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A Higher Level of Reliability

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**TECHNICAL SAFETY BC**
104 - 9525 201 St.
Langley, BC
V1M 4A5

Attention: Mr. Dean Schmitke

**Re: Outdoor Fibreglass Water Slide Cracking**

## 1.0 INTRODUCTION

An outdoor fibreglass waterslide suffered cracking which resulted in injuries to the users. An overall view of a typical cracked area is shown in Figure 1 and Figure 2. A sample of the cracked fibreglass was removed from the slide as shown in Figure 2.

The slide is constructed from two layers of fibreglass sheets with a wooden core. Foam had been injected beneath and around the core to support the fibreglass where the core had deteriorated. The slide is partially buried in the ground and has no other supporting structures.

Acuren was asked to examine the cracked slide material and determine the cause of the cracking and the overall condition of the slide material.

## 2.0 SLIDE EVALUATION

The fibreglass sliding surface is supported by the ground into which the slide is placed and the wooden core which separates the inner and outer fibreglass components of the slide. The slide construction is shown in Figure 3.

Any loss of support by ground erosion or by deterioration of the wood core pieces would result in increased deflection of the fibreglass on both the outer and inner fibreglass sheets. Bending stresses in the fibreglass would increase due to the larger deflections incurred. It is obvious that the owners attempted to limit deflection by injecting foam between the ground foundation and the lower sheet. It is not known what necessitated the foam injection and when it was done.

### 2.1 Visual Examination

The slide fibreglass material from the area of the fracture was removed from the site by TSBC personnel for laboratory examination. Overall views of the sample pieces are shown in Figures 4 - 23. The front and back sides of each sample piece are shown. The sample pieces were arbitrarily labeled A - I for identification purposes.

Samples A - E are relatively large pieces cut from the slide. The pieces contain evidence of drilled holes where foam was injected to prevent deflection. The time at which the foam was placed is not known. All of the pieces show evidence of discolouration and deterioration from exposure to the environment. Evidence of prior repair patches are present with samples A - C and show discolouration in the form of light patches (Figures 4, 6, and 8). The light patches are evidence of disbonding of the gel coat from the underlying glass fibres.

High intensity light was used to examine the samples A - C in different areas around the cut-out pieces. Fine cracks were found with most of the areas examined (Figures 23 - 33). Previously repaired areas (Figures 25, 28, 31, 34) appeared to be of poor quality and did not match the thickness or integrity of the original fibreglass material.

### 2.2 Scanning Electron Microscope Evaluation of Fractures

A scanning electron microscope (SEM) was used to examine fracture surfaces with fracture sample I (outer layer) and sample H (inner layer). Both samples contained transverse fractures that had "V" shaped notch sample removed by others.

Low magnification views of the sample I outer layer fracture surface are shown in Figures 35 - 47. The three low magnification images (35 - 37) are from the same long fracture shown in Figure 21. The layered nature of the hand laid up fibreglass can be seen in the images. Fibres can be seen running both longitudinally and transverse to the direction of the fracture. Typical longitudinal fibres can be seen in Figure 38. The fibre surfaces are relatively clean and appear to be free of protective resin. Closer views of the longitudinal fibres are shown in Figures 39 and 40. The lack of well bonded resin on the fibres allows the fibres to become damaged and susceptible to fracture.

Some areas of the fracture contain well packed and well bonded fibres and have fractured in a single transverse plane. Matrix material in these areas appear well bonded to the fibres and the matrix is cracked by a fatigue mechanism (Figure 41). In other areas, the fibres are pulled out cleanly and the matrix material appears brittle (Figures 42 and 43). Both types of fracture may occur in the progressive-type failure observed with the fibreglass sheet.

The inner fibreglass sheet fracture is shown at low magnification in Figure 44. The fractured fibre layers are much tighter than with the outer layer fracture and show more evidence of fatigue rather than the outer fibreglass layer (Figures 45 and 46). Smaller areas of brittle fracture were found along the sample with long pulled out fibres (Figure

47). The amount of brittle fracture present on the inner fibreglass layer was less than that found with the outer layer.

## 3.0 DISCUSSION OF FINDINGS

The evidence shows that the fibreglass slide material failed by a progressive fracture mechanism consisting of both fatigue and brittle fracture. It is likely that continuous pounding of unsupported panels resulted in initial microcracking on gel-coat surfaces followed by progressive fracture of the underlying fiberglass. All surfaces of the fiberglass contain cracking, although the amount of cracking appears to be more related to the outer surface gelcoat quality (original or deteriorated) than the actual position within the slide. Deteriorated wood and/or missing ground support would definitely increase the rate of cracking in the fibreglass.

Small multi-directional cracks in the fibreglass and gelcoat are visible by viewing the panels under high intensity light. These small cracks will eventually join up in the direction of principle bending stress and result in fibre breaks near the outer and inner surfaces of the panel. Removal of resin by weathering (water ingress) and further dynamic loading would have increased the cracking rate exponentially. Once the gel coat was broken, weather anomalies such as freezing, UV exposure, and differential thermal expansion and contraction would increase the rate of cracking in both the gel coat and underlying fibreglass. It is likely the outer surface of the fibreglass panel cracked at a higher rate due to weather exposure not found at the inside surface.

The time at which the first cracks appear on the weather exposed fibreglass surfaces will depend on actual weather conditions, how clean the fibreglass surfaces are maintained, and the loading conditions experienced by the slide. A single ride by a very heavy rider might be enough to initiate a brittle crack in the gelcoat where support has been lost, exposing the underlying fibreglass. Seasonal freezing and thawing might be more frequent in some years than in others. The actual time it took to initiate and grow the observed cracks cannot be determined.

The cracking mechanism observed is progressive and would have been visible to a trained person before the day of the actual rupture. Something as simple as running a cotton cloth along the outer surface of the slide would likely have detected growing cracks on the gelcoat surface. Visual indications of deterioration such as fading, surface roughening, or biological growth would indicate that a more thorough inspection should be done to detect growing cracks.

Please call at your convenience if you have any questions.

Yours truly,

**ACUREN GROUP INC.**

R. W. A. MILNE 10/12/24

Bob Milne, P.Eng.
BM/dw

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# APPENDIX

**Figures 1 to 47**

**Figure 1** Overall view of transverse fracture in fibreglass slide.

**Figure 2** Area of cut out fibreglass showing deteriorated foam under cracked panel.

**Figure 3** Cut is slide near fracture showing slide construction with wood core and an inner and outer layer of fibreglass. Underlying dark material is injected foam.

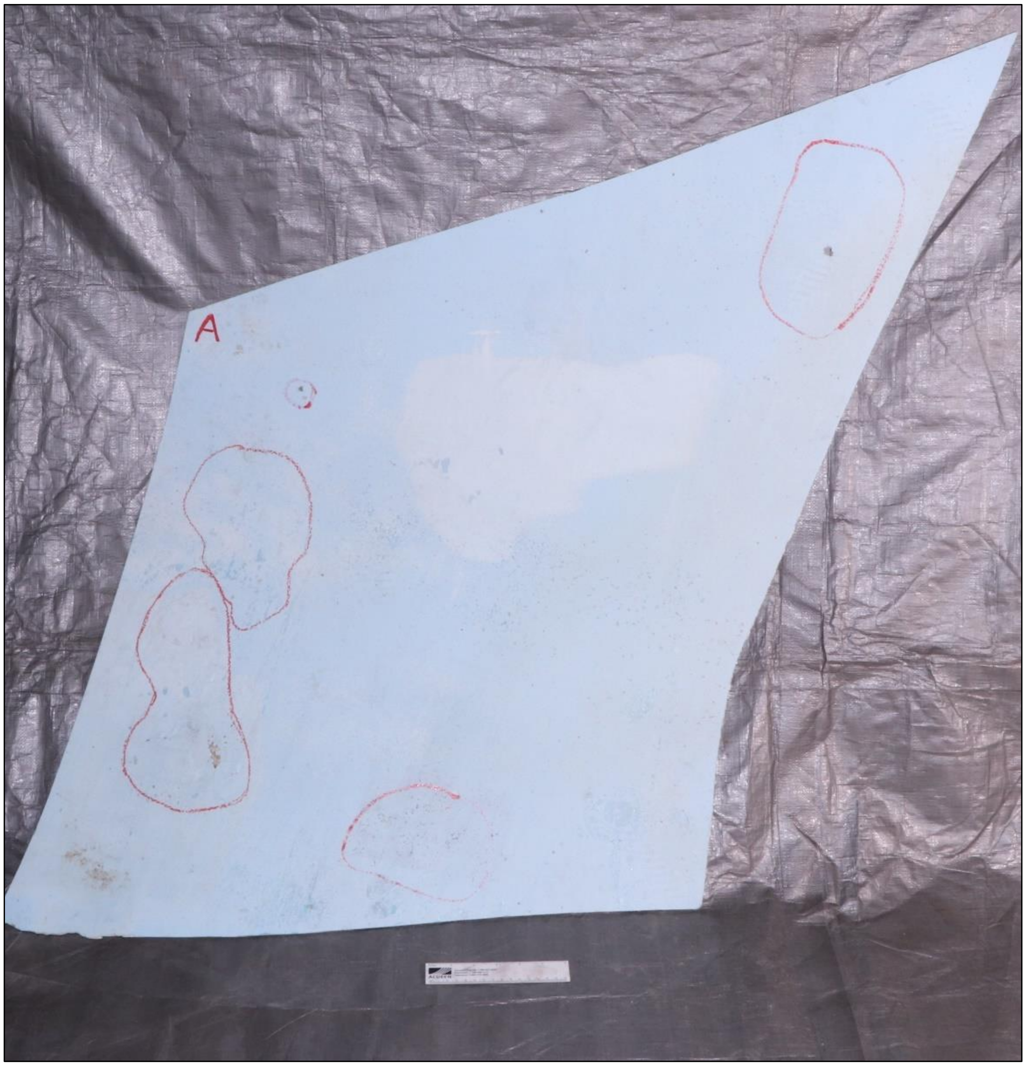


**Figure 4** Sample A running surface showing discolouration and areas of surface damage.

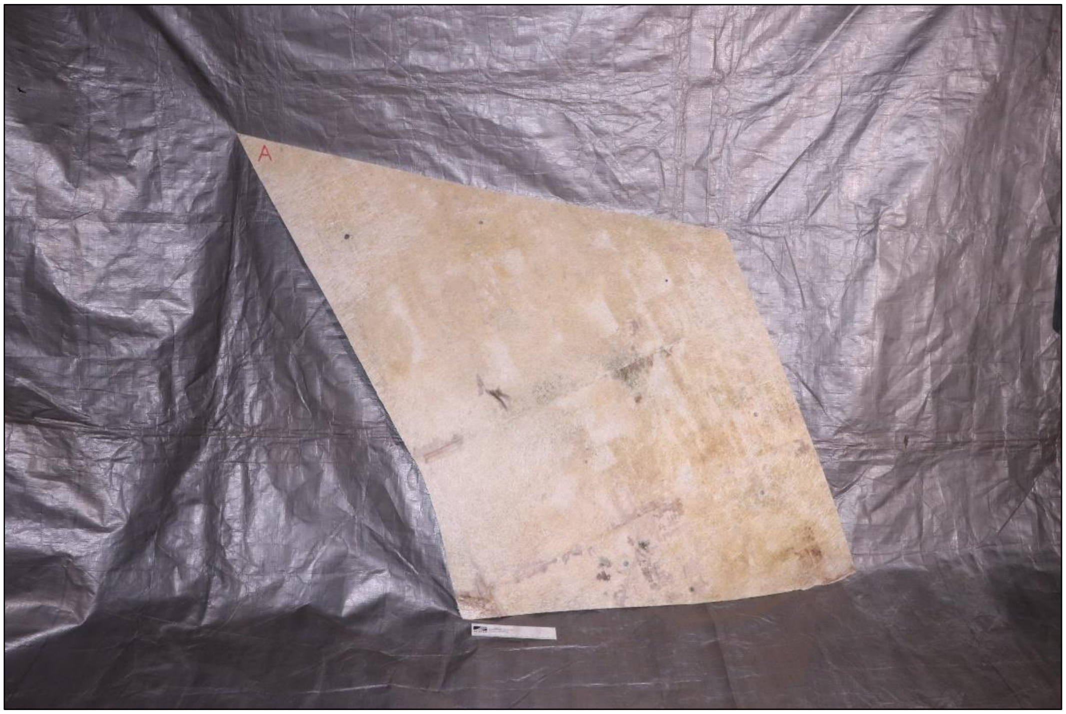


**Figure 5** Sample A back surface.

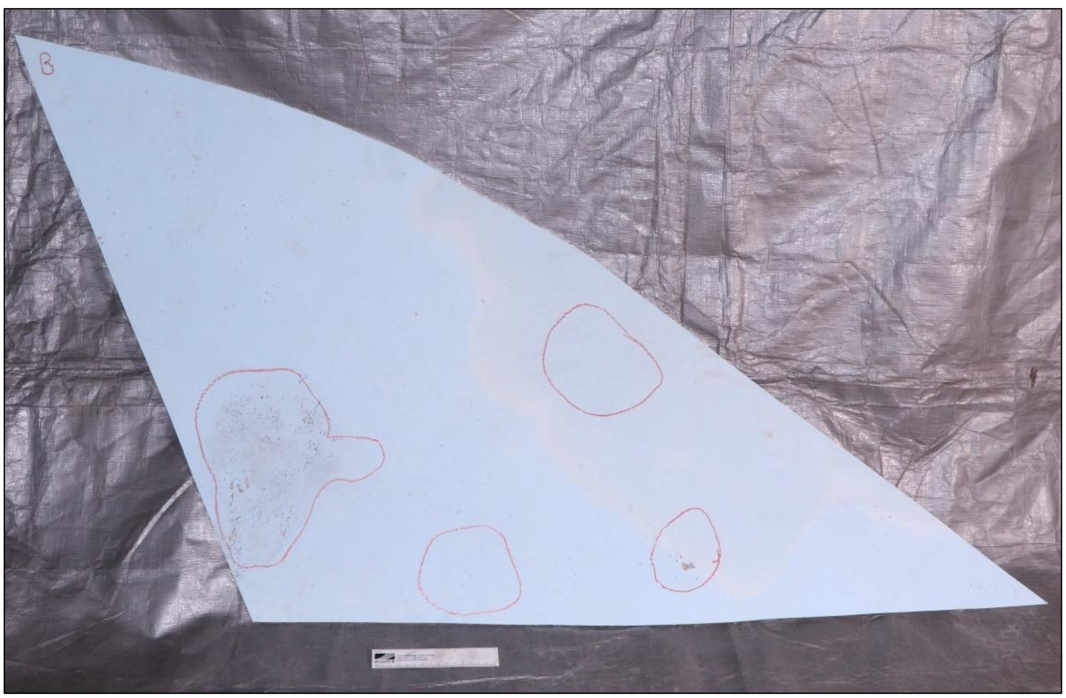


**Figure 6** Sample B running surface showing discolouration and areas of surface damage.

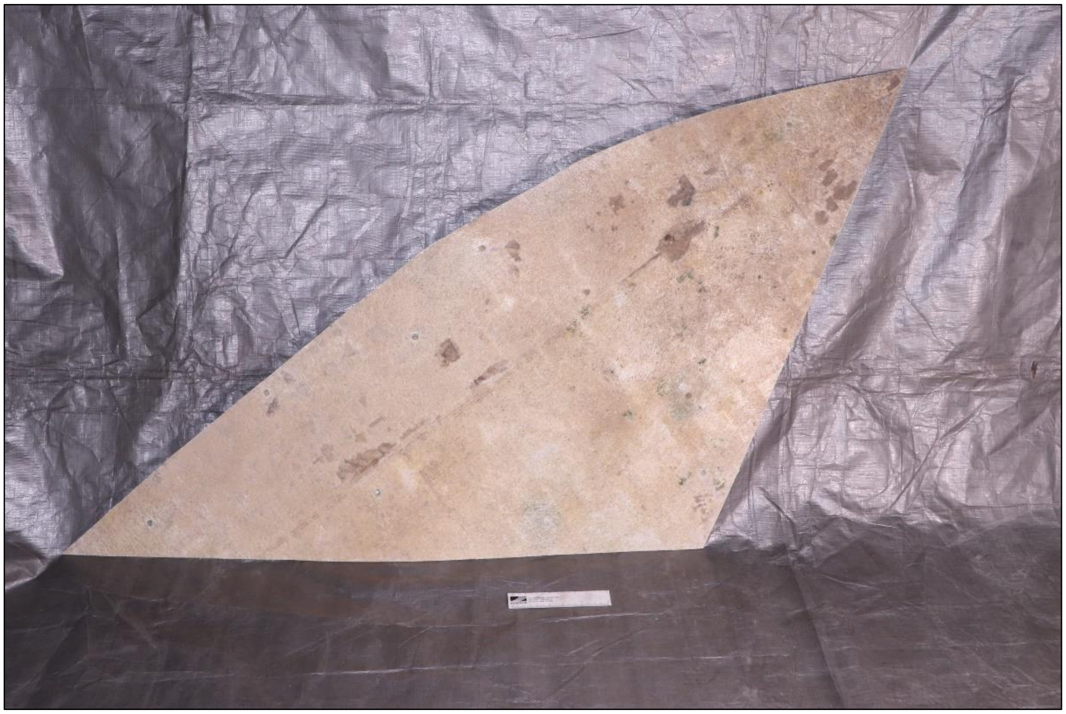

**Figure 7** Sample B back surface.


**Figure 8** Sample C running surface showing discolouration and areas of surface damage.

**Figure 9** Sample C back surface.

**Figure 10** Sample D front surface.

**Figure 11** Sample D back surface.


**Figure 12** Sample E front surface. Note holes drilled for foam injection.

**Figure 13** Sample E back surface.


**Figure 14** Sample F showing long transverse crack on running surface.


**Figure 15** Sample F back surface.

**Figure 16** Closer view of crack on sample F.

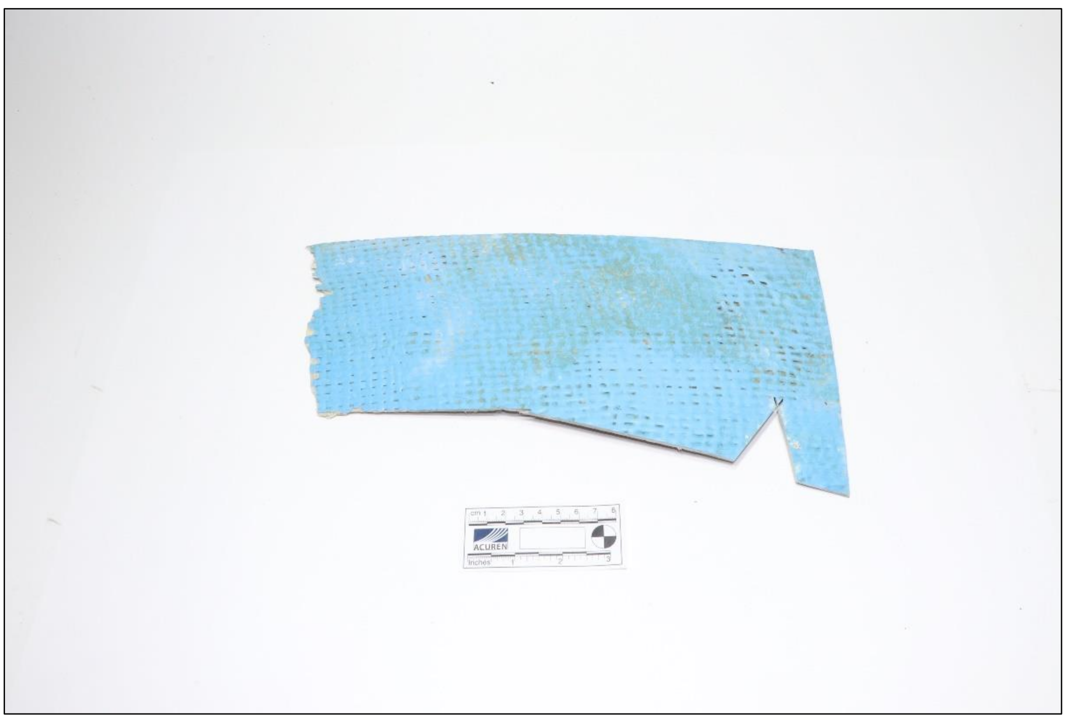

**Figure 17** Sample G front surface. Notch was cut by others.

**Figure 18** Sample G back surface.


**Figure 19** Sample H front surface containing fracture. Notch was cut by others.


**Figure 20** Sample H back surface.

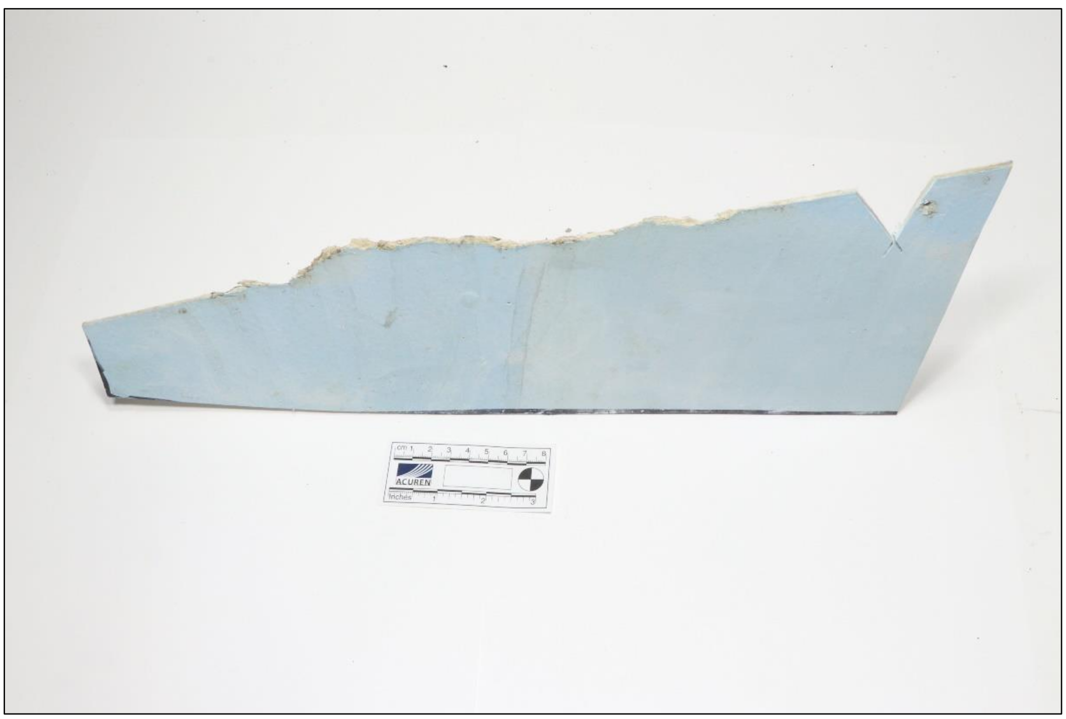

**Figure 21** Sample I running surface. Notch was cut by others. Fracture is present along 80% of the top edge.

**Figure 22** Back side of sample I.

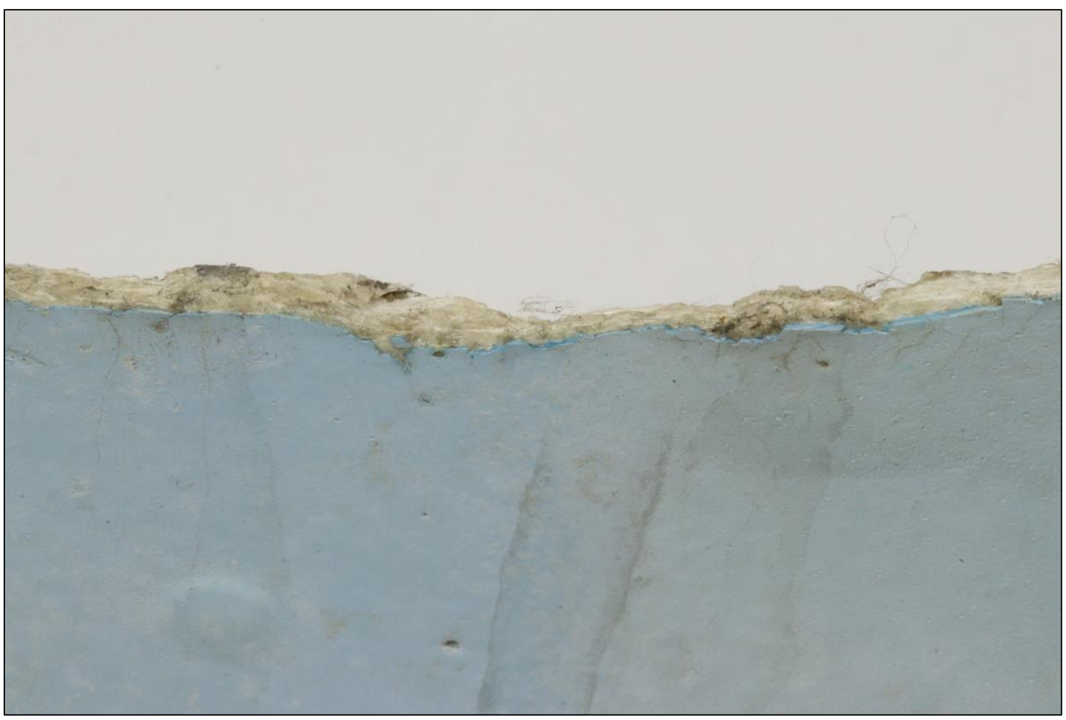

**Figure 23** Sample I fracture surface used for SEM examination.

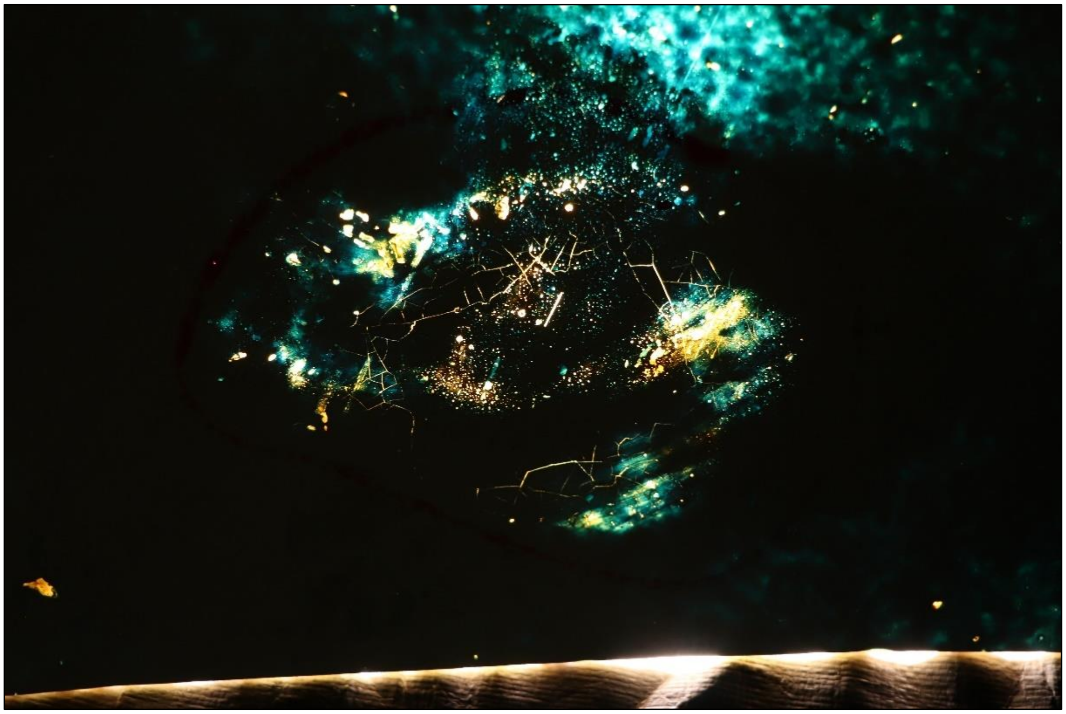

**Figure 24** Cracking exposed by backlighting sample A1.

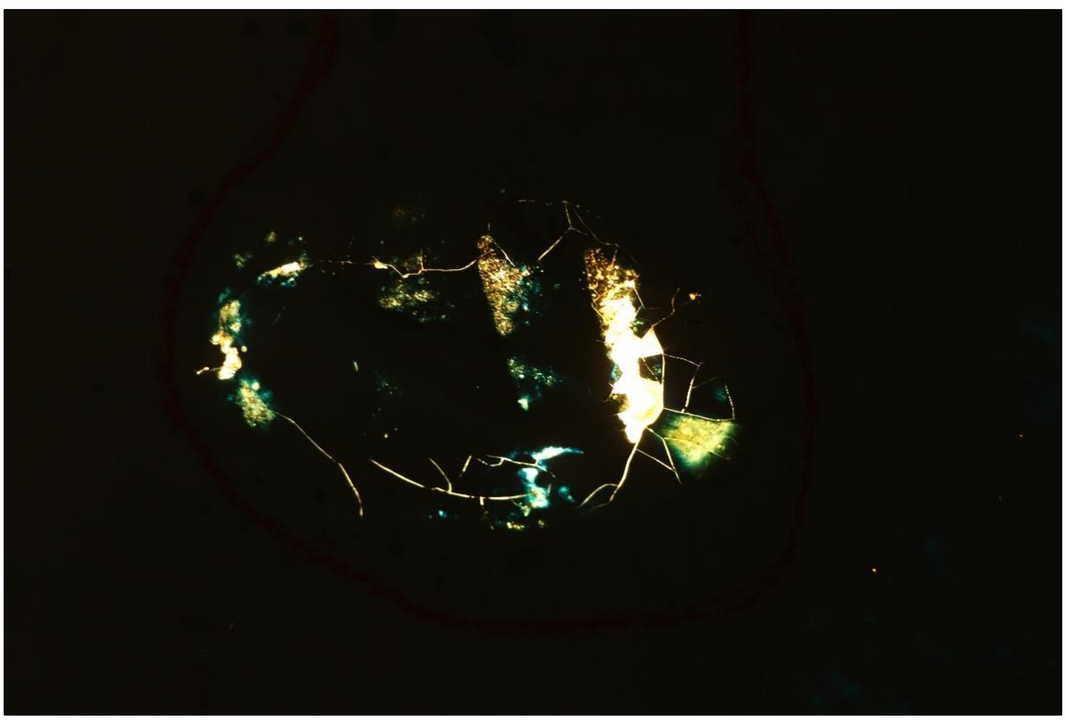

**Figure 25** Cracking exposed by backlighting sample A2.

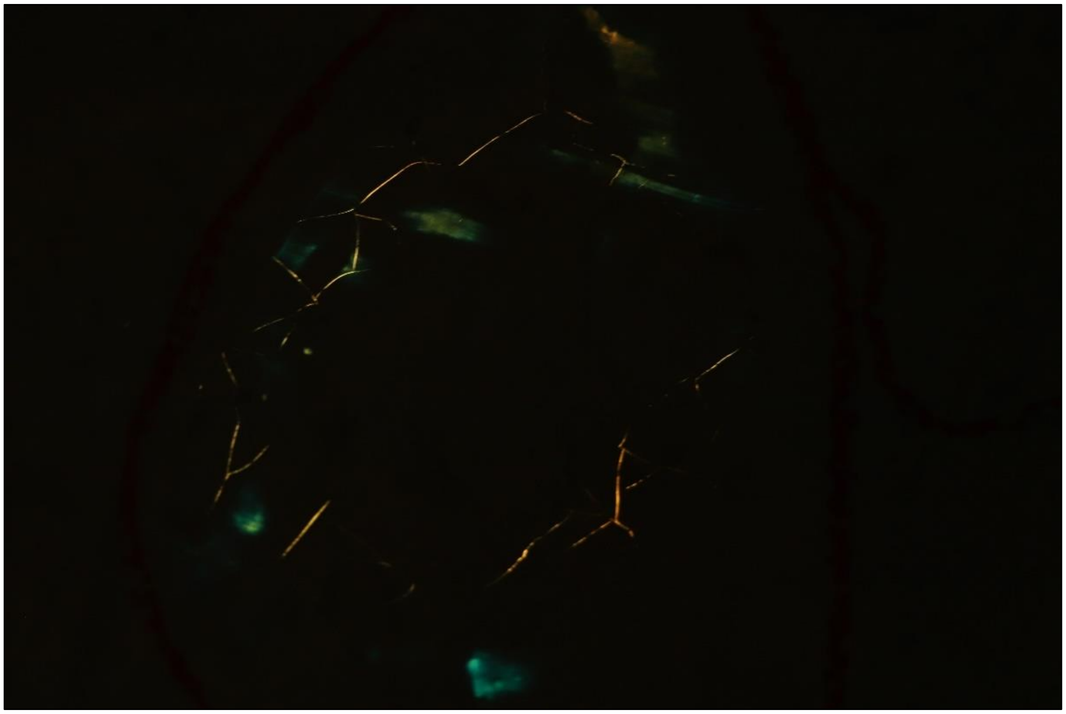

**Figure 26** Cracking exposed by backlighting sample A3.

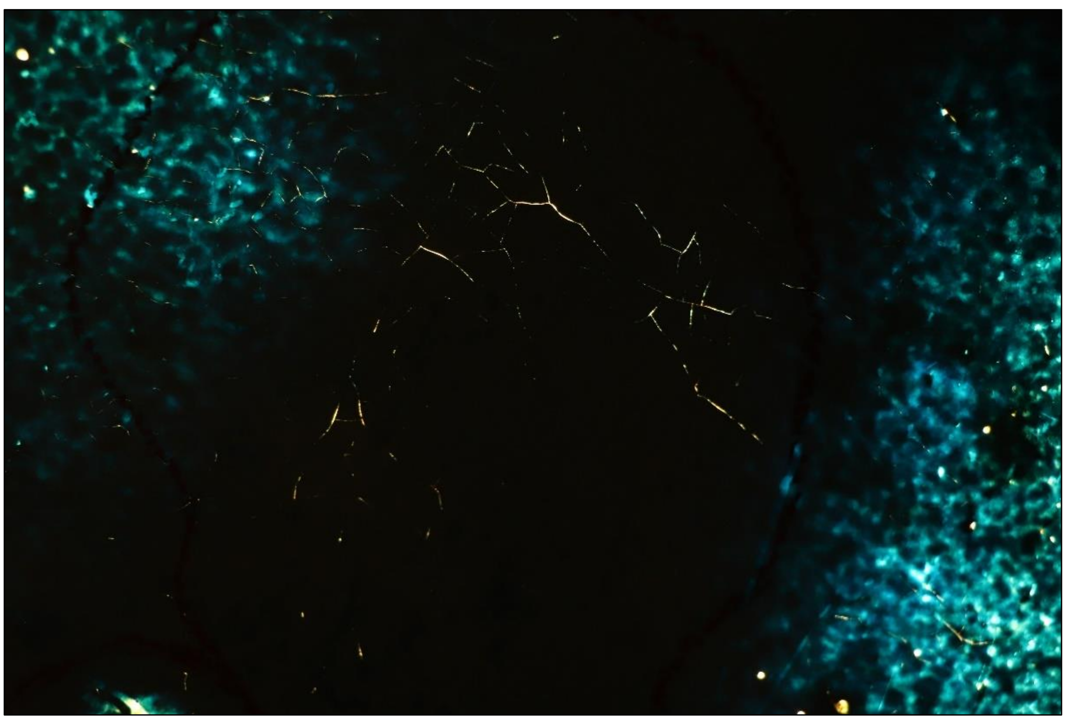

**Figure 27** Cracking exposed by backlighting sample A4.

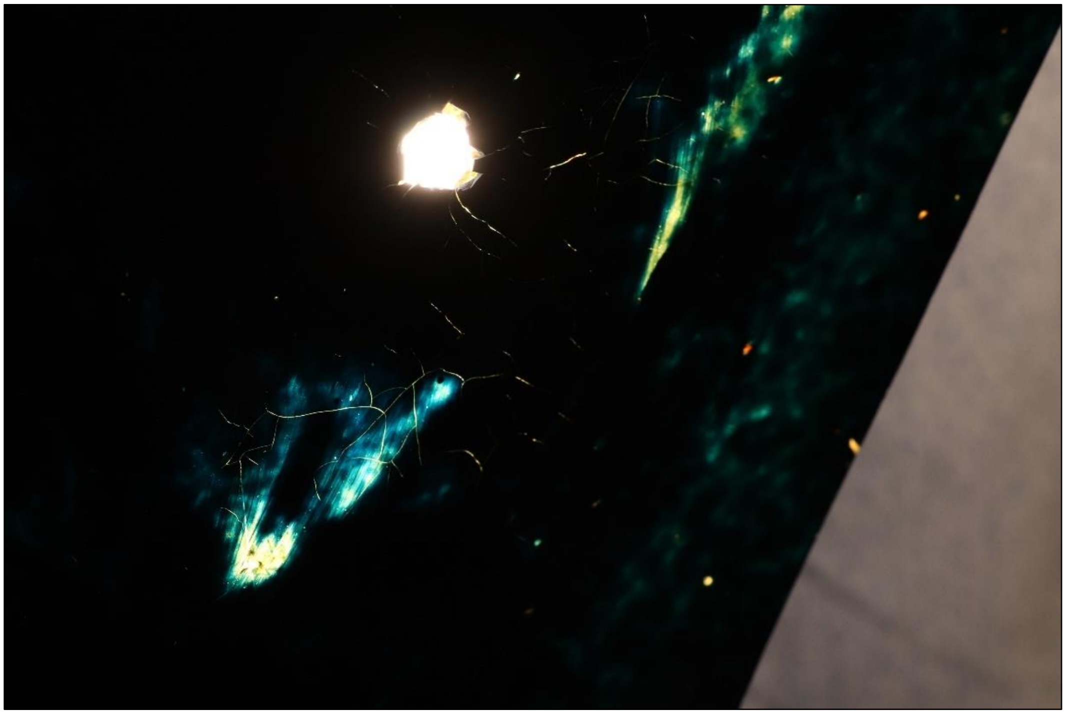

**Figure 28** Cracking exposed by backlighting sample A5.

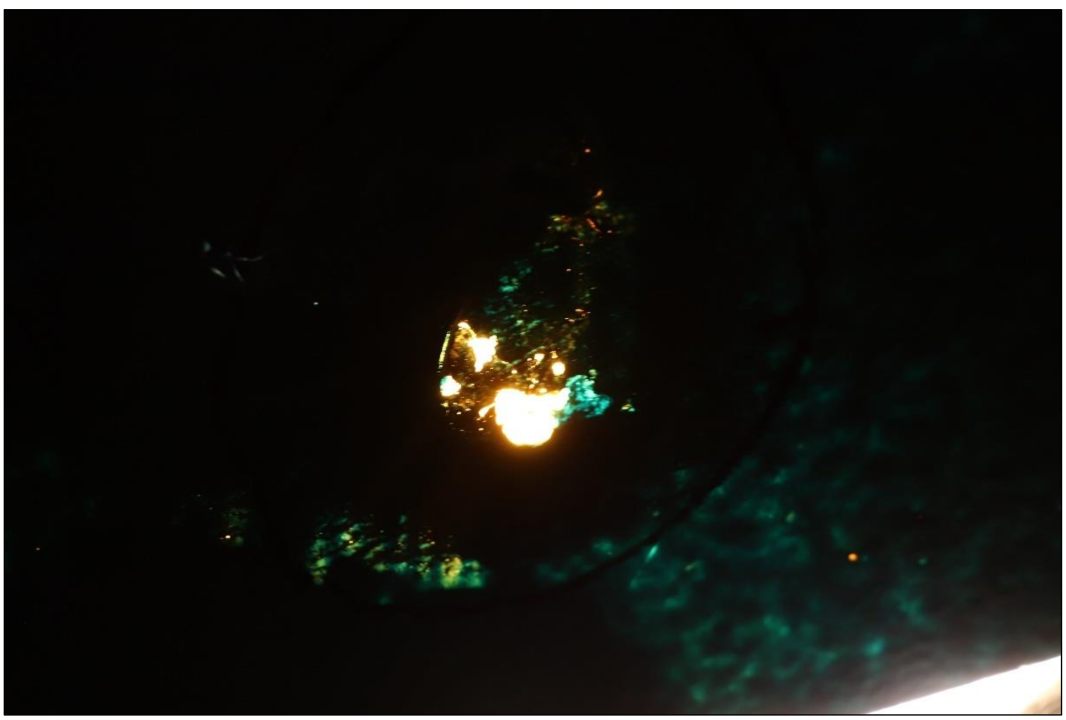

**Figure 29** Weak thin area exposed by backlighting sample B1.

**Figure 30** Cracking and weak areas exposed by backlighting sample B2.

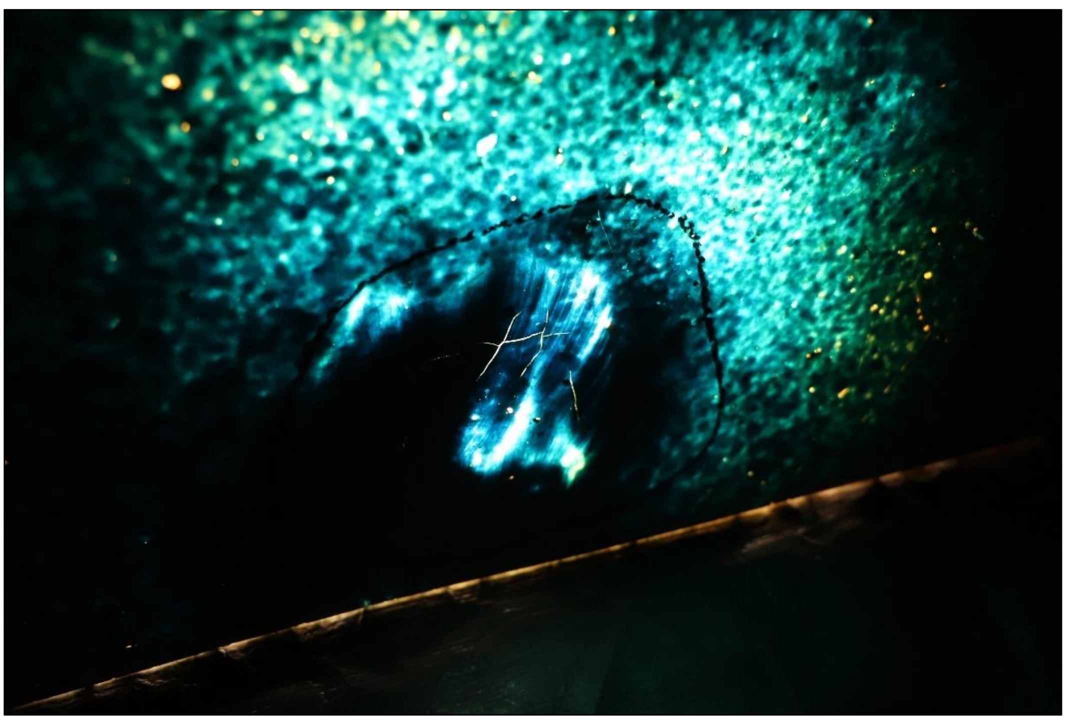

**Figure 31** Cracking and weak areas exposed by backlighting sample B3.

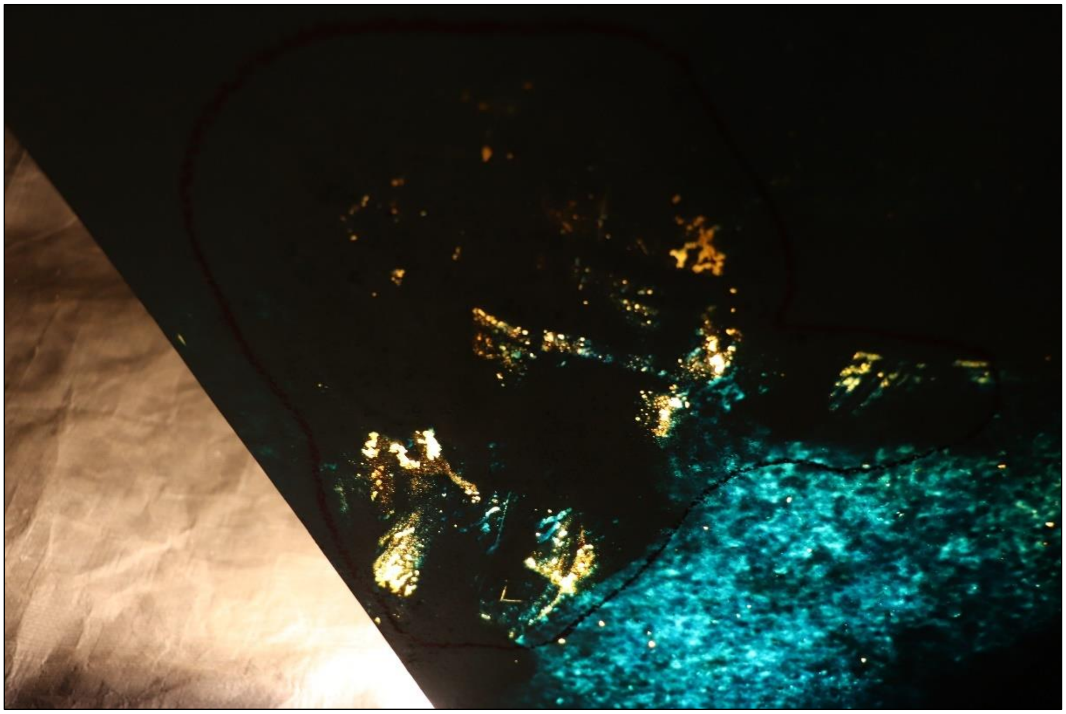

**Figure 32** Weak areas exposed by backlighting sample B4.

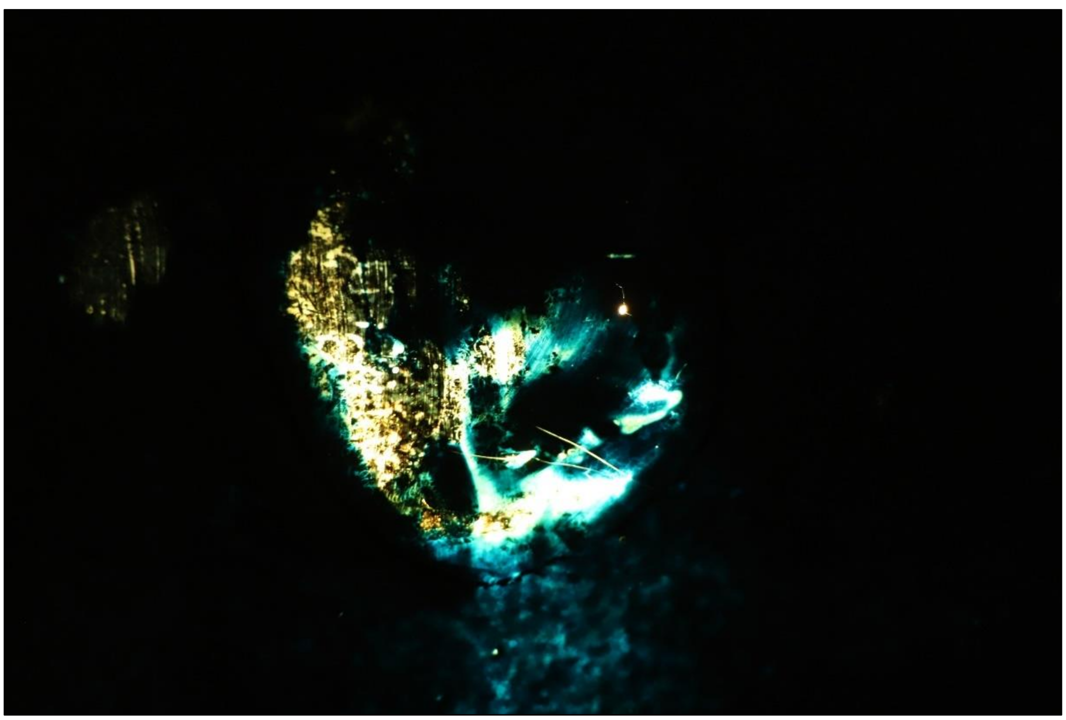

**Figure 33** Cracking and weak areas exposed by backlighting sample C1.

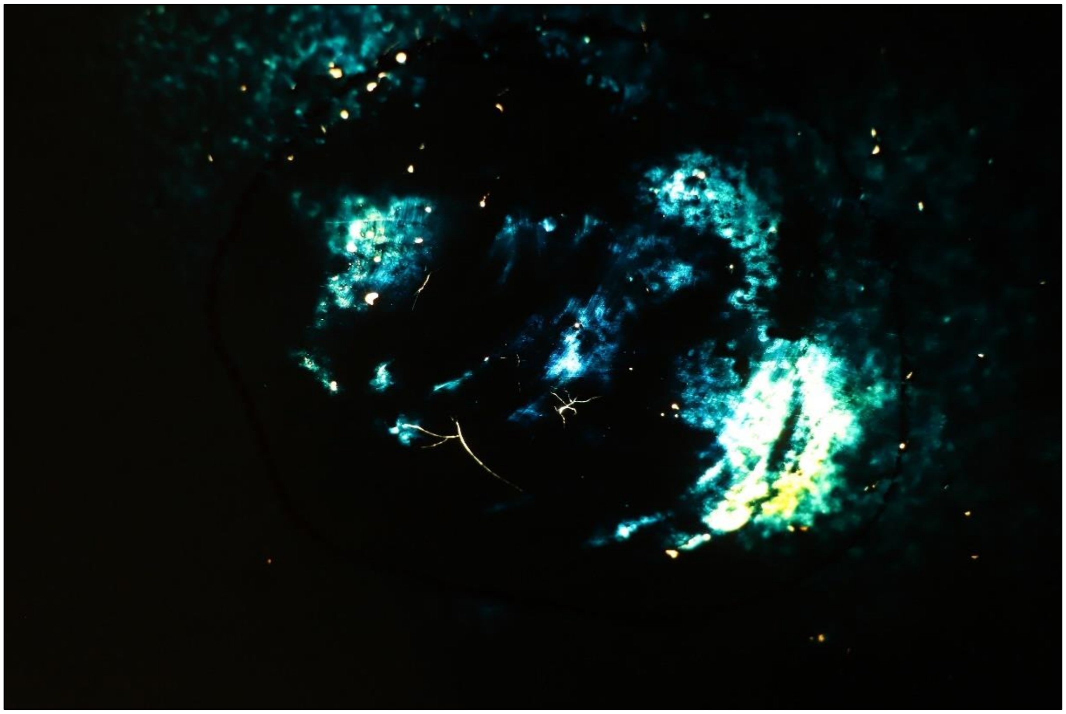

**Figure 34** Cracking and weak areas exposed by backlighting sample C2.

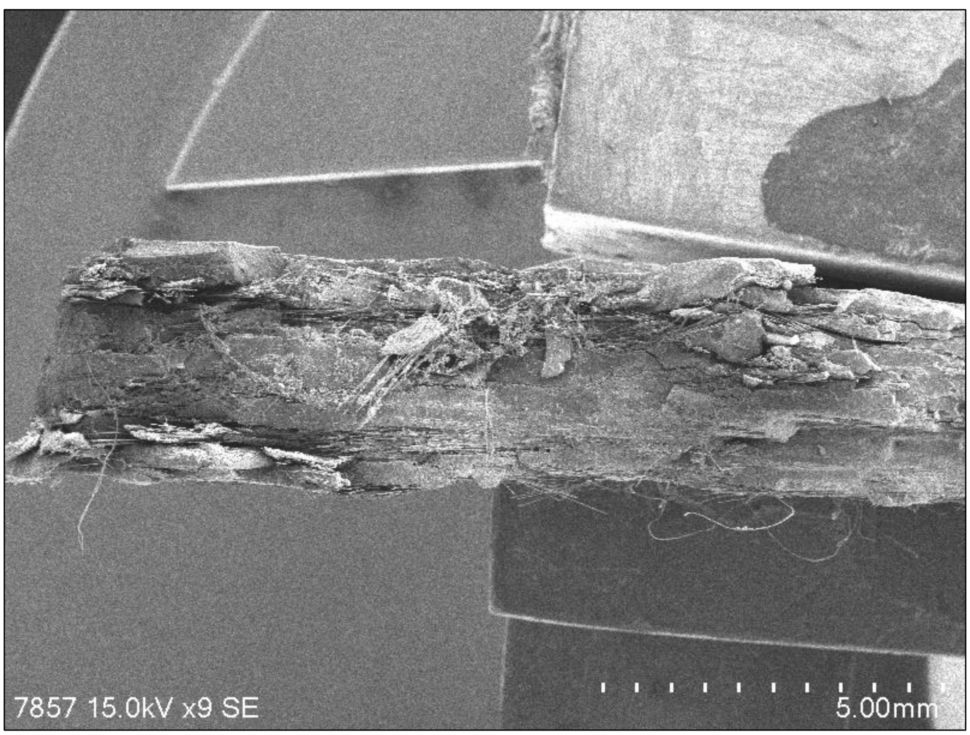


**Figure 35** SEM view of sample I left edge of sample.

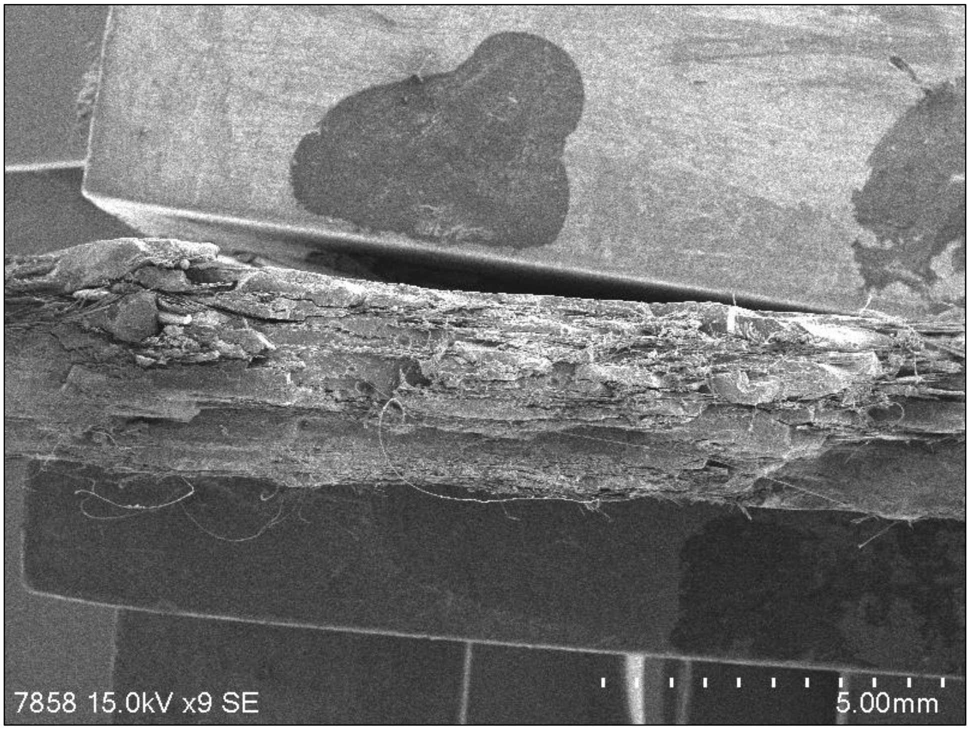


**Figure 36** SEM view of sample I left edge center of sample.

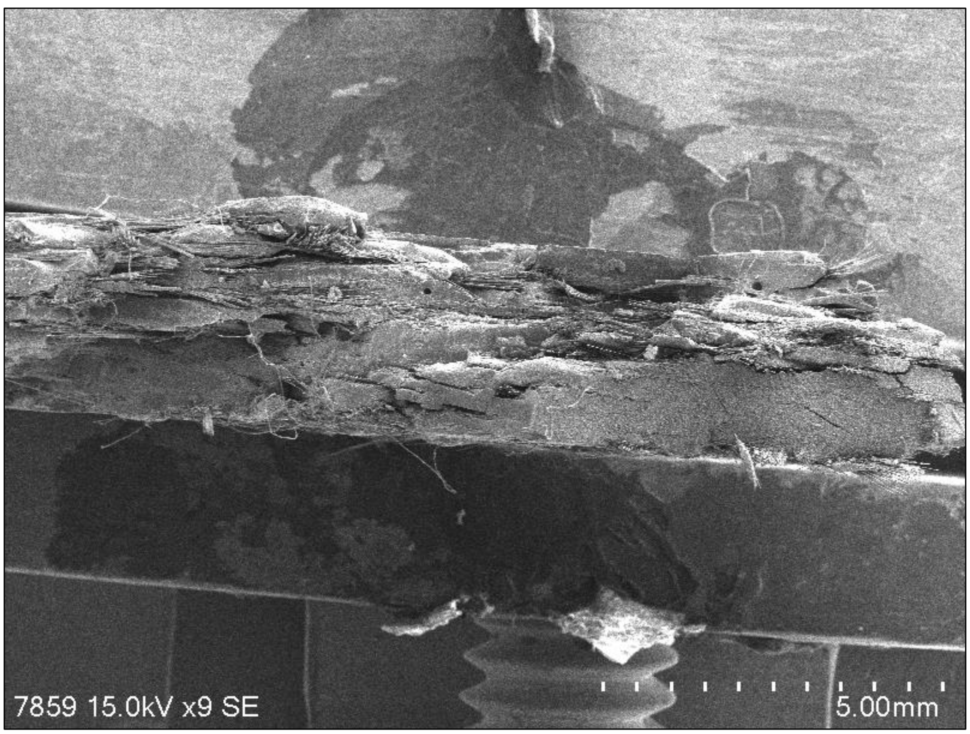


**Figure 37** SEM view of sample I right edge.

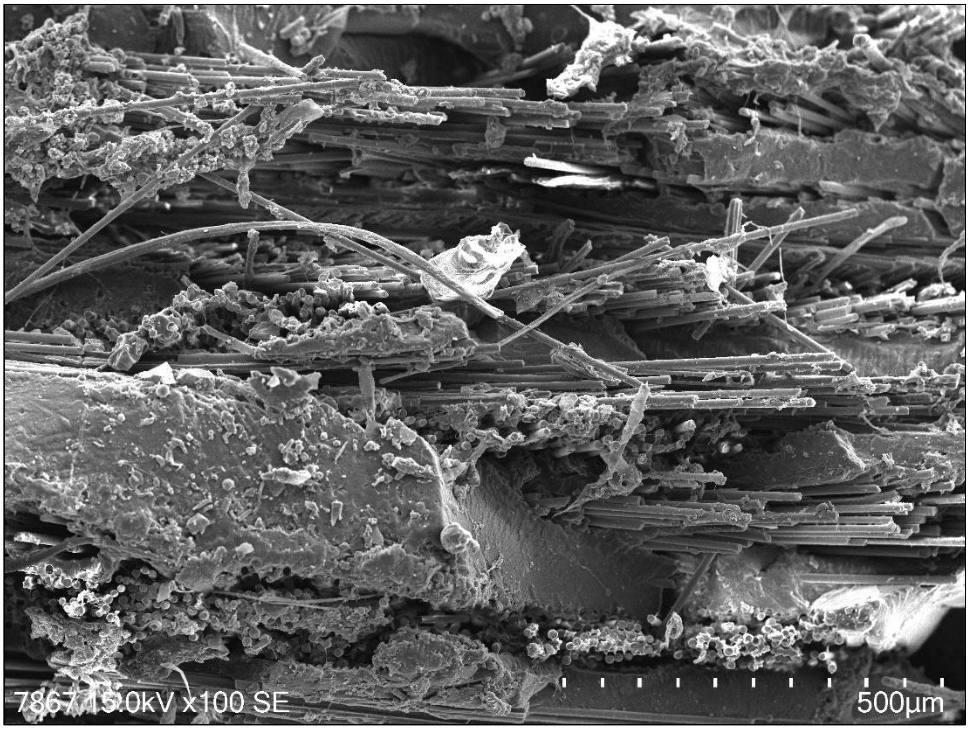


**Figure 38** SEM view of clean longitudinal fibres in area of fracture.

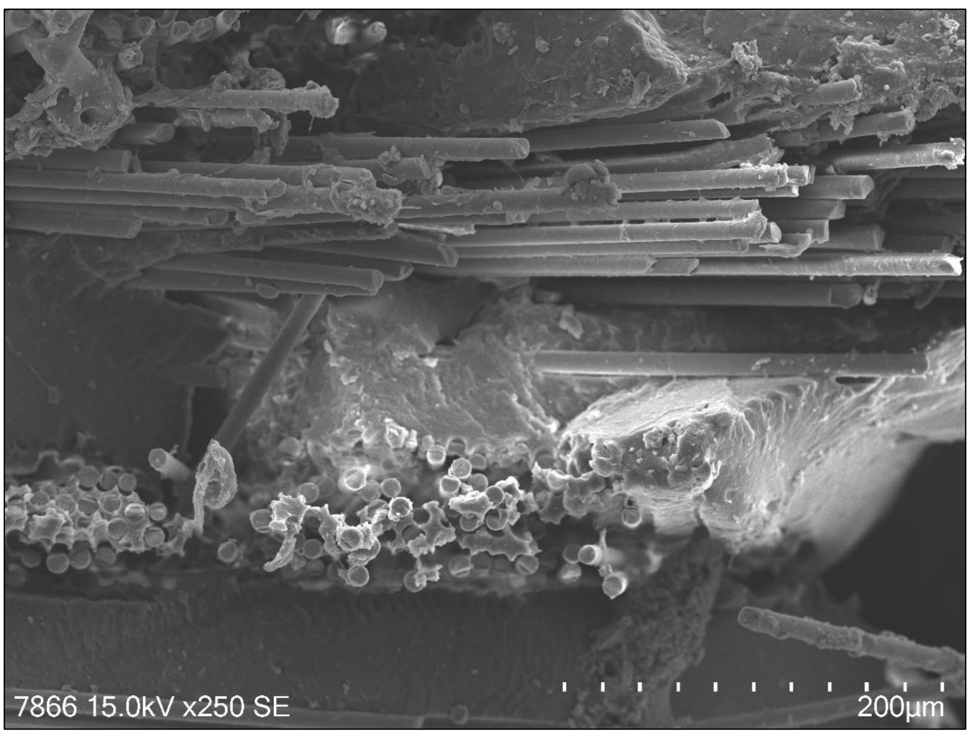


**Figure 39** SEM view of clean longitudinal fibres with no bonding to resin.

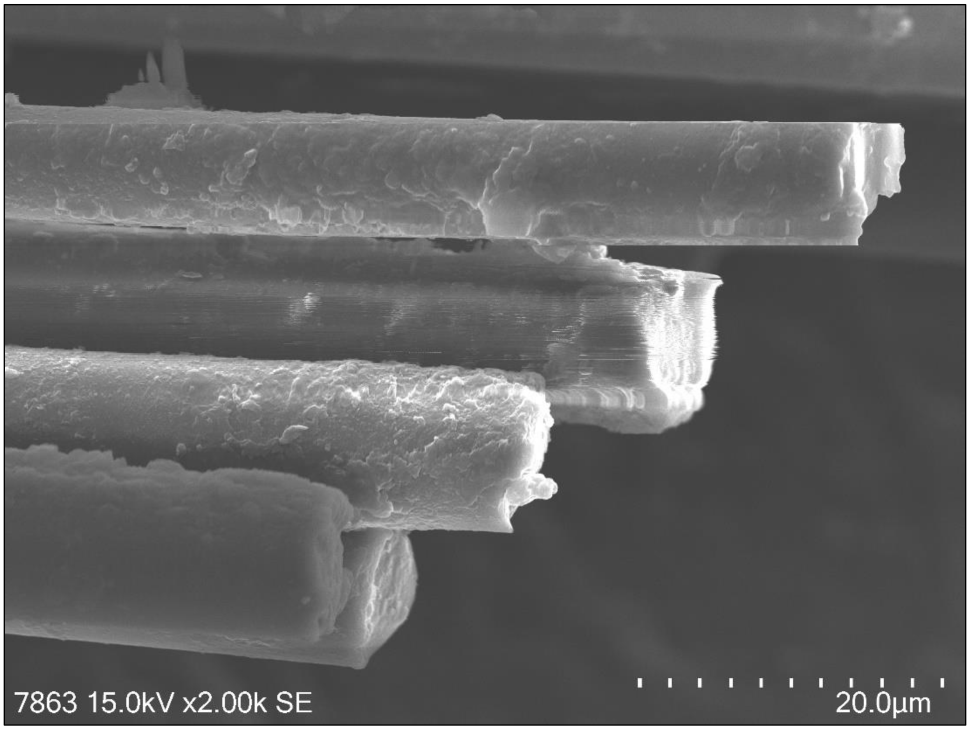


**Figure 40** Higher magnification SEM view of clean longitudinal fibres with no bonding to resin.

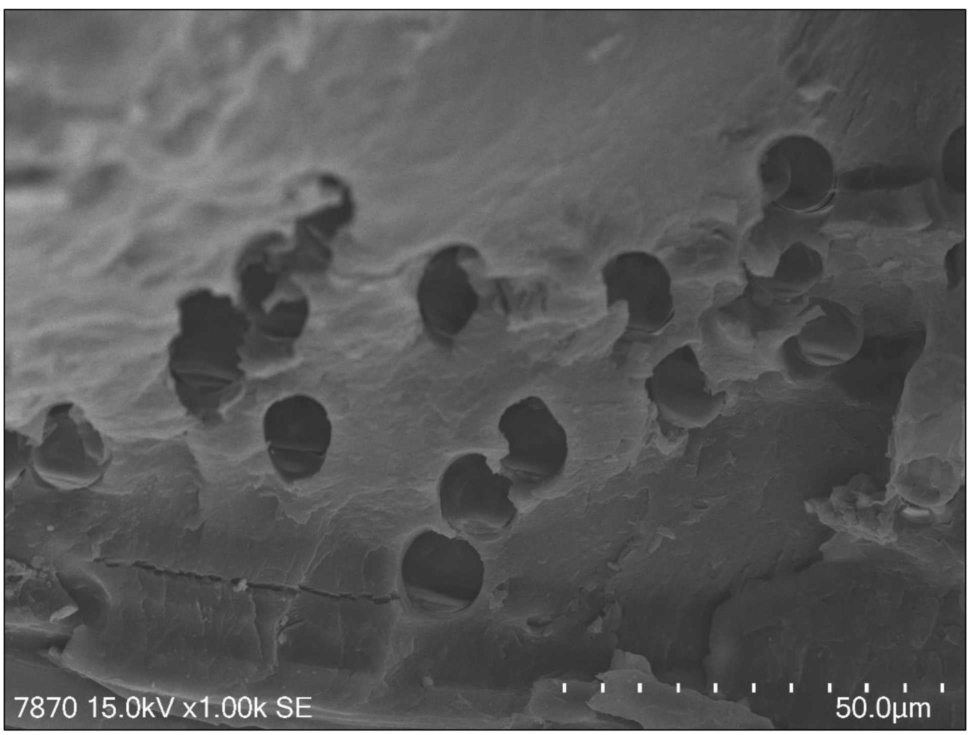


**Figure 41** Fatigue cracking in fracture zone. Note no extension of fibres.

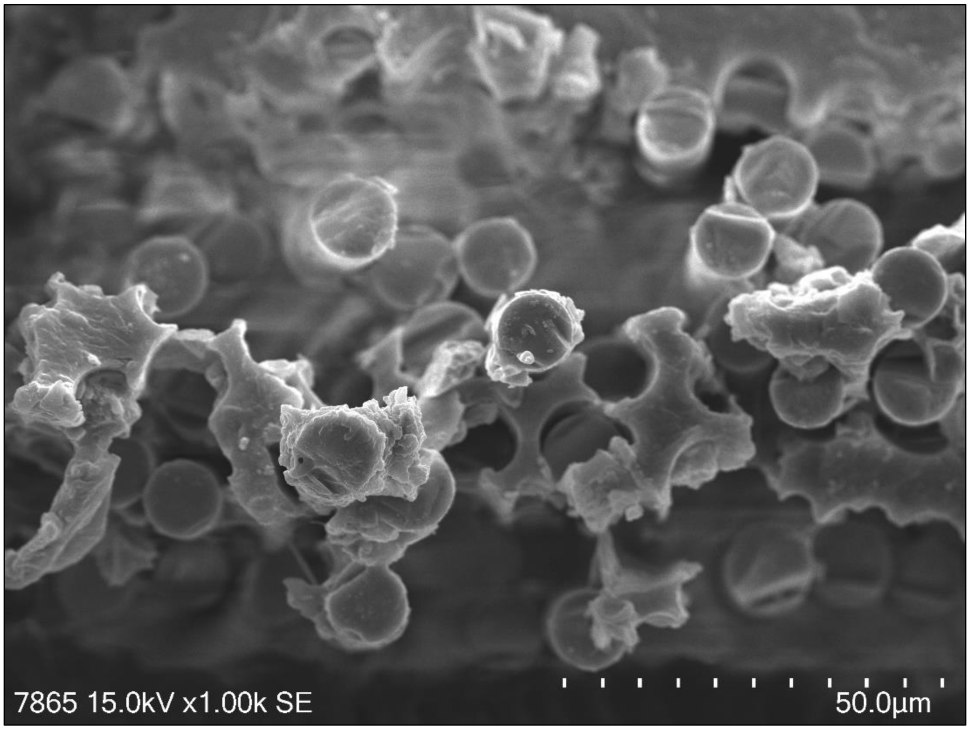


**Figure 42** Brittle fracture where fibres are pulled straight out of matrix.

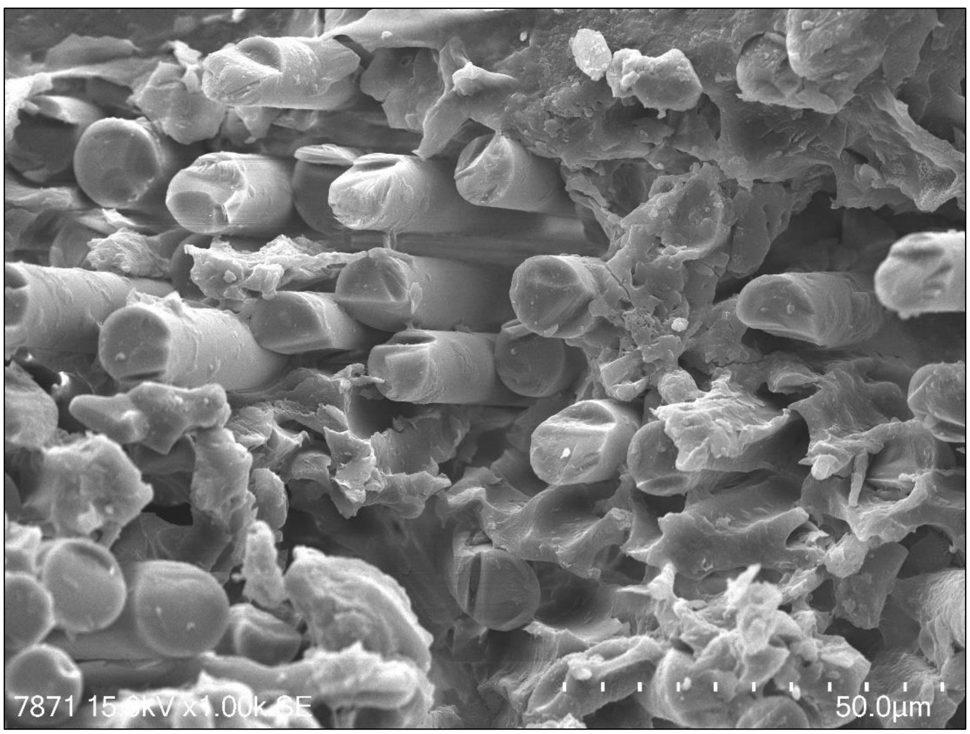


**Figure 43** Brittle fracture where fibres are pulled straight out of matrix.

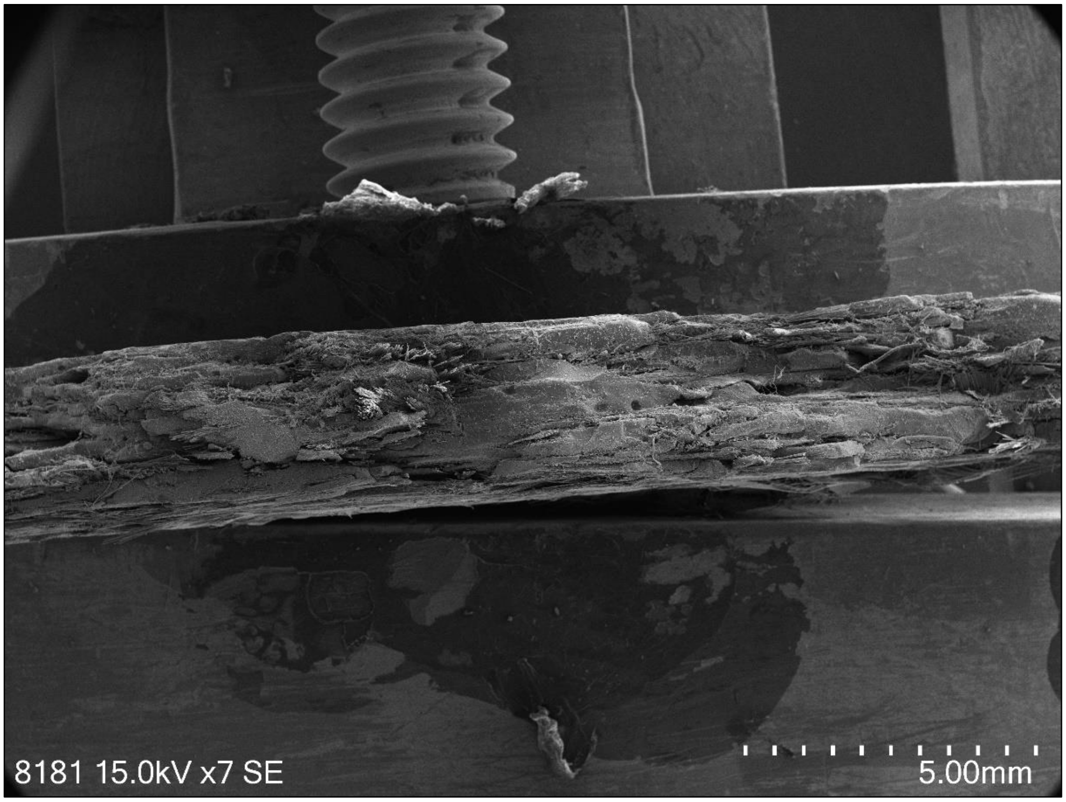


**Figure 44** Inner fibreglass sheet fracture from sample "H" at low magnification

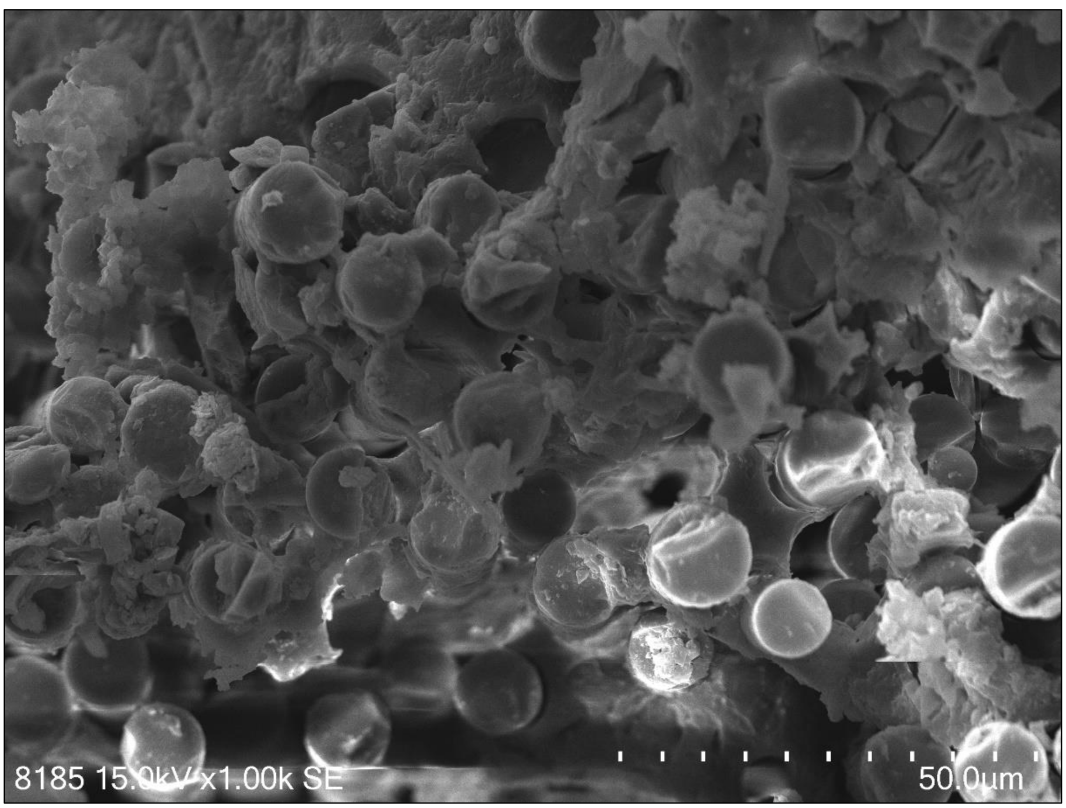


**Figure 45** Fatigue area on inner sheet fracture with resin well bonded.

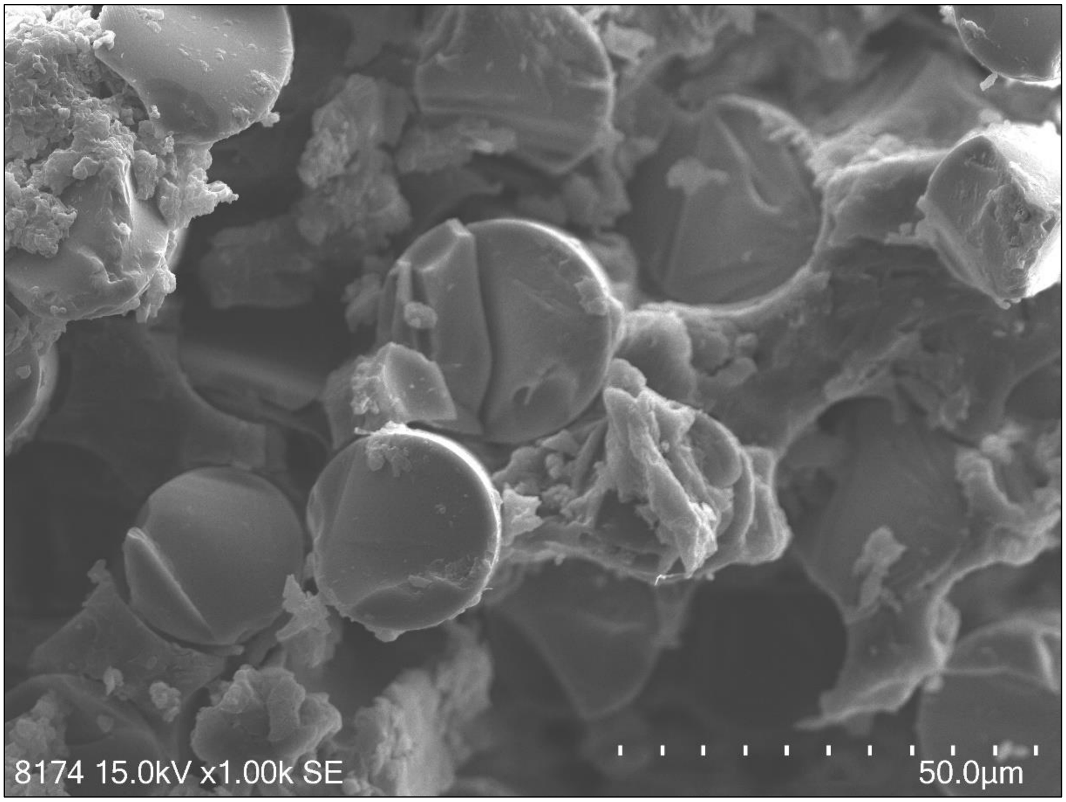


**Figure 46** Closer view of fatigue area showing short fibres and well bonded resin.

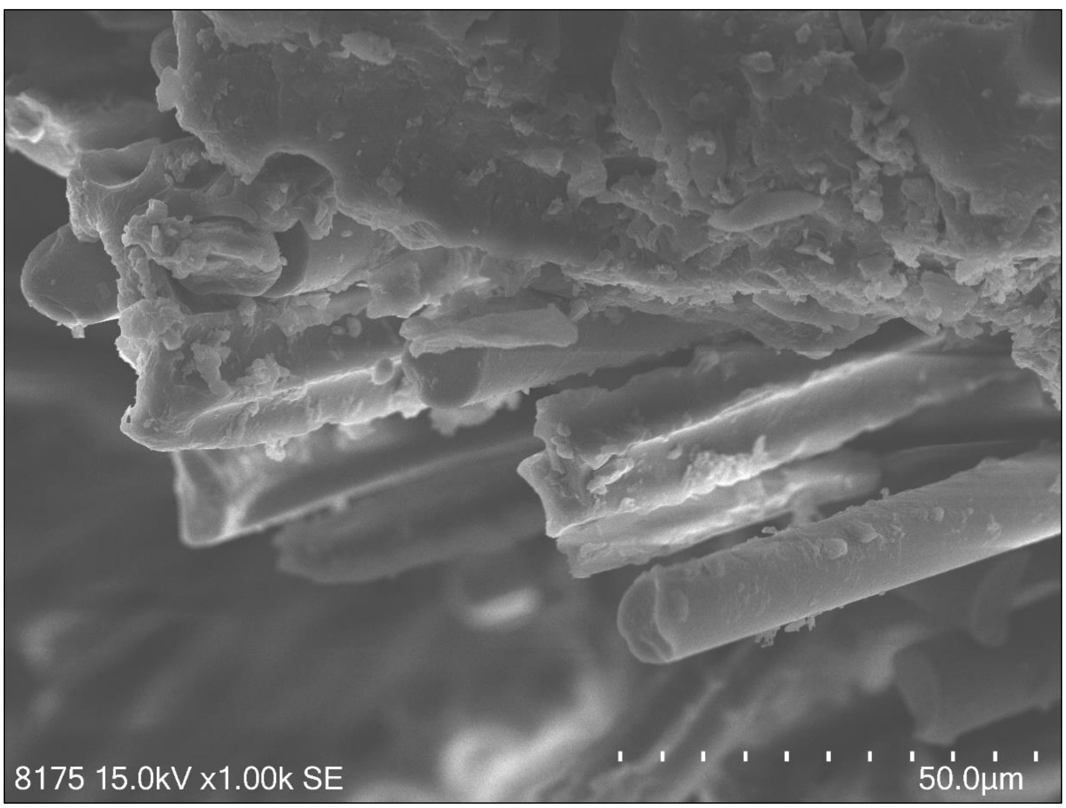


**Figure 47** Area of brittle fracture showing long fibres and lack of resin near fracture.