No. 95-017

Robinson R22 Beta

ZK-HKM

2 km North-East of Opotiki

25 October 1995

Abstract

On Wednesday 25 October 1995 at 0915 hours ZK-HKM, a Robinson R22 helicopter, broke up in flight and fell to the ground hitting State Highway 35 to the north-east of Opotiki. The pilot and a shooter died in the accident. The cause of the accident was the failure of a tail rotor blade on which an unauthorised repair had been carried out. The safety issues identified include the need to positively establish the history of critical components fitted to certificated aircraft, or to have the components supplied through approved distributors.

Transport Accident Investigation Commission

Aircraft Accident Report No. 95-017

Aircraft type, serial number and registration:	Robinson R22 Beta, 1252, ZK-HKM
Number and type of engines:	One Lycoming 0-320-B2C
Year of manufacture:	1990
Date and time:	25 October 1995, 0915 hours*
Location:	2 km north-east of Opotiki Latitude: 37° 59.6′ S Longitude: 177° 18′ E
Type of flight:	Aerial work, venison recovery
Persons on board:	Crew: 2 (Pilot and Shooter)
Injuries:	Crew: 2 Fatal
Nature of damage:	Helicopter destroyed
Pilot-in-Command's licence:	Commercial Pilot Licence, (Helicopter)
Pilot-in-Command's age:	27
Pilot-in-Command's total flying experience:	704 hours 617 hours on type
Information sources:	Transport Accident Investigation Commission field investigation
Investigator in Charge:	Mr K A Mathews

* All times in this report are in NZDT (UTC + 13 hours).

1. Factual Information

1.1 On Wednesday 25 October 1995 between 0530 hours and 0545 hours ZK-HKM, a Robinson R22 Beta, departed from Opotiki for the Ruakokore area some 65 km to the north-east. The helicopter was being used for venison recovery work and on board were the pilot and a shooter.

1.2 A truck driver who worked for the pilot and the shooter reported that the pilot had completed a pre-flight inspection of ZK-HKM before it departed from Opotiki. After the helicopter departed, the driver drove a truck to a pre-arranged location near the Ruakokore Bridge to meet up again with the helicopter. He arrived before ZK-HKM as the pilot and shooter had been hunting deer en-route to the location.

1.3 Five deer that had been shot the previous evening and stored in the area were carried on a sling under ZK-HKM to the waiting truck. This was completed in two loads, one with two deer and the other with three deer.

1.4 The pilot landed the helicopter and shut it down. The pilot, the shooter and the driver then had morning tea together. The driver said that after morning tea the helicopter was refuelled almost to capacity and the pilot completed a walk around inspection of it. A small oil leak was noticed around the engine by the pilot and he commented on this to the others. The driver observed the leak and said it was only a little "drip" or "blob" of oil. No other abnormalities or problems were mentioned to the driver by the pilot and the driver did not notice anything unusual with the helicopter.

1.5 The driver said he was instructed to return to Opotiki with the deer and the pilot and the shooter said they would see him there. The driver reported that he had placed a rope and chain used for slinging loads into the front of the helicopter's cabin and neither cabin door was fitted. The doors had been removed before departure and were stored at Opotiki. He said that apart from a rifle and some ammunition nothing else was loaded into the cabin. He reported that the helicopter sounded normal when it departed and that nothing was attached to its hook.

1.6 Witnesses observed the helicopter in cruise flight at a safe height several kilometres to the north-east of Opotiki, essentially following State Highway 35. A number of these witnesses saw the helicopter pass almost directly over them and they did not notice anything unusual with the helicopter.

1.7 A short time later the same witnesses reported hearing a loud "bang" and observed pieces flying off the helicopter. At the same time it was seen to pitch steeply nose down and fall onto the highway. Some witnesses thought they had heard two loud "bangs" and several of them believed the main rotor blades had stopped turning before the helicopter struck the ground. One witness who was about 500 m away at the time and was watching the helicopter fly directly towards him thought its engine was making a "putting" sound and that something was wrong with it. This was immediately followed by two loud "bangs" and then the pieces flying off the helicopter.

1.8 Several witnesses also said that following the "bang" or "bangs" the helicopter went "quiet" as though its engine had stopped. They said the helicopter did not spin and were certain that it had not struck a tree or another obstacle when it was flying. Nothing was seen to fly out of the helicopter before it broke up and nothing was observed attached to the helicopter's hook.

1.9 An intense fire erupted shortly after the helicopter struck the road and a number of the witnesses called the police and emergency services. No immediate assistance could be given to the occupants due to the fire and the ammunition that began exploding.

1.10 The accident was not survivable, and both occupants died on impact. The helicopter was destroyed.

1.11 The weather conditions at the time of the accident were reported by the witnesses to have been calm, clear, and warm, with no rain. The truck driver reported similar weather conditions.

1.12 Examination of the wreckage and the trail of debris showed that the helicopter had broken up in flight and that the main rotor blades were not rotating when it struck the road. The first piece of wreckage in the trail was a piece of tail rotor blade that had separated from its root fitting. It lay about 160 m from the main wreckage. This piece comprised the inner third of the blade and it had been cut through at an angle of approximately 45°, apparently by a main rotor blade.

1.13 The helicopter's complete empennage was the next piece found on the wreckage trail. It had broken at its attachment fitting to the tail boom and was located in the top of a tall tree. There was no evidence that the helicopter had struck this tree or any other object.

1.14 The outer two thirds of the separated tail rotor blade was found about 130 m from the main wreckage. Beyond this was a general line of helicopter debris, such as pieces of perspex, leading to the main wreckage. Located some 50 m from the main wreckage was the rear half of the helicopter's tail boom. This piece had been struck at about 45° on its left side by a main rotor blade and had separated from the forward part of the boom. The tail rotor gearbox which is normally fastened to the rear of the tail boom was not attached to it.

1.15 Located alongside the main wreckage was the separated tail rotor gearbox with the complete tail rotor hub assembly attached. One complete tail rotor blade and the root fitting for the separated tail rotor blade remained attached to the hub assembly. The root fitting had a row of four rivets on each side that helped secure the blade's aerofoil section to it. Around these rivets were torn pieces of metal that matched the tears in the metal on the separated inboard section of the blade.

1.16 The forward piece of the tail boom was located at the main wreckage but detached from the fuselage. It matched the piece of the boom found in the wreckage trail and it had a matching main rotor strike mark across it.

1.17 The main rotor blades were attached to the hub and mast, and the mast was intact. The main transmission turned freely and was anchored to its mounts. It did not show any evidence of pre-impact failure. The free wheeling unit worked correctly and both flexible couplings were intact. The drive to the tail rotor gearbox was intact except that the drive shaft had failed due to torsional overload at its coupling to the tail rotor gearbox. It showed evidence of having been struck by the main rotor. The tail rotor gearbox rotated freely and did not show any evidence of pre-impact failure.

1.18 A search along the wreckage trail, and a close inspection of the tail rotor blades and hub assembly, did not produce any evidence to indicate that an object other than a main rotor blade had struck the separated blade.

1.19 The rest of the helicopter was accounted for and nothing additional was found that might have contributed to the accident.

1.20 The empennage attachment fitting and the tail rotor blades and their root fittings were taken to Industrial Research Ltd for analysis. It was found that the empennage attachment fitting had failed in overload. However it was established that the separated tail rotor blade, serial number 5666C, had failed as a result of de-bonding at the adhesive to metal aerofoil interface. Once the de-bonding occurred the load was transferred to eight non-load bearing rivets. Despite the centrifugal and torsional loads induced during tail-rotor rotation the non-load bearing rivets evidently held the aerofoil to the root fitting for a period of time, but the aerofoil eventually cracked from the rivets as a result of environmentally assisted (corrosion) fatigue. Final overload of the remaining sound metal ligament occurred and the aerofoil separated from its root fitting.

1.21 Examination of the other tail rotor blade, serial number 5638C, from ZK-HKM, showed that a de-bonding of its adhesive had also occurred, in a similar manner to the failed blade. The adhesive down the trailing edge on both blades had also de-bonded and could be peeled off easily. This suggested that the trailing edges may have opened some time before the accident.

1.22 From consultation with the manufacturer and safety authorities it was determined that this type of failure had not occurred previously with this helicopter type.

1.23 Each tail rotor blade consisted of a root fitting, aerofoil section, tip cap and balance weights. A length of honeycomb material was bonded internally along the complete length of the aerofoil. The tip cap contained the balance weights and was bonded to the outer end of the aerofoil. The aerofoil was bonded together along its trailing edge and to the root fitting, and eight non-load bearing rivets helped secure the aerofoil to the root fitting. The rivets were not designed to carry the load of the aerofoil section. A data plate with the serial number and part number was secured to the arm of the root fitting, and the serial number was also mechanically etched to the tip cap. (See Figure 1.)

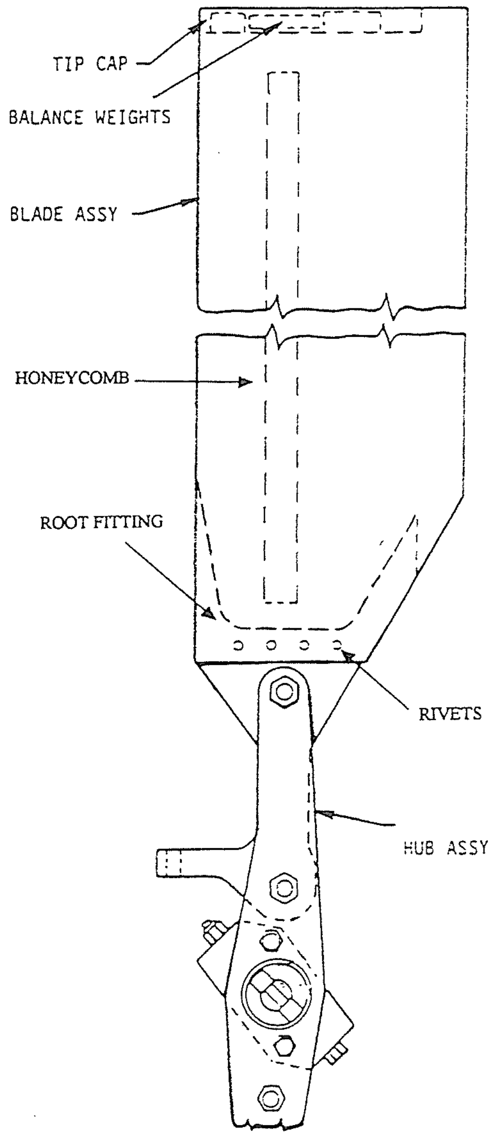

Figure 1
Tail Rotor Assembly

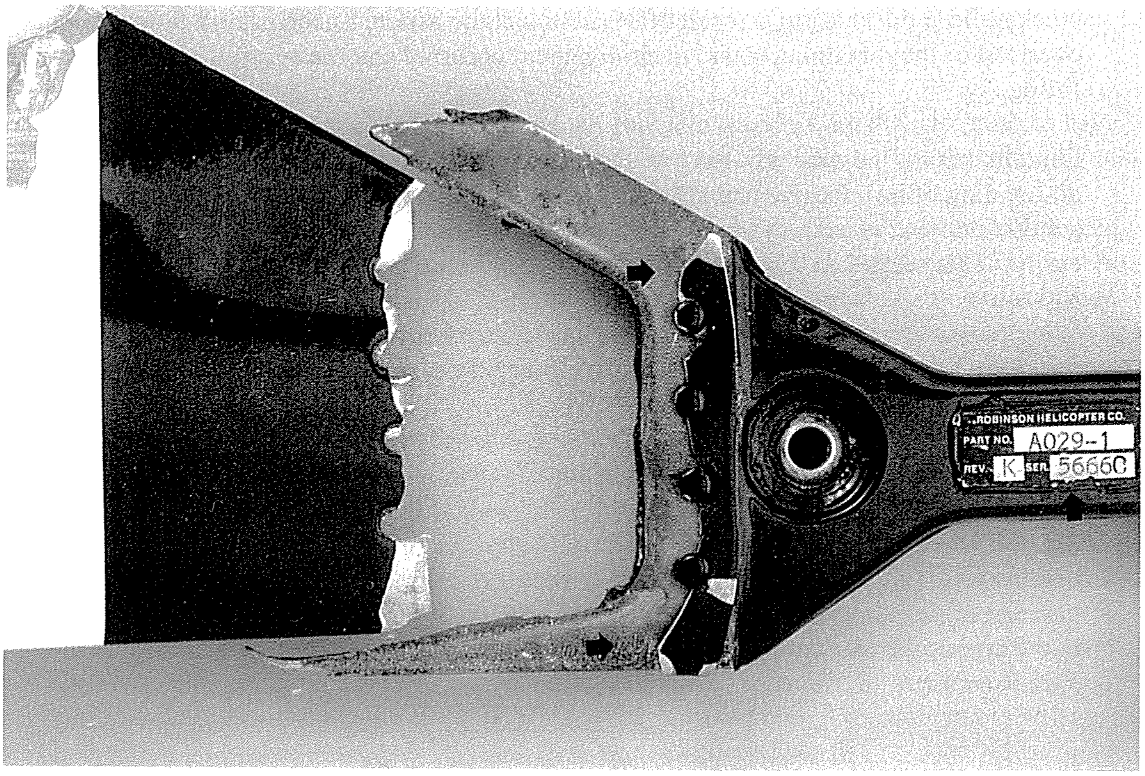

Figure 2a
The root fitting and detached aerofoil from blade 5666C.

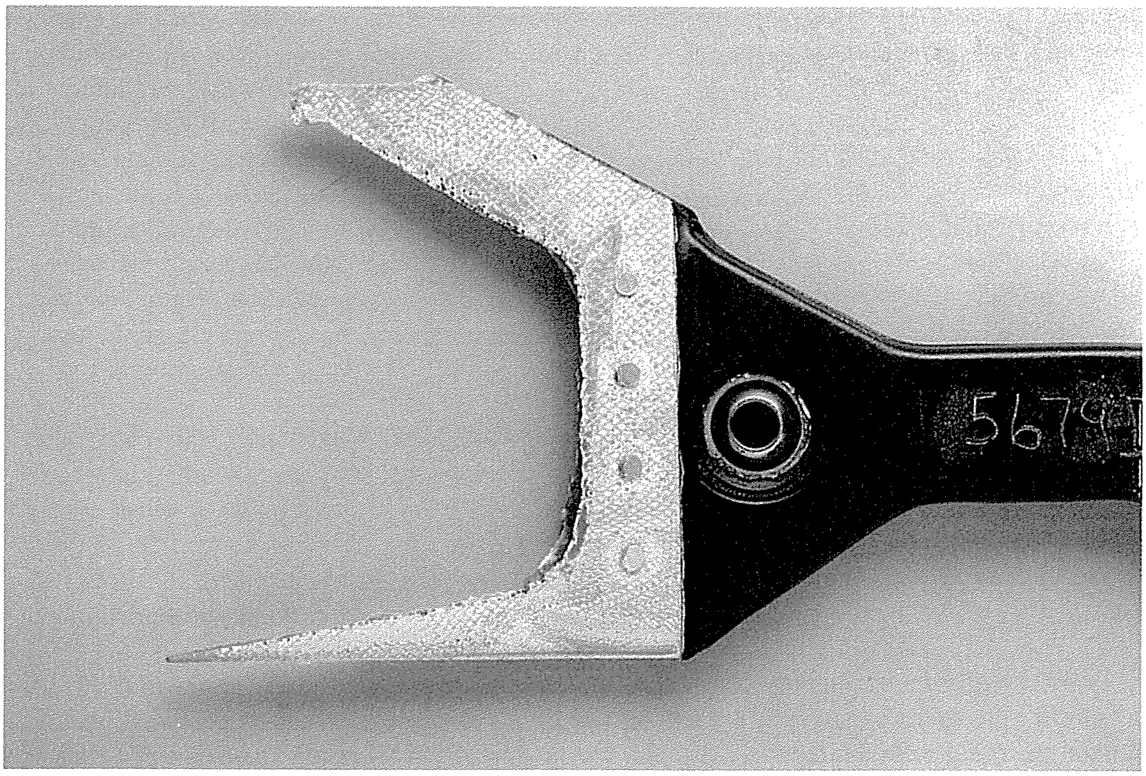

Figure 2b
The blade root from a sample blade, showing a light brown adhesive and knit carrier.

1.24 The helicopter manufacturer advised that during fabrication of R22 tail rotor blades the aerofoil, root fitting, and tip cap are etched and chromic acid anodized in accordance with a specific process. After the anodizing American Cyanamide BR127 primer is applied and baked on. Then the bonding is carried out using American Cyanamide FM73 adhesive which has a knit polyester carrier. The cured adhesive is "yellow to butterscotch brown" in colour and the manufacturer has never used any other type of adhesive in the manufacture of R22 tail rotor blades. After each blade is bonded the manufacturer carries out a pull test on a specimen coupon from each blade. The failed blade had this test carried out after it was manufactured and a satisfactory result was obtained.

1.25 Further examination of the failed tail rotor blade and the other blade from ZK-HKM, showed that a purple coloured adhesive had been used to bond the aerofoils along their trailing edges, honeycomb inserts, tip caps, and to the root fittings. The internal skins of the aerofoils had not been treated or prepared by any process and were bare metal. At the root fittings the purple coloured adhesive had been layered over and alongside a "yellow to butterscotch brown" coloured adhesive. There was no knit carrier present in the purple adhesive.

1.26 Two sample Robinson R22 tail rotor blades that had been removed from service were examined. One blade had been manufactured five days after the failed blade. Its aerofoil skin section was removed from the root fitting and the aerofoil section exposed internally. The other blade was cut through adjacent to the root fitting and the trailing edge of the aerofoil section separated. The two sample blades were similar in appearance and had been fabricated as described by the manufacturer. No purple coloured adhesive was present in the sample blades, only a "yellow to butterscotch brown" coloured adhesive with a knit carrier. The colour and texture of the adhesive used on the failed blade and its matching blade, and the internal skin preparation, were very different from that on the sample blades. (See Figures 2a, b, c, d.)

1.27 Sections of metal from the aerofoil of the failed blade and a sample blade were analysed. The analysis showed that the metals were similar in composition and hardness, and the thickness was the same.

1.28 The metallurgical examination of the blades also showed evidence that the data plates on the root sections could have been removed, and refitted after cleaning the root section.

1.29 The Robinson R22 Maintenance Manual, Section 9.220, states that for repair of tail rotor blades, "repairs are limited to blending out mechanical scratches, dents, nicks, removing corrosion and refinishing the blades. Warning. Any damaged tail rotor blade that cannot be repaired within the limits of this section must be declared NON-AIRWORTHY and be removed from service immediately."

1.30 The manufacturer stated they: did not repair the tail rotor blades (S/N's 5666C and 5638C), do not repair tail rotor blades by re-bonding, have not authorised anyone to repair tail rotor or main rotor blades by re-bonding, do not supply replacement aerofoil sections, and the only authorised repairs are those detailed in Section 9.220 of the R22 Maintenance Manual.

1.31 ZK-HKM was manufactured in January 1990. It was purchased new, shipped to its original owner in New Zealand and began flying on 16 February 1990. In October 1990 it was involved in a rollover accident after having flown some 425 hours. It was subsequently sold, rebuilt and put back into service on 26 August 1994.

1.32 The helicopter's original tail rotor blades were damaged in the rollover accident and were replaced by tail rotor blades, serial numbers 5638C and 5666C. These blades were previously installed on Robinson R22 serial number 1987, registered as N192KC. They were manufactured in September 1991 and were fitted new to N192KC. They had a total recorded time of 1388 hours when they were fitted to ZK-HKM.

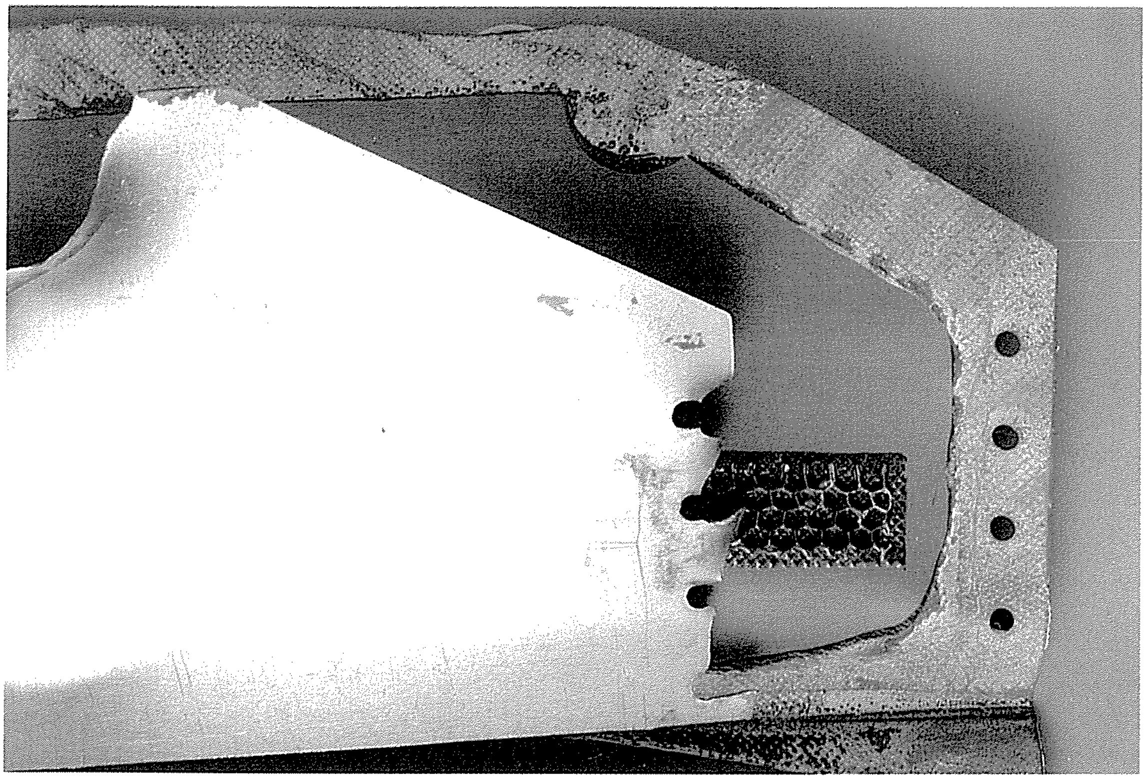

Figure 2c
A comparison of the inside of the aerofoil from blade 5666C, showing the bare metal and the inside of a sample blade showing the correct surface preparation and adhesive colour.

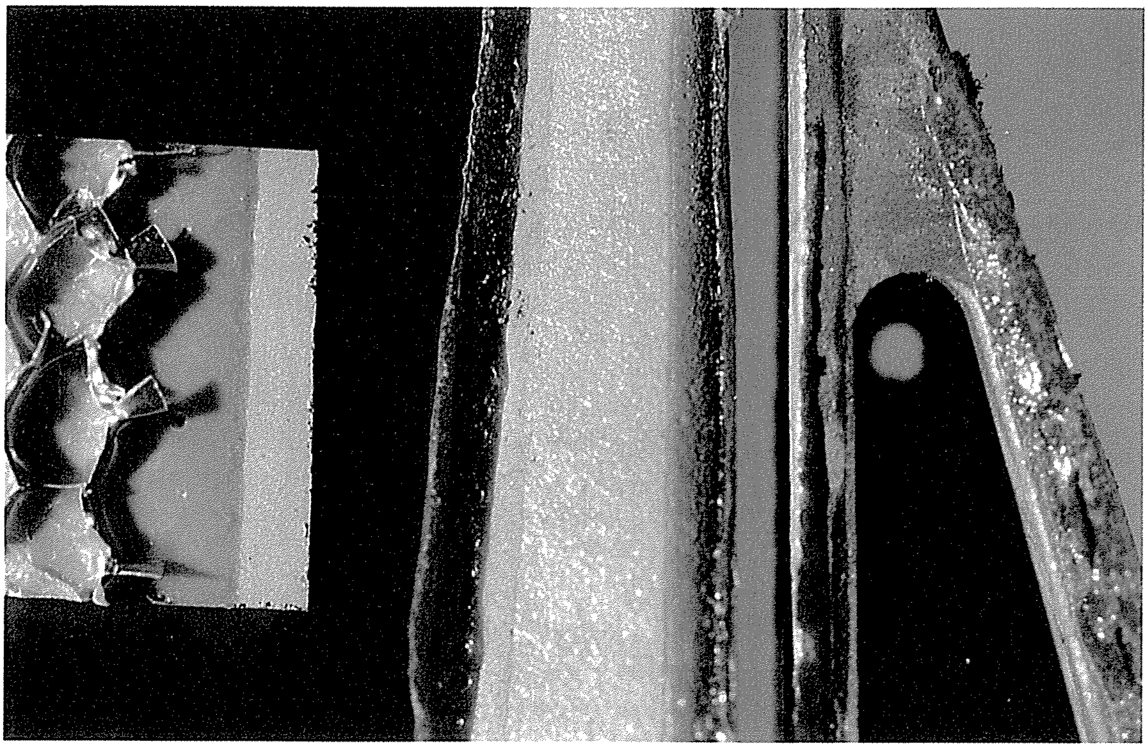

Figure 2d
The blade root and tip cap of blade 5666C, showing the purple coloured adhesive layered over tan brown coloured adhesive.

1.33 Following manufacture N192KC was delivered to a company in Kansas in October 1991. It was later resold to another company in California, and on 18 October 1993 it was involved in a hard landing accident in Sunland California during which it slid down the side of a mountain.

1.34 An insurance claim was settled with the owner and the wreckage was removed to an aircraft salvage company in Long Beach California for storage. The wreckage was subsequently resold to another party elsewhere in the United States but it remained in storage at Long Beach. The new owner of the wreckage disposed of some of its components but the remainder of the wreckage, including the tail rotor blades, remained at the salvage company for disposal.

1.35 From photographs and a video taken of the wreckage of N192KC at the accident site, it was established that the helicopter's tail rotor blades had been extensively damaged in that accident.

1.36 In April 1994 the owner of ZK-HKM travelled to the United States on business and while in California he purchased a number of components from N192KC including its tail rotor blades. He said that the main purpose of his trip to the United States was not to purchase R22 components, but he became aware of them through reading "Trade A Plane" magazine. He said that an Artificial Horizon included in the components for sale had primarily attracted him to look, and as a result he purchased other components as well. He could not recall from whom he purchased the tail rotor blades and other R22 components. He remembered that he paid cash for them but did not receive a receipt for the transaction. He said the components and the blades were at the same location.

1.37 He said he had to wait several days for N192KC's logbook to arrive before he could examine it. The logbook did not have any entries that showed the tail rotor blades had been damaged, removed, replaced, repaired, modified or overhauled. He said he knew the helicopter had been involved in an accident as it was quite obvious. He inspected the blades and, after comparing their serial numbers against entries in the logbook, believed they were serviceable. No form of release note or serviceability tag was attached to the blades.

1.38 The components, including the tail rotor blades and logbook, were shipped to New Zealand in a container along with other items he had purchased. The owner said he personally loaded the container in preparation for shipping. The container arrived in Auckland on 22 May 1994 and the tail rotor blades and other components were transported directly to Whakatane. He said he received the tail rotor blades in the same condition as when he purchased them.

1.39 The tail rotor blades and logbook were given directly to a Licenced Aircraft Maintenance Engineer (LAME) who was responsible for the maintenance of ZK-HKM. The LAME said he received the tail rotor blades in good condition from the owner of ZK-HKM and believed they were genuine. After inspecting the blades and examining N192KC's logbook the LAME said he assessed the blades as serviceable and locked them away in a cupboard in his hangar.

1.40 The owner said he never told the LAME specifically that N192KC had been involved in an accident. However, it was the owner's custom only to buy parts from wrecked helicopters, and he said the LAME was aware of that. In addition the logbook for N192KC did not accompany a complete helicopter, only parts of one.

1.41 On 20 August 1994 the LAME again inspected the blades, in accordance with the manufacturer's R22 Maintenance Manual, and examined the logbook entries. He said he believed the blades were serviceable and had no reason to suspect they had been repaired, and issued a "Serviceable" tag, MOT 1443, for each of them. He subsequently fitted and balanced the blades to ZK-HKM on 26 August 1994 without encountering any difficulty. He did not carry out any repair to the blades.

1.42 The manufacturer's Maintenance Manual for the R22 requires that tail rotor blades be matched even serial numbers with even or odd serial numbers with odd. This process helps ensure that a satisfactory balance of the blades will result once they are fitted to a helicopter. The LAME said that it was sometimes difficult to achieve a satisfactory balance even with matched blades, but in ZK-HKM's case the blades balanced with little or no adjustment. No concerns were therefore raised as to the serviceability of the blades, by the LAME.

1.43 With respect to the procurement and fitting of spare parts to aircraft and the repair of aircraft involved in an accident the following requirements were among those that applied at the time.

"New Zealand Civil Airworthiness Requirements (NZCAR)
Volume 1
Airworthiness Standards
Design, Manufacturing And Supply Procedures

Section E4

Approval And Use Of Components

1. General

1.1 Regulation 174 (d) states that for maintenance purposes, "all aircraft components used shall comply with the approved type design or as otherwise specified by the Director, and shall have been constructed and inspected under approved conditions." "

"NZCAR 1, E.4

3.0 CONFORMITY DETERMINATION

3.1 Before incorporating an aircraft component into an aircraft or aircraft component assembly during manufacture or maintenance, the person or firm performing the work shall:

(a) Determine the correct description (e.g. part number or specification) for the required component from one of the following types of document:

--.

(b) Ensure that the description of the actual component as marked on the component itself or as stated on an attachment or accompanying release note, is identical to that determined under (a) above.

(c) (i) Be in possession of a release note or equivalent as prescribed in CAR E5 issued in respect of the manufacture or supply of the component, or,

(ii) Determine by inspection that the component conforms to its approved design. For this inspection the user must be approved in accordance with NZCAR Section D and the engineering procedures manual must make provision for such conformity inspections."

Aeronautical Information Circular - Air Series contained the following advisory information.

"AIC - Air 22

REPAIR OF CRASHED AIRCRAFT

3. Assessment of damage to components

3.1 The components of an aircraft which have been involved in an accident may suffer damage, distortion, or changed characteristics of a nature that is not visually apparent. Before such components are returned to service it is essential that they be subject to competent assessment and inspection having regard to the circumstances of the accident, subsequent storage and transport conditions, and previous operational history. Such assessment should be made by a person or firm approved for the major maintenance of the aircraft or component(s) concerned, backed up by any necessary specialist advice or examinations."

There were no CAA rules or regulations that required aircraft components to be supplied through an approved distributor.

1.44 The LAME's maintenance organisation was approved, in accordance with CAR Section D, for conformity inspections. As the tail rotor blades did not have any form of release note attached to them the LAME determined, by inspection, that the blades conformed with their approved design. This action complied with the provisions of NZCAR 1, E4, 3.1 (c) (ii).

1.45 The LAME also believed that an aircraft logbook could be used as an equivalent of a release note, "because the relevant logbook entries contained the same information and certification expected of a release note". In accordance with CAR E5 however, an aircraft logbook was not an approved equivalent.

1.46 The LAME saw no reason to have the blades assessed by a person or firm approved for the major maintenance of aircraft components, as per the advisory information contained in AIC-AIR 22. He said that on other occasions he had referred parts for such assessment, but in this instance he "had no concerns as to their (tail rotor blades) airworthiness". In addition, no major maintenance was permitted to be carried out on the blades.

1.47 Following its return to service in August 1994 ZK-HKM was test flown by its owner. The helicopter flew a further 385 hours up to April 1995, according to its logbook entries, and was used primarily for venison recovery work and some personal transportation by the owner. The owner's son personally flew a high percentage of these hours. The helicopter was subsequently put into storage in a hangar at Whakatane in April 1995 at the end of the venison season, and it did not fly again until 10 October 1995.

1.48 The LAME advised that during the period August 1994 to October 1995 the tail rotor blades were not damaged and they remained on the helicopter.

1.49 During October 1995 ZK-HKM was purchased by the pilot and the shooter, and prior to delivery they had the tail rotor blades removed and repainted. Following the repainting the LAME said he inspected the blades and determined they were serviceable, so he refitted and balanced them to ZK-HKM and again obtained a good result.

1.50 A 100 hour inspection of the helicopter was completed on 10 October 1995 and it was returned to service. A Maintenance Release was issued for the helicopter and it had a non-terminating Certificate of Airworthiness.

1.51 Following the purchase the pilot and the shooter operated the helicopter for about 30 hours on venison recovery work, until its accident on 25 October 1995. There was no record of any maintenance having been carried out during this period. At the time of the accident the helicopter had a total airframe time of 840 hours and 1803 hours on the tail rotor blades. The manufacturer's Maintenance Manual for the helicopter permitted a maximum tail rotor blade life of 5525 hours or ten years, whichever came first.

1.52 The pilot had been issued with a Commercial Pilot Licence (Helicopter) on 12 October 1990 and was subsequently reissued with a lifetime licence on 27 September 1993. He had a valid Class 1 Medical Certificate and a Robinson R22 aircraft type rating. He had completed a Civil Aviation Regulation 76 check in March 1995. At the time of the accident he had flown 704 hours on helicopters and 617 hours on the R22 type. His experience had been gained principally on venison recovery work.

Bogus parts

1.53 The following extracts are taken from the Flight Safety Foundation January / February 1994 Flight Safety Digest, titled: "Bogus Parts - Detecting the Hidden Threat".

> "The aviation community has been plagued by bogus parts for decades. But there are alarming indications that the scope of the problem is growing".
>
> "Bogus parts can range from dangerous substandard components and blatant counterfeits to safe (airworthy) but "unauthorised parts".
>
> "The problem of bogus parts is serious because it is almost impossible to detect some of the phonies without extensive tests few of us are equipped to make. Many of the counterfeits are skillfully fabricated. Some carry the inspection marks and part numbers of the genuine articles. Some are even packaged like the original. Some differ from the part produced by the prime manufacturer only in the material, a difference often extremely difficult to discern. Any situation that threatens our lives and our livelihoods in spite of inspection and the exercise of our own best judgement is serious."
>
> "Bogus parts pose a special risk to helicopters, whose complex systems and operational rigors make them especially vulnerable to substandard critical parts".
>
> "The problem is aggravated by the amount of surplus military (helicopter) parts on the market."

2. Analysis

2.1 ZK-HKM had been fitted with tail rotor blades that were purported to have been fitted to Robinson R22 N192KC.

2.2 N192KC was involved in an accident in California on 18 October 1993 which resulted in its tail rotor blades being damaged beyond repair. Following settlement for the helicopter, the wreckage was stored in California awaiting disposal. It is likely that during this period an unauthorised repair of the blades was carried out, by an unknown party. It is likely that the repair consisted of bonding non-factory aerofoil sections of the blades, formed from the appropriate material, to the root fittings and tip caps. Alternatively, the data plates could have been removed from the damaged blades and fixed to blades that had been "remanufactured" previously. Another possibility was that new data plates had been fabricated using the data from the damaged blades and then fixed to the "remanufactured" blades.

2.3 During the "remanufacture" of the blades an inferior process to that of the manufacturer was used. The internal surfaces of the aerofoil sections were not prepared by any method and the adhesive used was different from the adhesive used by the manufacturer. Correct surface preparation is vital for successful bonding as it gives a base to which the adhesive can adhere.

2.4 As the repaired blades resembled factory R22 blades and there were no records to indicate they had been damaged or repaired, they were subsequently purchased in good faith by the owner of ZK-HKM, shipped to New Zealand and fitted to ZK-HKM. The owner said he had no knowledge the blades had been repaired, and in support of this he and his son flew the helicopter for a considerable number of hours after the blades were fitted.

2.5 The LAME who received the blades and fitted them to ZK-HKM also did so in good faith believing they were genuine Robinson manufactured blades in serviceable condition. There was no evidence on the components or in the logbook to suggest the aerofoils had been replaced, and he was not aware of the unauthorised repairs that had been carried out. The serial numbers matched the logbook entries and there were no entries in the logbook to suggest the blades had ever been damaged or repaired. Their recorded time in service and calendar life was well within the permitted maximum.

2.6 Apart from the logbook entries however, the tail rotor blades were supplied without any form of serviceability record attached to them, and the name of the supplier from the United States was not given to the LAME. It was also obvious that N192KC had been wrecked in an accident. Although the provisions of AIC-AIR 22 paragraph 3.1 were advisory only and not mandatory, had the LAME followed these provisions and had the blades assessed by a person or firm approved for the major maintenance of aircraft components, it is possible that the unauthorised repairs may have been detected.

2.7 There is no requirement for aircraft components to be supplied through an "approved" distributor. However had the tail rotor blades been supplied by this method it is likely that the buyer would have received genuine factory blades.

2.8 It is likely that the de-bonding of the adhesive in the tail rotor blades occurred over a period of time and progressively transferred operating loads to the non-load bearing rivets. During the accident flight the progressive failure reached a critical point and the aerofoil section eventually tore away from the root fitting.

2.9 It is unlikely that the de-bonding could be detected by external examination, and it had not been noticed by the LAME or the pilots who had flown the helicopter. However, a thorough examination of the tail rotor blades prior to the accident flight might have shown some evidence of fretting or cracking of the skin in the vicinity of the rivets, or an opening up of the aerofoil at its trailing edge.

2.10 After separation from the root fitting the detached portion of the tail rotor blade flew into the main rotor disc and was hit by the rotor blades. The massive instantaneous imbalance of the tail rotor which resulted, caused the tail rotor gearbox to tear free from the tail boom almost immediately. At the same time, the empennage to gearbox fitting failed in overload.

2.11 The separation of the gearbox and empennage from the tail boom would have caused a rapid forward movement of the helicopter's centre of gravity well beyond the forward limit. The helicopter's nose would have pitched down violently, and the tail boom would have pitched upwards at the same rate. The sudden pitch down combined with the instinctive reaction of the pilot to apply aft cyclic rapidly in an attempt to raise the nose, resulted in the main rotor blades striking the tail boom causing it to fail and separate from the helicopter.

2.12 Main rotor rpm would have decayed rapidly due to the tail boom strike and the evidence suggested that the engine stopped at this time. The helicopter then fell to the ground in a forward trajectory, followed by the separated tail rotor gearbox.

2.13 The pilot probably had little warning of the impending failure, although he may have felt a "buzz" through the yaw pedals or other vibration. Once the failure did occur the subsequent events would have taken place rapidly, and the pilot would not have been able to recover the situation.

3. Findings

3.1 The helicopter had a valid Maintenance Release and a non-terminating Certificate of Airworthiness.

3.2 The helicopter was fitted with tail rotor blades that had been subject to unauthorised repair.

3.3 The blades originally fitted to N192KC were damaged beyond repair, when the aircraft was involved in an accident in California.

3.4 The unauthorised repair probably consisted of replacing the aerofoil section of both blades and bonding them to the original root fittings, using a process inferior to that of the manufacturer.

3.5 The unauthorised repair procedure may have involved transferring the data plates, or data, from the damaged blades to other "remanufactured" blades and / or creating new data plates.

3.6 The identity of the person who carried out the unauthorised repair was not established.

3.7 The blades were purchased in California by a former owner of ZK-HKM in good faith, and shipped to New Zealand.

3.8 The blades did not have any form of serviceability record attached to them.

3.9 The LAME responsible for the maintenance of the helicopter accepted the blades as bona fide components.

3.10 The LAME inspected the blades and assessed that they were serviceable before fitting and balancing them to the helicopter.

3.11 The LAME was mistaken in his belief that he could use the logbook of N192KC as the equivalent of a release note, to determine the tail rotor blades history.

3.12 The LAME was not required to have the blades assessed by a person or firm approved for the major maintenance of aircraft components.

3.13 In the absence of a release note or equivalent, the LAME was entitled to inspect the blades to determine that they conformed to their approved design.

3.14 The helicopter had flown some 415 hours with the tail rotor blades fitted before one of them failed.

3.15 A progressive de-bonding within the blades occurred from the time they were fitted to ZK-HKM.

3.16 Periodic inspections of the tail rotor blades by the LAME and various pilots did not alert them to any problem.

3.17 The separation of one tail rotor blade's aerofoil section from its root fitting during the accident flight, resulted in further break-up of the helicopter which rendered it uncontrollable.

4. Safety Actions

4.1 On 2 November 1995, in response to a Safety Recommendation by the Commission, the Civil Aviation Authority issued a "Safety Recommendation" to all New Zealand owners and operators of the Robinson R22 helicopters, drawing attention to the circumstances of the accident and recommending steps to be taken by owners to check tail rotor blades for de-bonding.

4.2 On 14 November 1995 the Robinson Helicopter Company issued a "Safety Alert", drawing attention to the potential for the existence of R22 tail rotor blades which were either bogus parts or had been subject to unauthorised repair.

4.3 On 15 November 1995 the Civil Aviation Authority issued an "Alert Airworthiness Directive", effective immediately, requiring R22 owners to take the necessary steps to detect bogus tail rotor blades and remove them from service before further flight.

4.4 As the Commission's investigation into the accident is confined to the circumstances, safety deficiencies revealed and the issuing of any appropriate safety recommendations, the CAA in conjunction with the United States authorities is continuing the investigation to determine the source of the unauthorised repairs.

5. Safety Recommendations

5.1 It was recommended to the Director of Civil Aviation that he:

Take urgent steps to determine the validity of the Certificates of Airworthiness issued for the Robinson R22 helicopters currently operating in New Zealand and advise all operators accordingly (096/95), and

Review the current procedures for the procurement of critical aircraft components, with a view to requiring that such components be supplied through an approved distributor or the components' history be positively established by documentation, before they can be fitted to a certificated aircraft. (124/95)

5.2 The Director of Civil Aviation responded to Safety Recommendation 096/95 on 15 November 1995 as follows:

"The following comments are made in response:

(a) I do not intend to adopt the recommendation in the broad terms in which it is framed, but to focus on the known failure through an "Alert Airworthiness Directive".

(b) The Airworthiness Directive, attached, is mandatory and effective immediately on receipt.

(c) The reason for not adopting Recommendation 096/95 in the terms framed by TAIC is that Robinson R22 helicopters are granted New Zealand Certificates of Airworthiness based on the acceptance of the Type Certificate issued by the certificating authority in the country of design and manufacture ie. The Federal Aviation Administration in the USA.

The initiating cause to which this accident has been attributed has been identified as de-bonding of a tail rotor blade in flight. This is not seen as being an appropriate *reason for the validity of Certificates of Airworthiness, issued for Robinson R22 helicopters currently included in the New Zealand aircraft register, to be reviewed.*

However, on 2 November 1995 all Robinson R22 helicopter owners were notified of the relevant accident findings up to that date and were recommended to accomplish close visual inspection of all installed tail rotor blades. A copy of this notice was also sent to TAIC. Owners were requested to immediately notify CAA of any defects found. No reports have so far been received.

Further action has today been initiated, when more information concerning the origin of the failed blade became available from the manufacturer." *(See DCA/R22/29).*

21 February 1996

M F Dunphy
Chief Commissioner

Glossary of Aviation Abbreviations

AD	Airworthiness Directive
ADF	Automatic direction-finding equipment
agl	Above ground level
AI	Attitude indicator
AIC	Aeronautical Information Circular
AIP	Aeronautical Information Publication
amsl	Above mean sea level
AOD	Aft of datum
ASI	Airspeed indicator
ATA	Actual time of arrival
ATC	Air Traffic Control
ATD	Actual time of departure
ATPL (A *or* H)	Airline Transport Pilot Licence (Aeroplane *or* Helicopter)
AUW	All-up weight
°C	Celsius
CAA	Civil Aviation Authority
CASO	Civil Aviation Safety Order
CFI	Chief Flying Instructor
C of G (*or* CG)	Centre of gravity
CPL (A *or* H)	Commercial Pilot Licence (Aeroplane *or* Helicopter)
DME	Distance measuring equipment
E	East
ELT	Emergency location transmitter
ERC	Enroute chart
ETA	Estimated time of arrival
ETD	Estimated time of departure
°F	Fahrenheit
FAA	Federal Aviation Administration (United States)
FL	Flight level
ft	Foot/feet
g	Acceleration due to gravity
GPS	Global Positioning System
h	Hour
HF	High frequency
hPa	Hectopascals
hrs	Hours
IAS	Indicated airspeed
IFR	Instrument Flight Rules
IGE	In ground effect
ILS	Instrument landing system
IMC	Instrument meteorological conditions
in	Inch(es)
ins Hg	Inches of mercury

kg	Kilogram(s)
kHz	Kilohertz
KIAS	Knots indicated airspeed
km	Kilometre(s)
kt	Knot(s)
LAME	Licenced Aircraft Maintenance Engineer
lb	Pounds
LF	Low frequency
LLZ	Localiser
Ltd	Limited
m	Metre(s)
M	Mach number (e.g. M1.2)
°M	Magnetic
MAANZ	Microlight Aircraft Association of New Zealand
MAP	Manifold absolute pressure (measured in inches of mercury)
MAUW	Maximum all-up weight
METAR	Aviation routine weather report (in aeronautical meteorological code)
MF	Medium frequency
MHz	Megahertz
mm	Millimetre(s)
mph	Miles per hour
N	North
NDB	Non-directional radio beacon
nm	Nautical mile
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board (United States)
NZAACA	New Zealand Amateur Aircraft Constructors Association
NZDT	New Zealand daylight time (UTC + 13 hours)
NZGA	New Zealand Gliding Association
NZHGPA	New Zealand Hang Gliding and Paragliding Association
NZMS	New Zealand Mapping Service map series number
NZST	New Zealand Standard Time (UTC + 12 hours)
OGE	Out of ground effect
okta	Eighths of sky cloud cover (e.g. 4 oktas = 4/8 of cloud cover)
PAR	Precision approach radar
PIC	Pilot in command
PPL (A *or* H)	Private Pilot Licence (Aeroplane *or* Helicopter)
psi	Pounds per square inch
QFE	An altimeter subscale setting to obtain height above aerodrome
QNH	An altimeter subscale setting to obtain elevation above mean sea level
RNZAC	Royal New Zealand Aero Club
RNZAF	Royal New Zealand Air Force
rpm	revolutions per minute
RTF	Radio telephone or radio telephony

s	Second(s)
S	South
SAR	Search and Rescue
SSR	Secondary surveillance radar
°T	True
TACAN	Tactical Air Navigation aid
TAF	Aerodrome forecast
TAS	True airspeed
UHF	Ultra high frequency
UTC	Coordinated Universal Time
VASIS	Visual approach slope indicator system
VFG	Visual Flight Guide
VFR	Visual flight rules
VHF	Very high frequency
VMC	Visual meteorological conditions
VOR	VHF omnidirectional radio range
VORTAC	VOR and TACAN combined
VTC	Visual terminal chart
W	West