Introduction

In accordance with the instructions contained in your Purchase Order 376/1057, we have undertaken examination of two failed rope samples.

This report describes the methods of examination, presents the results and provides a discussion on the most likely causes of failure.

Details of Samples

Two samples of synthetic ropes were received from yourselves on 3rd July 2006. The samples were 12mm diameter braided climbing ropes, 390mm and 420mm in length. The ropes which were given our laboratory reference numbers EP3042 and EP 3043 were noted to have partially failed over a central portion of their lengths. In the case of sample EP3042 the affected length of rope was 35mm whilst in the case of sample EP3043 the affected length was 45mm.

Sample EP3043 was observed to have a small label within the failed area of the rope. This label which was marked "MAMMUT AG EN 1891 A 2002" appeared to be part of the rope construction since its ends appeared to be embedded within the rope strands below the surface layers.

Both rope samples were noted to comprise of coloured strands, namely white and dark brown with the majority of the strands being white. The brown strands are probably for colour coding since they are contained within the outer strand layers only.

Examination

The rope samples were examined visually and also with the aid of a binocular microscope up to a magnification of x50.

The results of the examination indicated that the amount of damage on sample EP3043 was markedly greater than that on sample EP3042, such that a significant number of the strands appeared to have failed. Furthermore, discolouration of the brown strands within the affected areas appeared to have taken place on both samples. No obvious discolouration of the brown strands adjacent to the affected areas was noted.

The binocular microscope examination indicated that a significant number of the fibres had undergone some form of degradation resulting of what appeared to be a brittle type failure. These particular fibres did not appear to have failed due to mechanical damage such as rubbing against a sharp metallic object, but they were probably weakened due to embrittlement resulting from an attacking agent.

Examination of the remaining length of the rope samples outside the affected areas did not display any significant signs of damage apart from fraying of the surface fibres due to normal use. In this respect, sample EP3042 was considered to be in better condition than sample EP3043.

Scanning Electron Microscope Analysis

Small fibre specimens were removed from both samples, these included fibres from the affected and intact areas of the rope. The intact fibres were cut from one of the free ends of sample EP3043.

The specimens were then mounted on sample holders, coated with a thin layer of gold using vacuum sputtering technique and then offered to the vacuum chamber of a Scanning Electron Microscope (SEM).

The specimens were analysed using an Energy Dispersive X-ray Analysis system (EDXA).

The analysis indicated that the fractured ends of the fibres had been degraded which had resulted in cracking of the fibre material, with some of these cracks extending as much as 90 microns from the fracture.

The analysis also showed that the average fibre diameter was 31 microns and some of the affected fibres had a diameter of approximately 42 microns adjacent to the failed top.

A significant number of fibres were observed to have surface deposits, however, there was no apparent alteration to the fibre material at or adjacent to these fibres suggesting they had not contributed to the failure.

The EDXA analysis revealed that:

i) The affected fibres from the damaged areas composed of a significant amount of sulphur (S) with small amounts of Iron (Fe) and trace amounts of Aluminium (Al), Silicon (Si) and Chlorine (Cl).

ii) The fibres from an area remote from the damaged section contained large amounts of Sulphur (S) with trace amounts of Aluminium (Al), Silicon (Si), Chlorine (Cl) and Iron (Fe).

iii) The tips of the failed fibres comprised of a large amount of Sulphur (S), a significant amount of Aluminium (Al) and smaller amounts of Chlorine (Cl), Potassium (K), Calcium (Ca) and Iron (Fe).

The results therefore suggest that the rope material is probably a polymeric material having significant amounts of Sulphur (S) with smaller amounts of Silicon (Si), Chlorine)Cl) and Iron (Fe).

It has not been possible to determine the likely cause of the measured level of Aluminium (Al) at the tips of the failed fibres.

Conclusions

a. The rope samples were observed to have failed in localised areas covering approximately 35mm and 45mm length of the ropes.

b. The observed damage was in the form of fracture of whole strands of fibres and discolouration of the brown coloured fibres within the affected areas. No discolouration of the fibres could be observed outside the failure regions.

c. The binocular microscope and Scanning Electron Microscope examination revealed that some of the failed fibres had been subjected to physical degradation causing embrittlement and development of cracks adjacent to the fractured ends.

Fibres remote from the failure regions did not exhibit any obvious signs of degradation.

d. The EDXA analysis indicated that no significant chemical alteration had taken place in the fibres of the affected areas apart from an obvious increase in the level of Aluminium at the fracture tips.

e. The above would therefore suggest that the most likely cause of failure of the ropes is contact with an attacking agent such as a volatile solvent that resulted in loss of flexibility, development of cracks and ultimately failure which could have occurred whilst the ropes were under tension. No clear evidence of the attacking medium could be detected.

The discolouration of the brown fibres is also another indication that the ropes in the affected areas had probably been in contact with an attacking agent.

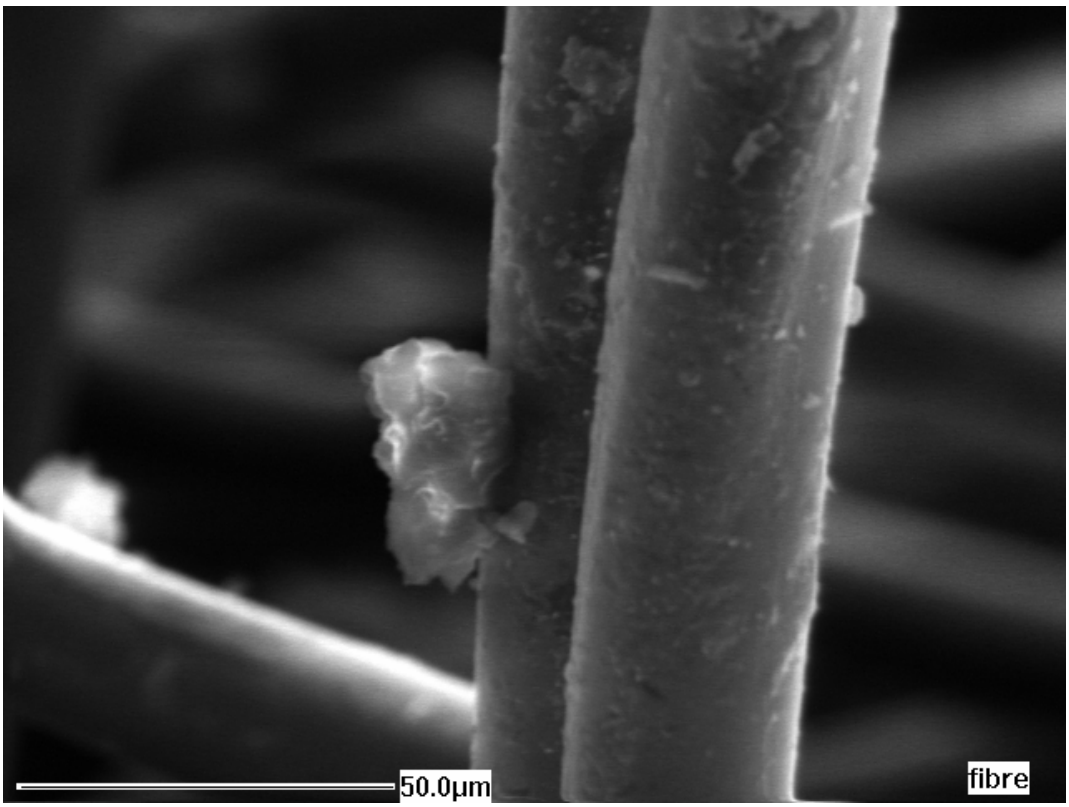

Plate 5
Showing a deposit on the surface of one fibre

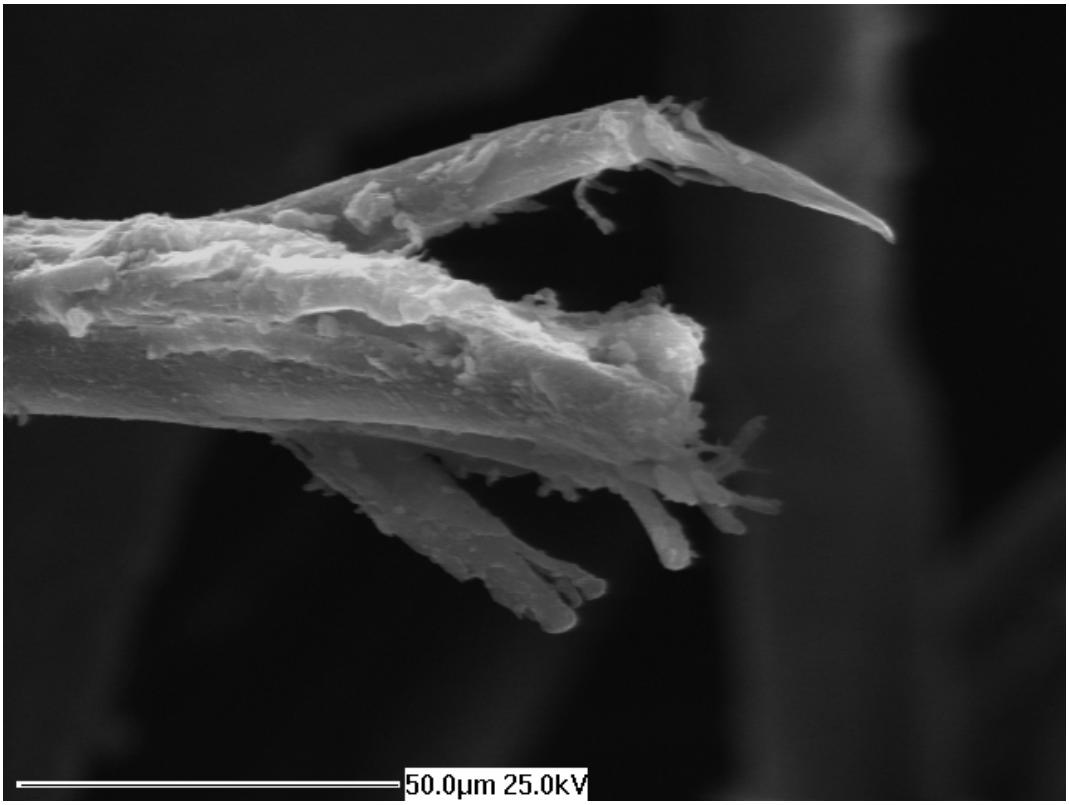

Plate 6
Illustrates the degradation of the fibre material close to the failed end