IN SITU SCANNING ELECTRON MICROSCOPE OBSERVATIONS OF FLEXURAL FAILURE OF ASBESTOS CEMENT

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The strengthening effect of the addition of asbestos fibres to ordinary Portland cement (O.P.C.), and the failure mechanisms of such a composite has proved to be a complex situation to describe despite various models for fibre reinforced materials (1). This paper concerns a microscopic study of four point flexural loading of asbestos cement specimens in the specimen chamber of a Cambridge S180 Stereo Scanning Electron Microscope.

Specimens were prepared using Rhodesian Crysotile asbestos and O.P.C. in a fiberized asbestos cement ratio of 0,1. After curing for 28 days at 22°C and relative humidity of 80%, specimens (of dimensions 42 x 4 x 1,2mm) were cut and polished from the large samples and dried under high vaccuum and using P_2O_5 as a dessicant. Specimens were prepared for the Microscope by depositing a layer of carbon and then a layer of 60/40 gold palladium approx. 100Å thick on the relevant surfaces. In an effort to minimise the effects of charging when the specimens were fractured and uncoated surfaces exposed to the electron beam, copper leads were connected from the specimen to earth. The symmetric four point loading rig used provided a region of constant bending moment within which the fracture occurred yet without the restriction of crack predetermination which would be the case in three point bending (2). The middle third was scanned at high magnification (x 1000) in order to detect the first occurrence of micro-cracking. Because of the discontinuous nature of the small 3 micron microcracking (see fig. 1), it seems plausible to suggest that a fibre bundle acts as a crack arrestor with subsequent microcrack failure of similar dimensions at the end of the fibre bundle (arrow A). This so-called "pullout" is shown in fig. 2, arrow B marking the hole left by the fibre, which is typically 25 - 30 microns in diameter. Failure also occurs by fracture of the fibre bundle itself, figs. 3,4, when the failure strength of the bundle is of the same order as the bond and appears to depend on the fibre bundle diameter (typically <10 microns). Fig. 5 illustrates pullout of a surface fibre bundle where, because of the reduced bonding surface fibre pullout even at this low diameter (6μ) is energetically preferable to fibre fracture.

Although the investigations have so far been of a preliminary nature, it would appear that the strength of an asbestos cement composite is a function of the degree of fiberization (optimum bundle size) and on fibre:cement ratio. This scanning electron microscope technique of achieving cracking in asbestos cement promises to be a useful tool in the understanding of fracture in this material.

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References

1. Naaman, A.E., Argon, A.S. and Moavenzadeh, F., 1973, Cement and Concrete Research, 3, 397.
2. Hammant, B., December 1971, Composites, 246.

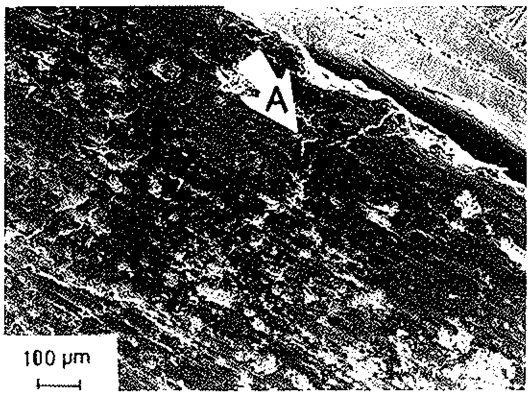

Fig 1

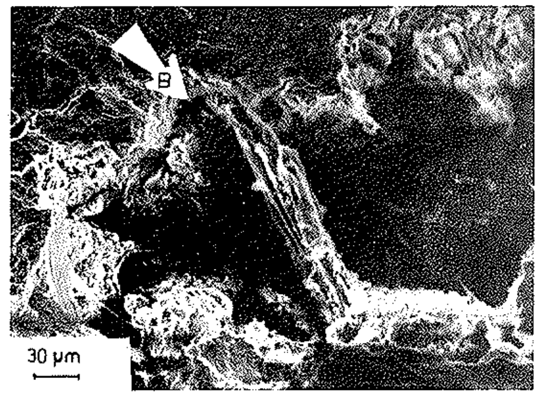

Fig 2

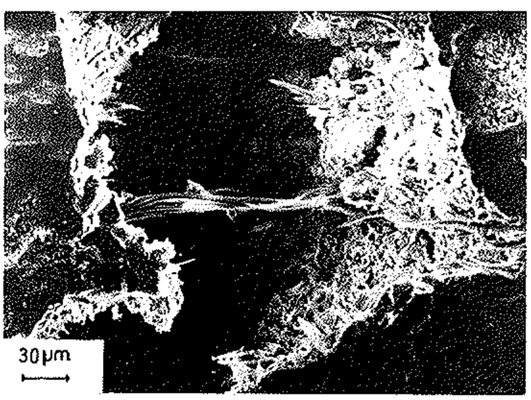

Fig 3

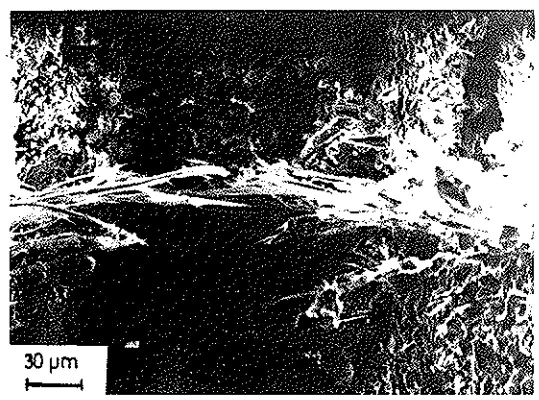

Fig 4

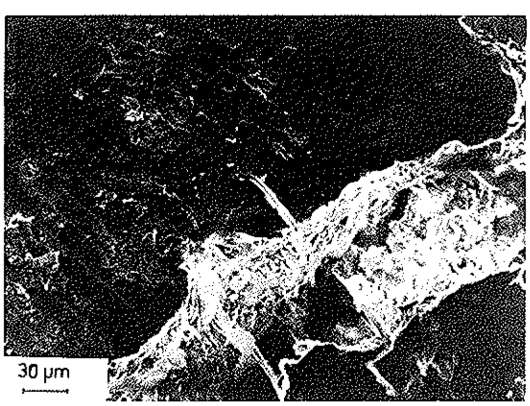

Fig 5

Fig. 1 - Initial Microcracking.

Fig. 2 - Fibre bundle pulled out of the cement matrix.

Figs. 3 & 4 - Fibre bundle breaking at the centre of the matrix.

Fig. 5 - Fibre bundle "pullout" at the surface of the specimen.