselage as constructed in Gordon Aerolite.

Fibre Properties

Fibre	E (GPa)	σ (MPa)
E-glass	76	2,000
Flax	28 - 103	345 - 2,000
Hemp	25 - 60	310 - 900

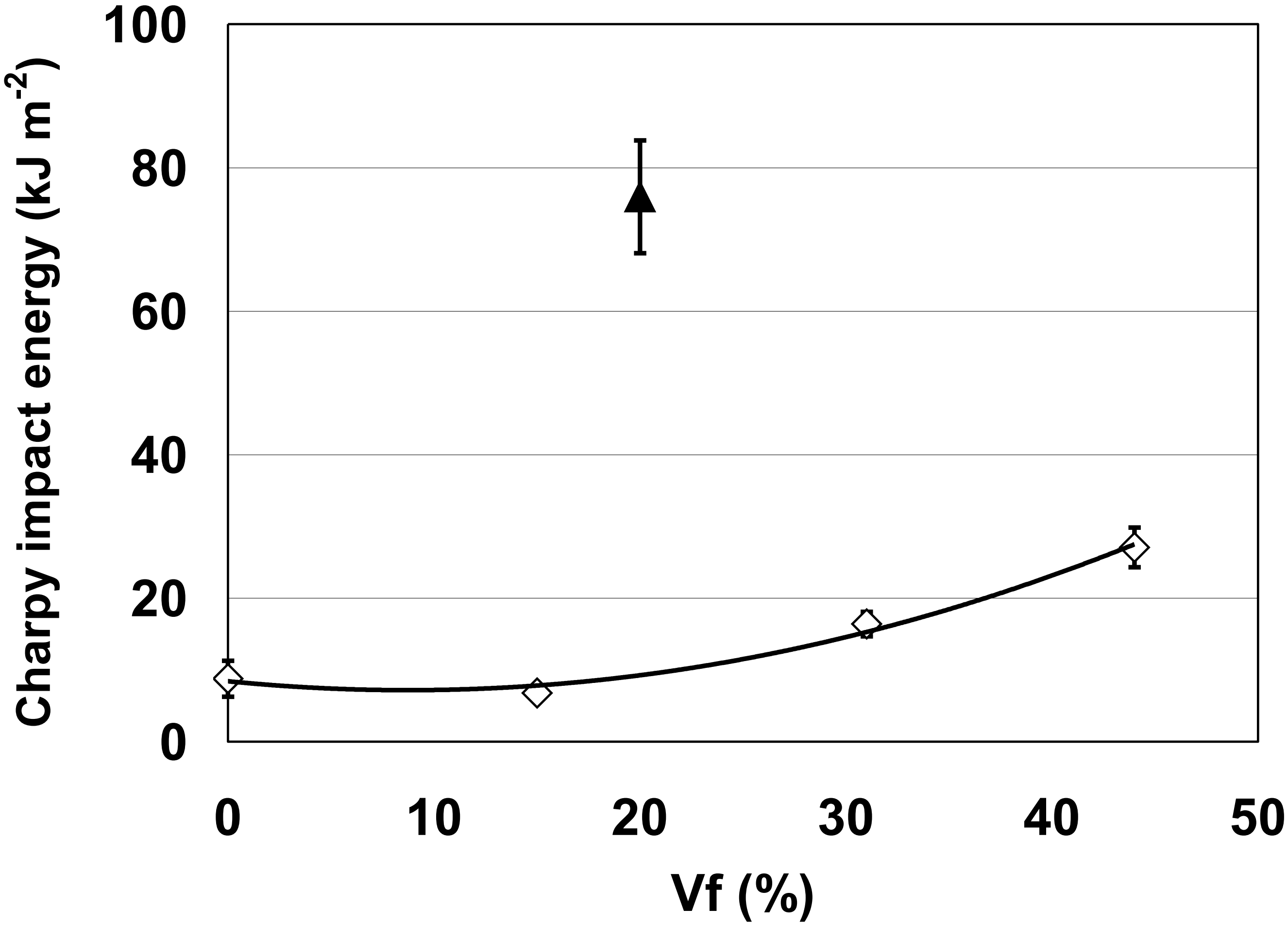
Fibre	E (GPa)	σ (MPa)
E-glass	76	2,000
Flax	28 - 103	345 - 2,000
Hemp	25 - 60	310 - 900

JCH

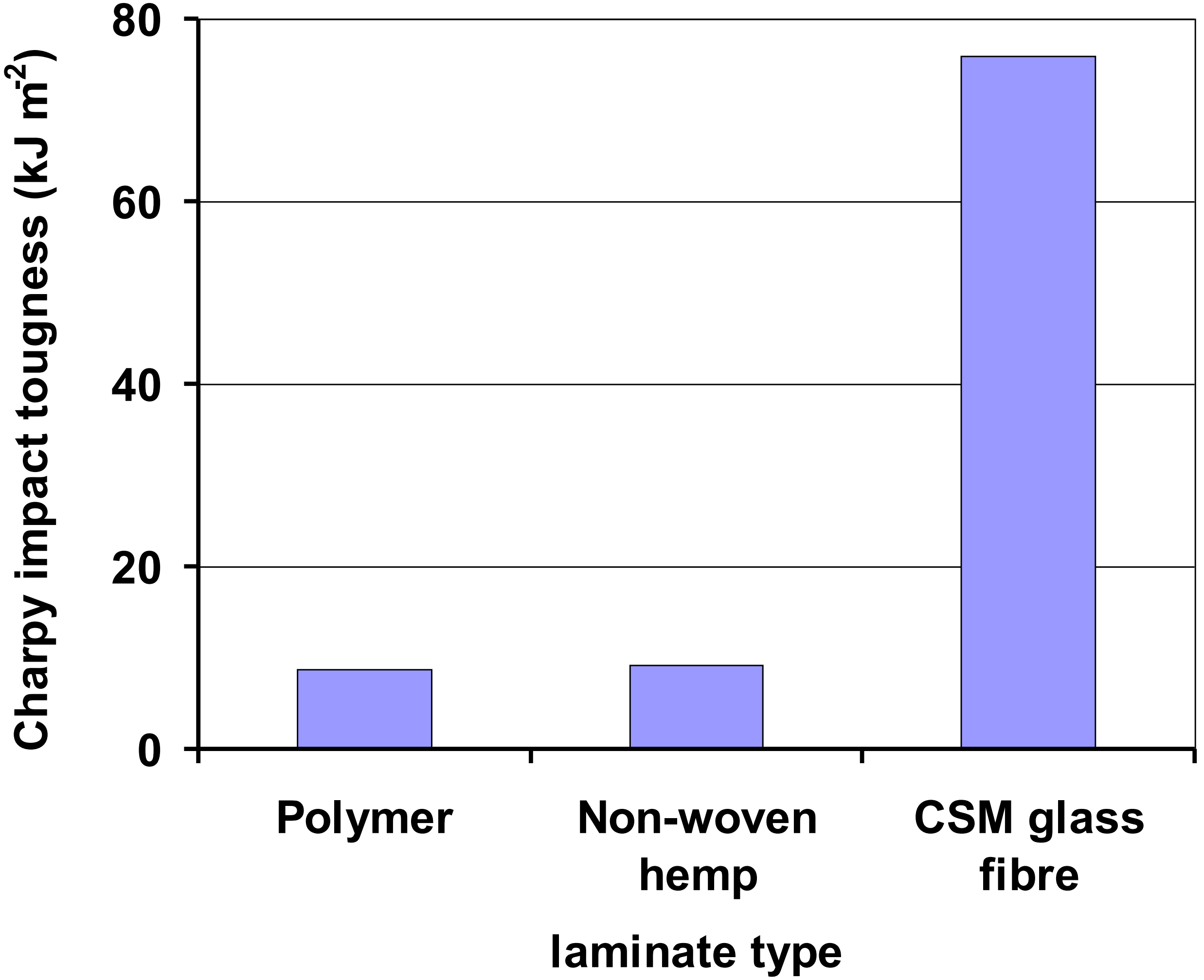
Fibre	E (GPa)	σ (MPa)
E-glass	76	2,000
Flax	28 - 103	345 - 2,000
Hemp	25 - 60	310 - 900

JCH

Composite Properties



JCH



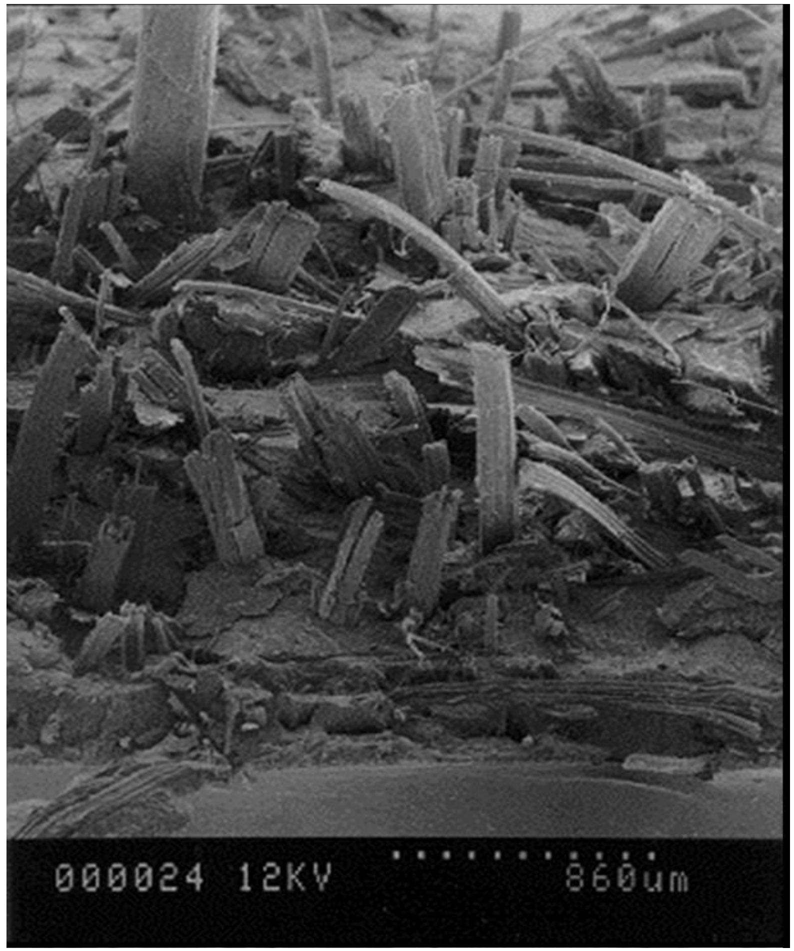
Charpy impact tougness (kJ m-2)
80
60
40
20
0
Polymer
Non-woven hemp
CSM glass fibre
laminate type

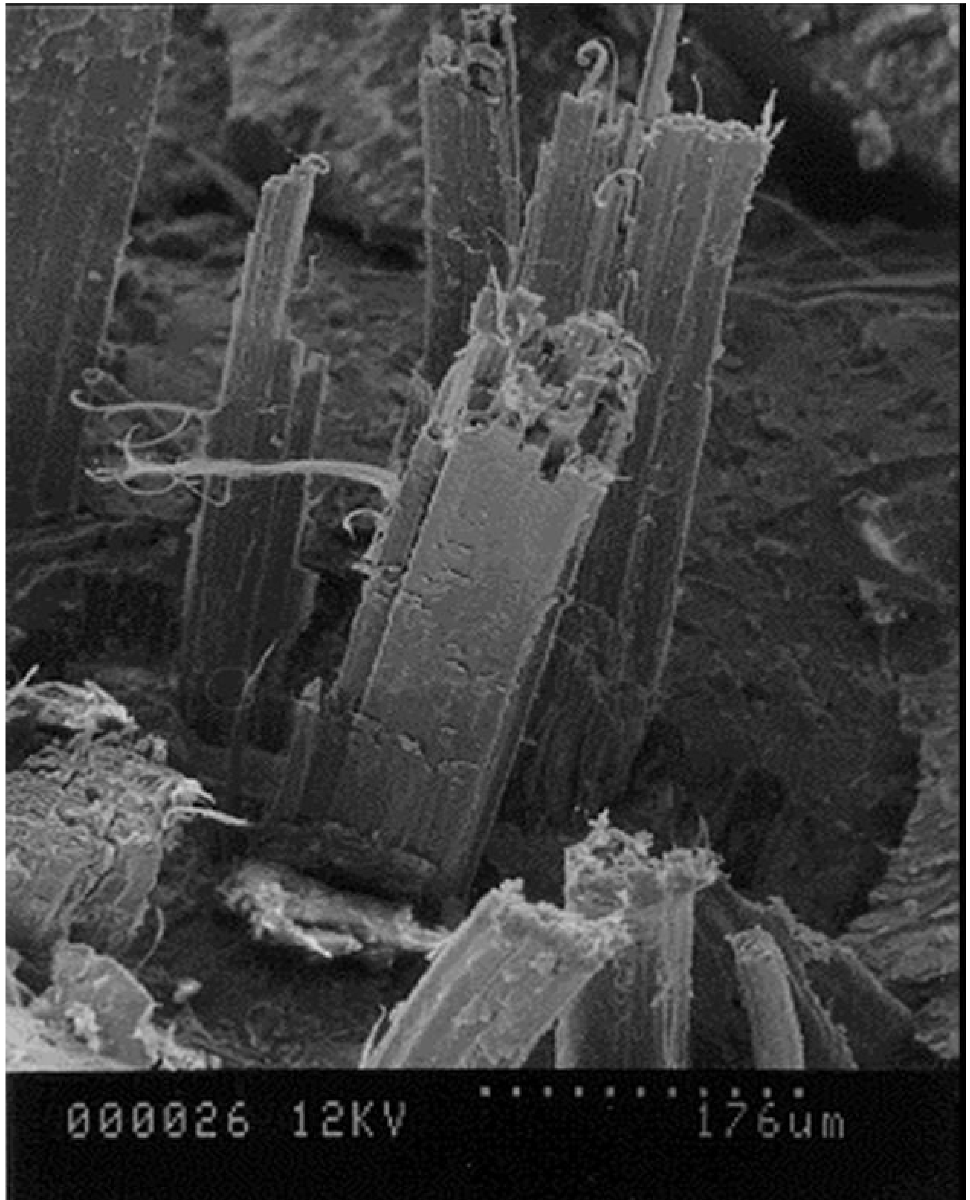
JCH

What is the Problem?

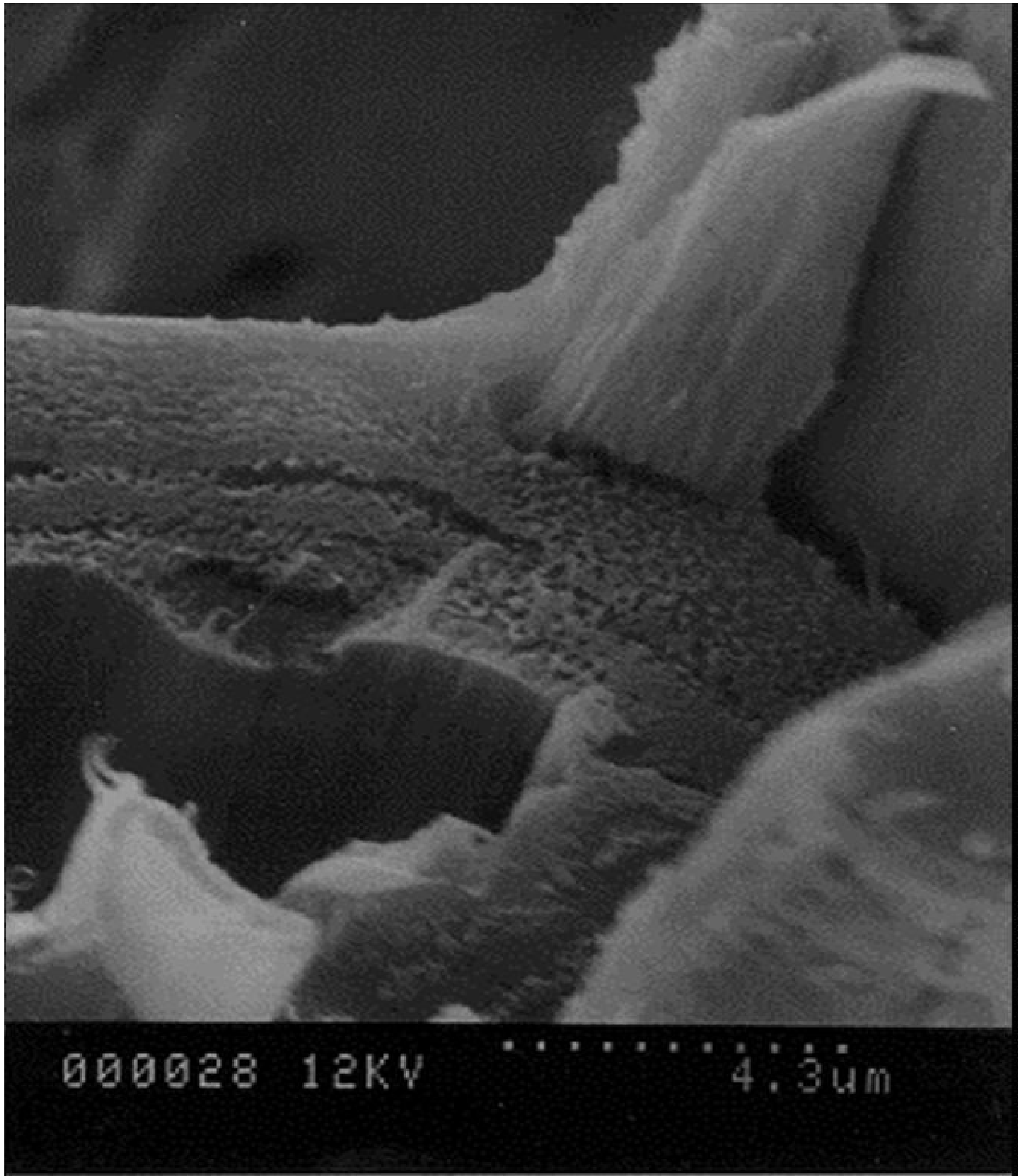
JCH

JCH


000024 12KV
860um



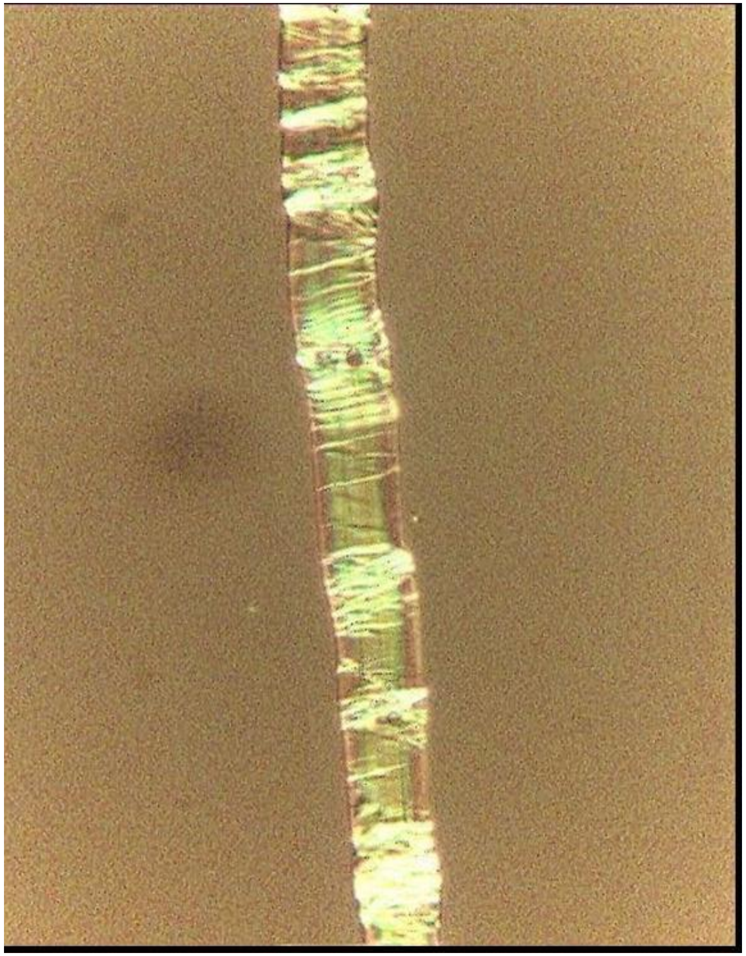
JCH

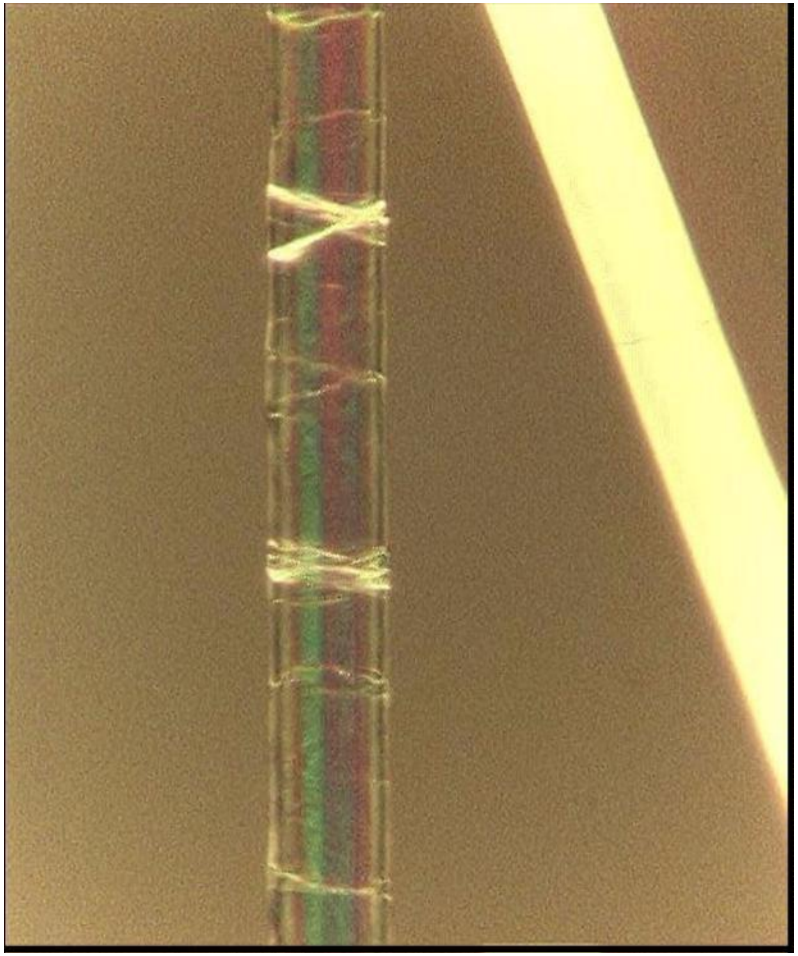

000028 12KV
4.3um

Why is the fibre exhibiting brittle failure?

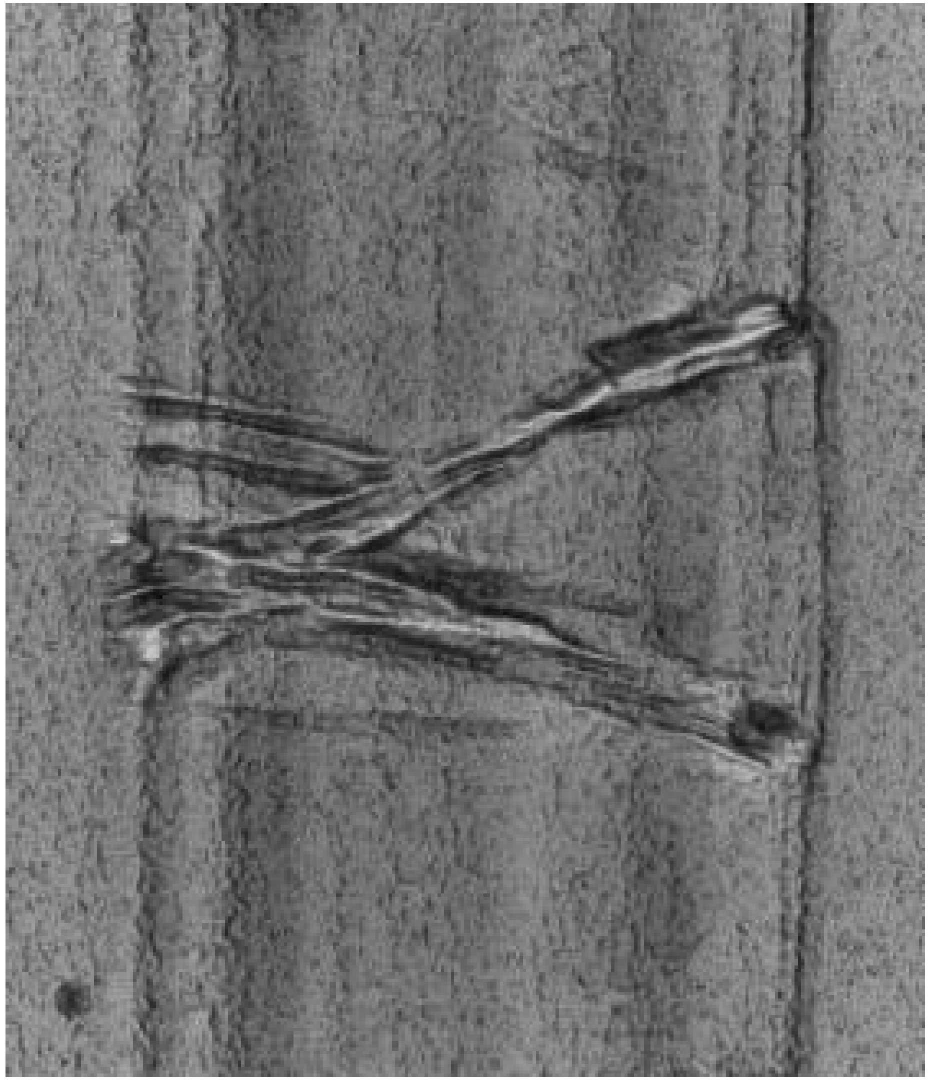
JCH

Microcompressive Defects





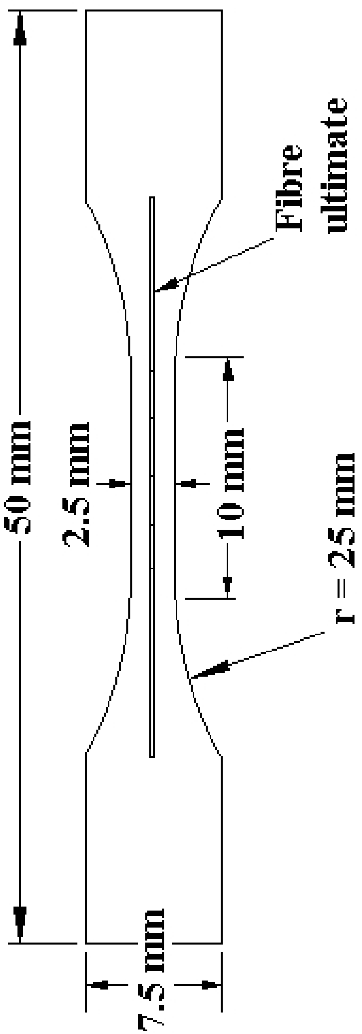
JCH

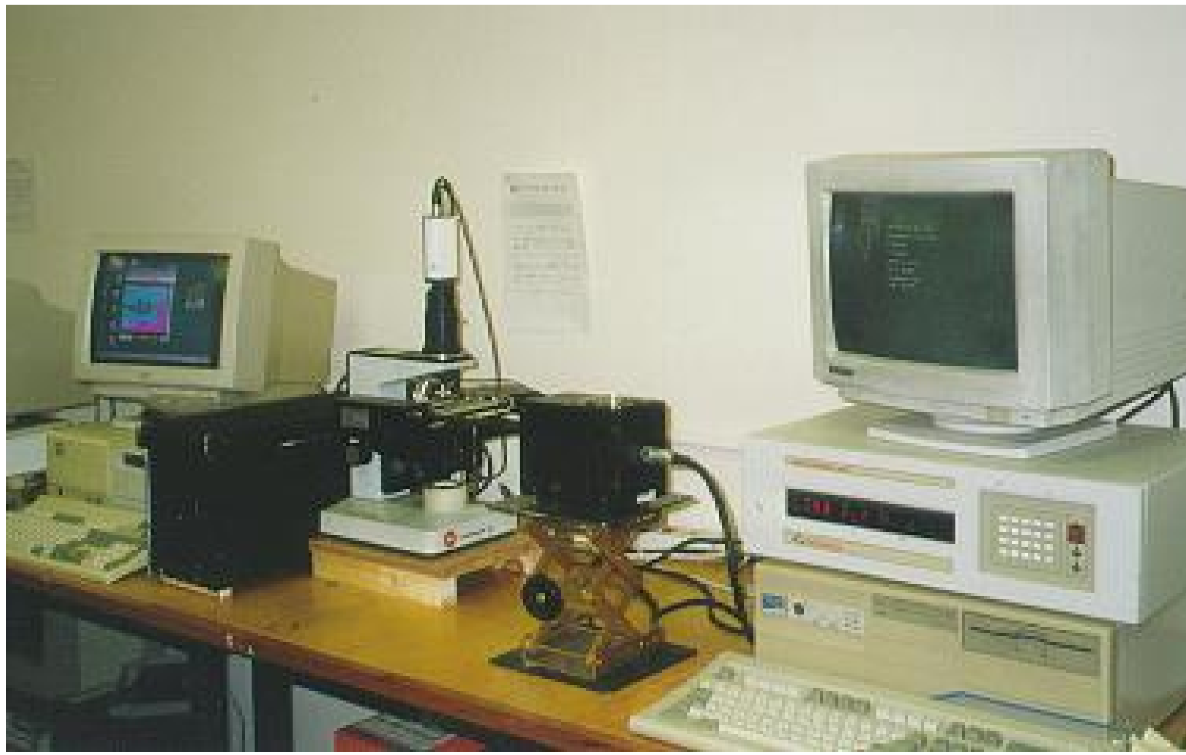


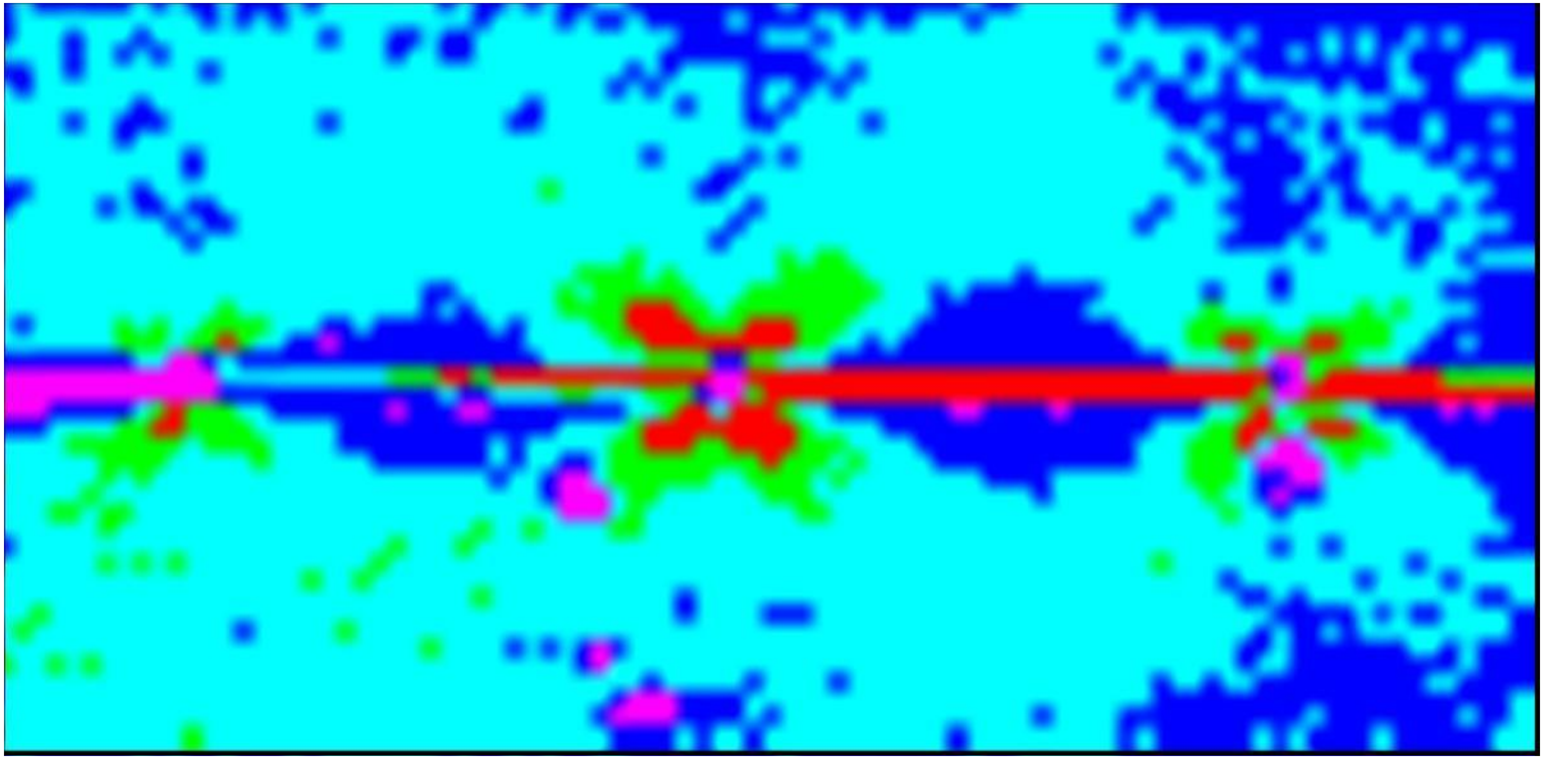
JCH

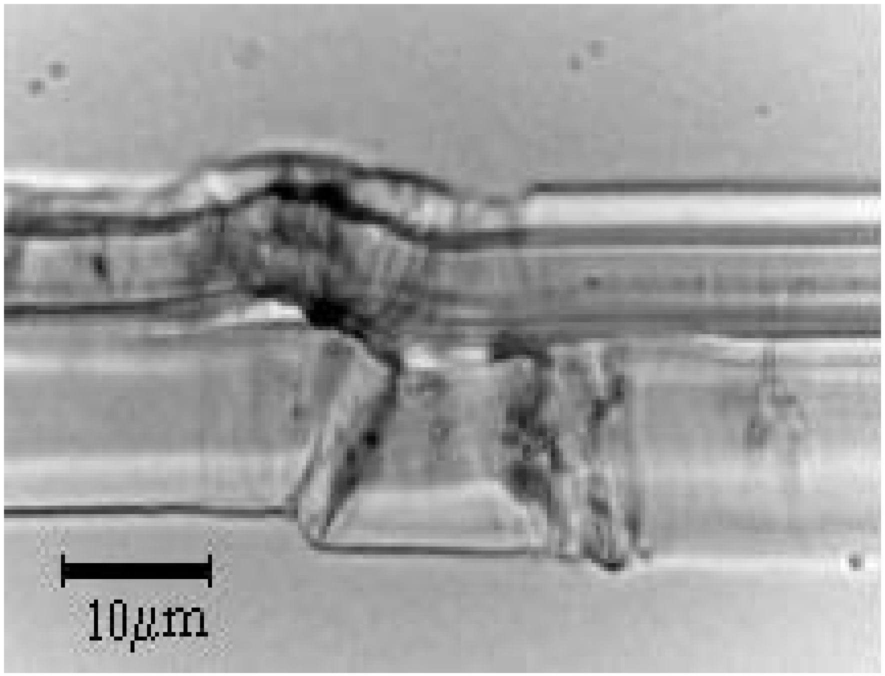
Half Fringe Photoelasticity

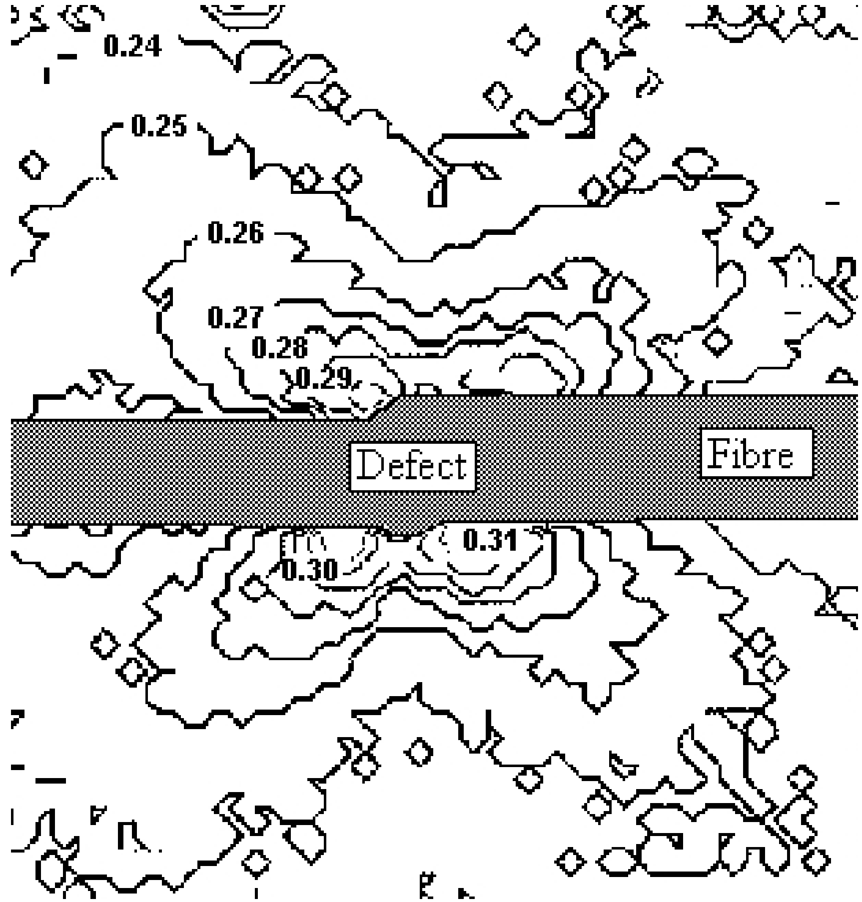
JCH

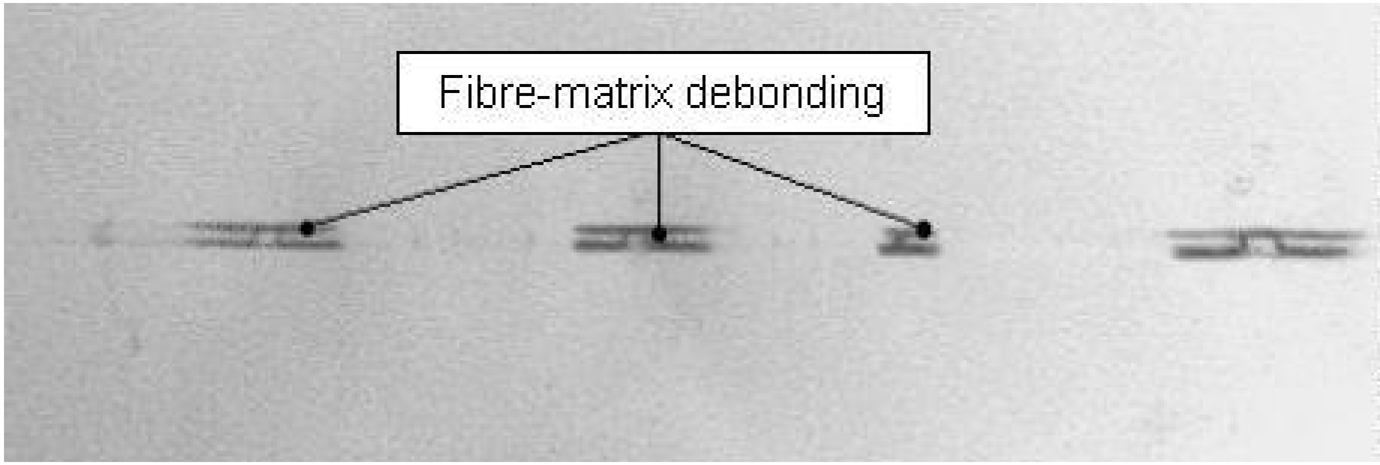

50 mm
2.5 mm
10 mm
r = 25 mm
7.5 mm
Fibre
ultimate



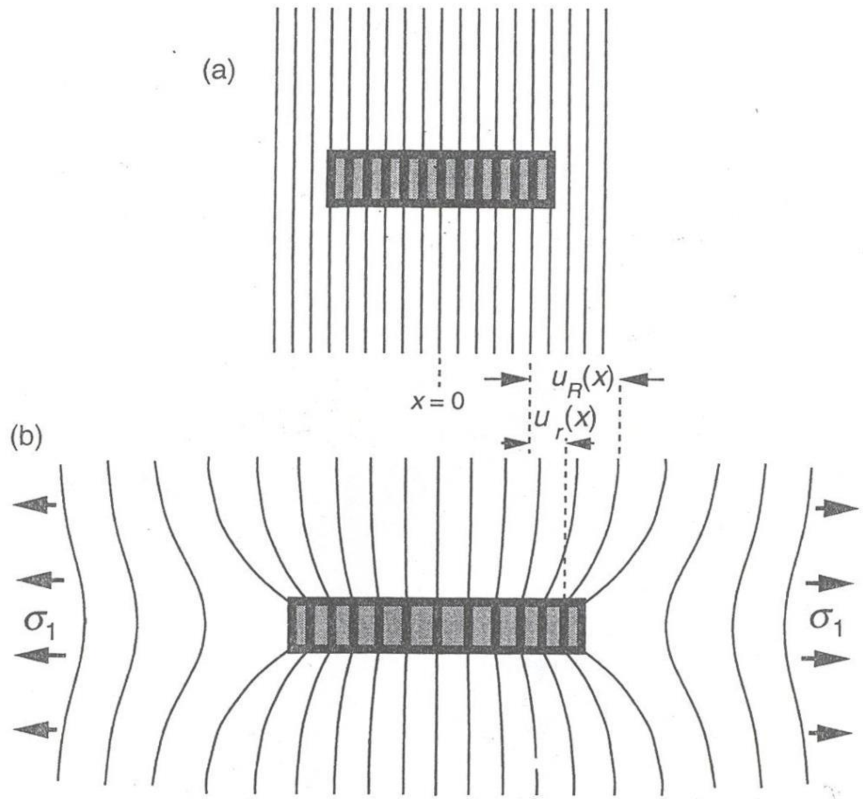



10μm

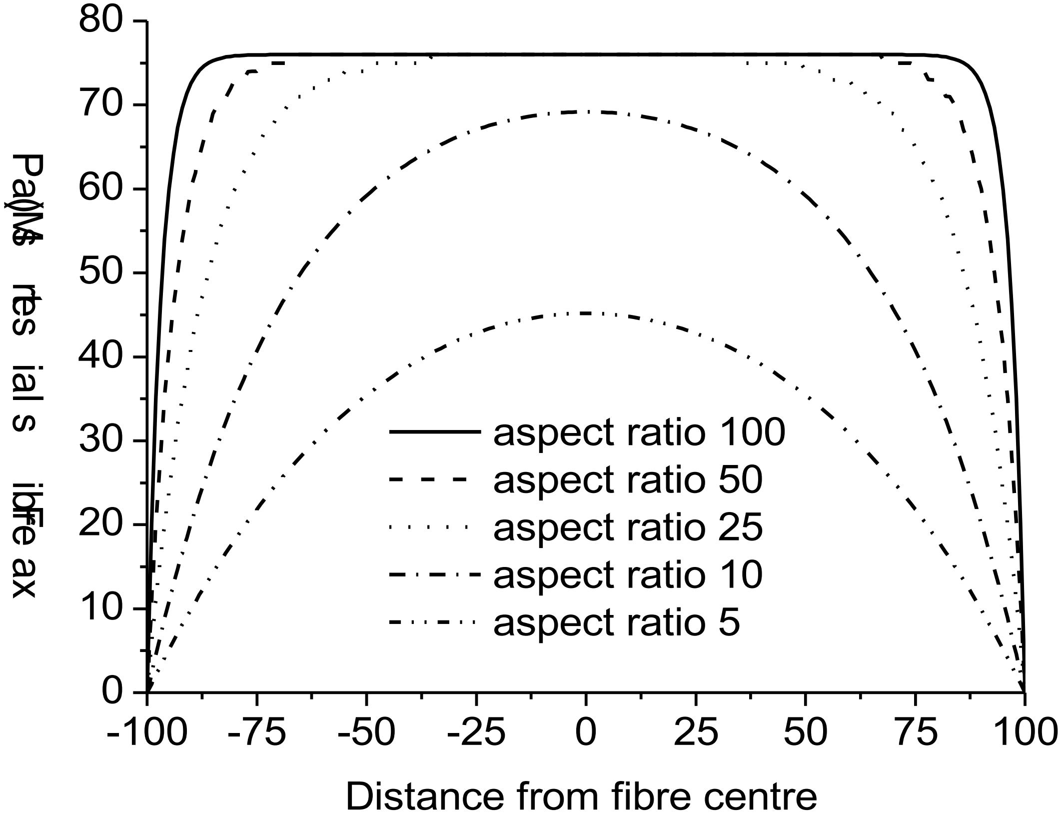

0.24
0.25
0.26
0.27
0.28
0.29
Defect
Fibre
0.31
0.30



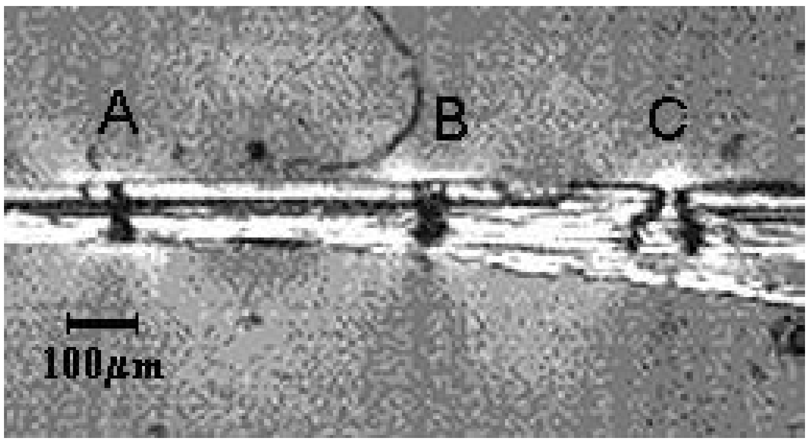
JCH

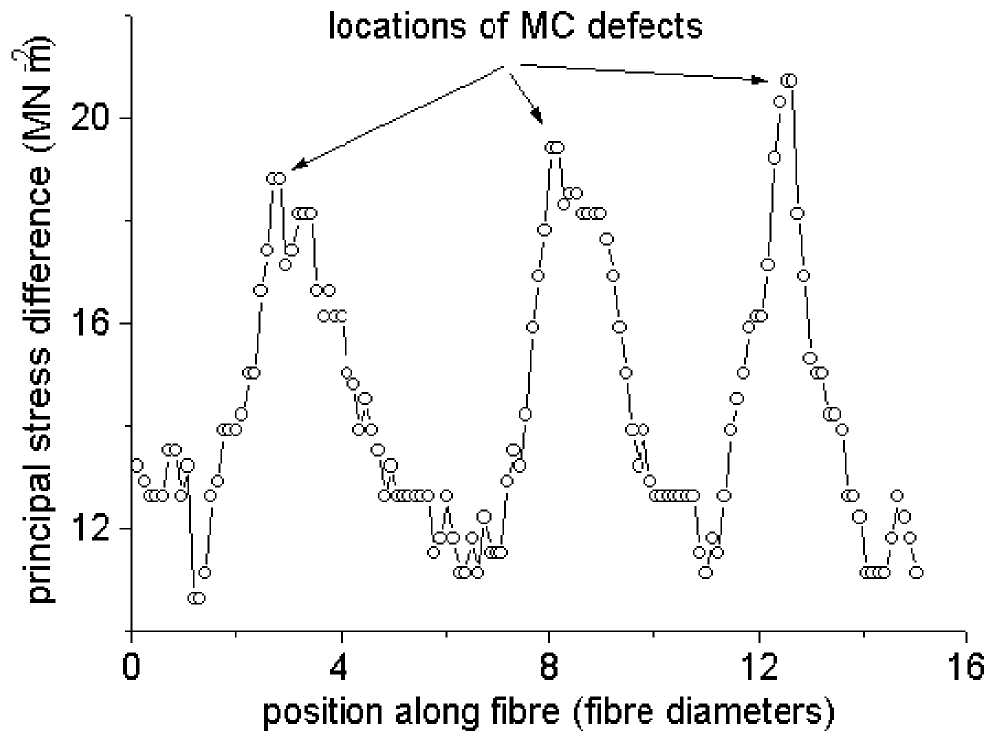


JCH



80
70
60
50
40
30
20
10
0
-100
-75
-50
-25
0
25
50
75
100
Distance from fibre centre
aspect ratio 100
aspect ratio 50
aspect ratio 25
aspect ratio 10
aspect ratio 5


A
B
C
100μm


locations of MC defects
principal stress difference (MN m^{-2})
20
16
12
0
4
8
12
16
position along fibre (fibre diameters)

JCH

Acknowledgements

Professor Mark Hughes Aalto University