

AIRCRAFT ACCIDENT REPORT
OCCURRENCE NUMBER 03/127
ROBINSON R22 BETA
ZK-HUL
MASTERTON
17 JANUARY 2003



Glossary of abbreviations used in this report:

amsl	above mean sea level
avgas	aviation gasoline
C	Celsius
CAA	Civil Aviation Authority
E	east
ELT	emergency locator transmitter
ft	foot or feet
hPa	hectopascals
kg	kilogram(s)
km	kilometre(s)
m	metre(s)
METAR	aviation routine weather report
mm	millimetre(s)
NZDT	New Zealand Daylight Time
QNH	altimeter subscale setting to obtain height above mean sea level
rpm	revolutions per minute
S	south
T	true
UTC	Coordinated Universal Time
VHF	very high frequency

AIRCRAFT ACCIDENT REPORT

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Aircraft type, serial number and registration:	Robinson R22 Beta, 0945, ZK-HUL
Number and type of engines:	1 Lycoming O-320-B2C
Year of manufacture:	1989
Date and time:	17 January 2003, 1645 hours ¹
Location:	Near Masterton Aerodrome Latitude ² : S 40° 58.4' Longitude: E 175° 39.0'
Type of flight:	Training
Persons on board:	Crew: 1
Injuries:	Crew: 1 fatal
Nature of damage:	Helicopter destroyed
Pilot-in-command's licence	Private Pilot Licence (Helicopter)
Pilot-in-command's age	36 years
Pilot-in-command's total flying experience:	158 hours, 10.5 on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr Richard White

¹ Times are NZDT (UTC + 13 hours)

² NZ Geodetic Datum 1949 coordinates

Synopsis

The Civil Aviation Authority was notified of the accident at 1730 hours on Friday 17 January 2003. The Transport Accident Investigation Commission was in turn notified shortly thereafter, but declined to investigate. A CAA site investigation was commenced that evening.

The pilot was on a solo consolidation flight following dual type-rating instruction on the R22. As the helicopter was climbing out after take-off and had reached an altitude of about 400 feet, witnesses on the aerodrome heard a loud noise and saw pieces flying off the helicopter. It free-fell to the ground; the pilot was killed and the helicopter destroyed in the impact.

1. Factual information

1.1 History of the flight

- 1.1.1 The pilot was undergoing type-rating training on the Robinson R22, and on 17 January 2003, completed a dual check flight with his instructor before being authorised to continue solo. This solo flight was completed without any problems.
- 1.1.2 The dual check included practice engine failures, with autorotation entry and recovery. The pilot was then authorised by the instructor to conduct solo consolidation flights in the aerodrome circuit.
- 1.1.3 The pilot refuelled the helicopter and completed a pre-flight inspection. Normal practice was to refuel until the tank was three-quarters full, and the fuel records showed an uplift of 30 litres. Added to the fuel known to be on board beforehand, this gave a total of about 54 litres, sufficient for up to 1.5 hours flight time.
- 1.1.4 The helicopter took off about 1620 hours and was seen carrying out apparently normal circuits, taking off and landing parallel to runway 06. Some 25 minutes into the flight, as the helicopter was climbing straight ahead after take-off and had reached about 400 feet, witnesses on the airfield heard a loud noise and saw pieces flying off the helicopter. Another witness who was closer to the helicopter reported that after one or two rotations about the vertical axis, it then fell straight to the ground, landing in a field of young barley.
- 1.1.5 One nearby witness ran to the scene, and seeing a fire in the cabin area, attempted to pull the apparently unconscious pilot from the wreckage. The pilot was trapped by the distorted cabin structure, and this witness was unable to both lift the structure and pull the pilot clear. Two more people arrived and with their combined efforts, the pilot was lifted clear of the burning wreckage.

- 1.1.6 On arrival of emergency services, the fire was extinguished, and it was confirmed that the pilot had sustained fatal injuries.
- 1.1.7 The accident occurred in daylight, at 1645 hours NZDT, adjacent to Masterton Aerodrome, at an elevation of about 330 feet. Grid reference 260-T26-331227, latitude S 40° 58.4', longitude E 175° 39.0'.

1.2 Injuries to persons

<i>Injuries</i>	<i>Crew</i>	<i>Passenger s</i>	<i>Other</i>
Fatal	1	0	0
Serious	0	0	0
Minor/None	0	0	

1.3 Damage to aircraft

- 1.3.1 The helicopter was destroyed.

1.4 Other damage

- 1.4.1 Some minor damage was inflicted on the barley crop both by the initial impact and by post-accident activity.

1.5 Personnel information

- 1.5.1 The male pilot, aged 36, held a Private Pilot Licence (Helicopter) first issued in December 2001, and a Class 2 medical certificate valid until 22 January 2006. His licence was endorsed with a Hughes 269 type rating.
- 1.5.2 The pilot's logbook recorded a total of 157.4 hours on helicopters, including 10.5 hours on Robinson R22s. His most recent flights were a 4.2 hour dual cross-country on 16 January, 1.4 hours dual instruction on 17 January and 0.6 hours solo preceding the accident flight.
- 1.5.3 His log book had also been endorsed by his instructor, certifying that he had satisfactorily completed Robinson Helicopter Company safety awareness training as mandated by the limitations section of the R22 flight manual. He had not yet completed a type rating flight examination.
- 1.5.4 The instructor was interviewed and confirmed that the pilot was of good ability and was in good spirits on the day of the accident. There were no indications of any stress or tension.

1.6 Aircraft information

- 1.6.1 Robinson R22 Beta helicopter, serial number 0945, was manufactured in March 1989, and was first registered in New Zealand on 19 March 1999, at which time it was issued with a non-terminating airworthiness certificate.
- 1.6.2 Up to the last flight on 17 January 2003, the helicopter had accrued a total of 3174 hours in service.
- 1.6.3 The last scheduled maintenance was a 100-hourly inspection carried out on 9 November 2002. An annual review of airworthiness was completed on 23 August 2002.
- 1.6.4 The engine, Lycoming O-320-B2C, serial number L-15058-39A, had run 1194.2 hours since overhaul. It also had been subjected to a 100-hourly check on 9 November 2002.
- 1.6.5 The helicopter had been maintained adequately, and appeared to be in good pre-accident condition.
- 1.6.6 Fuel used was 100/130 avgas, which had been drawn from a mobile tank unit supplied to the operator by Air BP.
- 1.6.7 The weight and centre of gravity of the helicopter at the time of the accident were calculated and found to be within normal limits.

1.7 Meteorological information

- 1.7.1 The conditions at Masterton throughout the afternoon were fine and clear, with fair-weather cumulus cloud and a very light east to south-easterly breeze.
- 1.7.2 The 1700 METAR as recorded by the Masterton automatic weather station indicated: wind 120° T at 3 knots, temperature 19° C, dewpoint 11° C, and QNH 1017 hPa.
- 1.7.3 Weather was not a factor in this accident.

1.8 Aids to navigation

- 1.8.1 Not applicable.

1.9 Communications

- 1.9.1 Not applicable.

1.10 Aerodrome information

- 1.10.1 Not applicable.

1.11 Flight recorders

- 1.11.1 Not applicable.

1.12 Wreckage and impact information

- 1.12.1 The helicopter struck the ground heavily on its right side, with practically no forward speed. A 100-metre wreckage trail lay back along the general line of flight, and comprised: pieces of cabin transparency; the battery box cover; the left door; the left half of the cabin “bubble” transparency; and one main rotor blade.
- 1.12.2 The detached rotor blade was found to have entered the cabin at an extreme, almost vertical angle, literally slicing off the left half of the bubble, some of the fibreglass structure immediately beneath it, as well as the left door. In the process, it struck the instrument console, one tail rotor pedal and the cyclic pitch control (which the pilot operates with his right hand). The blade showed major leading edge strike marks and had taken a coned up set to the spar.
- 1.12.3 The blade then struck the battery box area and the left rear skid mount, bending beyond 90° before breaking away from the rotor head. Subsequent examination showed that this blade, complete with spindle, had detached from the main rotor hub and fractured the hub trailing edge side mounting bolt hole area in overload.
- 1.12.4 The other main rotor blade had remained attached to the hub and although showing evidence of having coned up, had very little leading edge damage. The droop stop “tusk” had broken off, and there was corresponding damage to the main rotor driveshaft droop stop fittings. Neither rotor blade had struck the tail boom.
- 1.12.5 The main transmission remained attached to its mounts, but the main rotor mast had fractured just above the top of the transmission to mast attachment flange. This was confirmed by examination as an overload fracture, which occurred when the main rotor hub struck the ground. The main rotor driveshaft was not damaged and the main rotor hub remained attached to the shaft.
- 1.12.6 Examination of the engine-to-transmission drive train, the tail rotor driveshaft and blades, and in particular of the flex-plates incorporated in the drive train, found that there was no rotation at the time of ground impact. Witness marks made on the oil cooler by the starter ring gear, and by the cooling fan similarly showed that the engine was stopped at the time the helicopter hit the ground.
- 1.12.7 Although the flight control runs were disrupted in the accident sequence, pre-accident integrity was established. All fracture surfaces were examined and found to be a result of overload, consistent with impact forces. The cyclic grip had been detached when struck by the rotor blade that entered the cabin; the collective lever was bent to the left (away from the pilot); and the collective friction device, although distorted, was found in the off position.

- 1.12.8 The flight and engine instruments did not yield any useful information. Examination of the low rotor speed warning light bulb found hot stretch of the filament; the alternator low voltage warning light bulb showed none.
- 1.12.9 The fuel system was severely disrupted, and no indication of its pre-accident integrity or functioning could be gleaned. The fuel tank ruptured and partially detached from the airframe on impact and its contents were lost. The fuel filter and bowl detached from the filter mount, and the carburettor float chamber had been struck and detached from the carburettor body. The throttle and mixture controls had also come away from the carburettor.
- 1.12.10 The carburettor heat control was in the off position.
- 1.12.11 The fuel tank filler cap could not be accounted for at the accident site. The operator advised that the cap attachment chain had broken at some time in the past, and that it was possible that the cap was not replaced at the last refuel. Searches of the wreckage trail, impact point and the refuel area did not locate the missing cap. However, with the cap not in place, it is not normal for fuel to be lost from the tank in any significant quantity, especially when the fuel level is some distance below the filler orifice.

1.13 Medical and pathological information

- 1.13.1 Post-mortem examination of the pilot concluded that death was due to multiple injuries consistent with high impact forces. The pilot's right thumb and forefinger were found to be fractured in a manner compatible with his holding the cyclic control at the time it was struck by the main rotor blade.
- 1.13.2 Toxicological tests disclosed no evidence of alcohol, or medicinal or recreational drugs.

1.14 Fire

- 1.14.1 After impact, a fire developed in the left side of the cabin area. Although this was consistent with fuel escaping from the ruptured fuel tank, the fire did not burn with great intensity before being extinguished. The battery was detached from its mounting bracket, and had struck the metal engine mounting frame structure giving a possible ignition source for the fire.
- 1.14.2 The pilot was removed from the wreckage before the fire took hold and burnt part of the seat back and seat belt webbing. The damaged fuel tank was moved away from the helicopter and the fire was extinguished by the emergency services crew.

1.15 Survival aspects

- 1.15.1 The accident was not survivable, as the impact forces were beyond human tolerance.
- 1.15.2 The helicopter was fitted with an Ameriking AK450 emergency locator transmitter, which was severely impact-damaged and did not operate.

1.16 Tests and research

- 1.16.1 On completion of the site examination, the helicopter wreckage was recovered to the owner's hangar for further examination.
- 1.16.2 The engine was removed and sent to an approved overhaul facility for detailed inspection. It was stripped under CAA supervision, and the inspection disclosed no internal damage. Further tests on the magnetos and other components concluded that the engine was capable of running normally prior to the impact.
- 1.16.3 A number of components including the main rotor hub, pitch links and the main drive belt tension actuator were examined by a metallurgist. The damage exhibited by these components was all consistent with overload failure sustained during the accident sequence. The carburettor was examined under a microscope and the damage to the fuel float chamber indicated a side impact causing the attachment studs and main fuel jet to shear off.
- 1.16.4 The governor motor and control box were sent to the manufacturer for testing, and the results showed that they were probably fully functional before the post-crash fire.

1.17 Organisational and management information

- 1.17.1 Not applicable.

1.18 Additional information

- 1.18.1 Section 7 *Systems Description* of the R22 Flight Manual contains, in part, the following information on control trim and friction:

“Balancing trim springs are incorporated in the cyclic and collective controls. The collective up spring balances the rotor loads, allowing the pilot to remove his left hand from the collective during most flight regimes. The longitudinal cyclic has a fixed bungee spring which cancels most longitudinal stick forces during cruise flight.

The lateral cyclic is equipped with an on off trim spring to cancel the left stick force which occurs during high speed flight. The spring is activated by a push pull knob located just forward of the cyclic stick. For S/N 560

and subsequent, fine adjustment of the trim force is controlled by a knob located on the left side of the console.

CAUTION

If the mixture control is inadvertently pulled in flight, engine stoppage will result. To avoid pulling wrong control, always reach around the left side of cyclic to actuate lateral trim.

The cyclic and collective controls are equipped with adjustable friction devices. A toggle type lever is located near the aft end of the centre collective stick. It is actuated aft to increase friction and forward to release it.”

- 1.18.3 The R22 Maintenance Manual includes instructions for installation and adjustment of the spring tension used to balance the in-flight main rotor collective control forces. There is no guidance as to the correct setting of the spring force in relation to flight conditions. Normally the correct setting would be obtained after flight testing the helicopter and adjusting the spring to achieve a neutral effect depending on the operator’s or pilot’s preference. Best practice is that any tendency for the collective to increase in pitch when flown hands off should be minimised or eliminated if possible.
- 1.18.4 The manufacturer was consulted on the optimum rigging effect for the collective spring assembly, and replied: “When properly adjusted by the maintenance personnel, the collective rigging should, with hands off and no friction applied, produce a near-neutral tendency for the collective to increase or decrease pitch. The collective spring selection and adjustment is normally set to be neutral at cruise airspeed and half tank fuel with one or two people, depending on how the helicopter is normally flown. There are a number of variables but there may be a tendency for the collective to increase pitch if insufficient collective friction is applied and the aircraft is flown at lighter weights.”
- 1.18.5 The pilot’s instructor commented that this helicopter had a tendency to increase collective pitch if the pilot’s hand was removed from the collective pitch lever, but did not consider the rate to be unacceptable. This could be controlled by the application of the collective friction device, and he had briefed the pilot about this during their recent training flights. Another student who flew the helicopter before the accident flight said that he was aware of the tendency for the pitch to increase, and he applied collective friction when flying this helicopter.
- 1.18.6 The instructor also said that he believed that when the accident occurred, the helicopter was approaching the height and position in the circuit where it would be a possibility for the pilot to engage the lateral cyclic trim spring. To do this the pilot would take his hand from the collective control, reach round the cyclic control and actuate the push-pull knob located on the centre console.

- 1.18.7 Section 4 *Normal Procedures* of the Flight Manual is preceded by a note which refers to “Main Rotor Stall” and states:

“Many factors may contribute to main rotor stall and pilots should be familiar with them. Any flight condition that creates excessive angle of attack on the main rotor blades can produce a stall. Low rotor rpm, aggressive manoeuvring, high collective angle (often the result of high density altitude, over-pitching [exceeding power available] during climb, or high forward airspeed) and slow response to the low main rotor rpm warning horn and light may result in main rotor stall. The effect of these conditions can be amplified in turbulence. Main rotor stall can ultimately result in contact between the main rotor and airframe. Additional information on main rotor stall is provided in the Robinson Helicopter Company Safety Notices SN-10, SN-15, SN-20, SN-24, SN-27 and SN-29.”

- 1.18.8 Main rotor blade stall can occur when the rotor rpm decay, and the collective pitch is not reduced to allow the rpm to recover. If the rotor rpm fall below about 80% of the normal operating figure, the situation will become irretrievable. The drag on the blades at the resulting high angle of attack will cause the rotor to quite literally stop turning. Engine torque may cause the helicopter to rotate initially to the right, but the engine will be unable to counter the extreme drag forces on the rotor, and will eventually stop running.
- 1.18.9 On the other hand, if the engine fails in forward flight, the pilot must immediately (within one second) lower the collective pitch lever to the minimum stop in order to maintain rotor rpm. This will establish autorotation, in which the relative airflow through the rotor sustains the normal operating rpm, with the helicopter descending under full control. Best practice is that because of high blade pitch angles in the climb it is very important to keep hold of the collective pitch lever to enable it to be lowered in the event of an engine failure.
- 1.18.10 The main rotor rpm warning light and horn will operate when the rotor rpm drop below 97%, with the collective pitch lever off the minimum stop.

1.19 Useful or effective investigation techniques

- 1.19.1 Nil.

2. Analysis

- 2.1 As the helicopter struck the ground with neither rotor nor engine rotation, the possibility of an engine failure was considered, after the elimination of possible control run or other airframe component malfunctions.
- 2.2 Mechanical failure was ruled out by a detailed engine examination; the possibility of fuel exhaustion was unlikely, given the known quantity of fuel on board at the start of the flight, and the improbability of fuel loss from the tank even had the filler cap not been replaced; and carburettor ice was

unlikely in the conditions, especially with the engine operating at climb power.

- 2.3 The most telling indicator of engine operation was the lack of hot stretch on the alternator warning light bulb filament. The instrument panel had been struck by one main rotor blade, and had the light been on (as it would have been if the engine was stopped at that point), the bulb filament would have exhibited hot stretch similar to that of the low rotor rpm warning light, which was illuminated. The lack of hot stretch on the alternator filament also means that electrical power was disrupted to the instrument lights before the helicopter struck the ground.
- 2.4 This indication of engine operation also then eliminates the possibility that the pilot mistakenly pulled the mixture control into cut-off instead of operating the cyclic trim.
- 2.5 The collective control had a tendency to increase pitch if friction was not applied. Although the collective pitch lever and friction device were damaged in the ground impact, examination of the controls concluded that the friction device was in the off position when the helicopter struck the ground.
- 2.6 The possibility that the pilot removed his hand from the collective to adjust the cyclic control spring was considered. With the tendency of the collective pitch to increase without manual restraint and without friction applied, the governor system would attempt to maintain engine (and therefore rotor) rpm by increasing the throttle opening. If the throttle was fully open and collective pitch further applied, then main rotor rpm would decay, activating the rotor warning light and horn.
- 2.7 The recovery action is to reduce collective pitch immediately. The time available to do this is limited, and if the pilot was surprised by the unexpected warning he may have not reacted instinctively to reduce collective pitch, in which case the rpm could have rapidly reduced to a value from which recovery was simply not possible.
- 2.8 The observed evolutions of the helicopter, and the fact that all rotor rotation had ceased by the time the machine hit the ground, all point to an over pitching of the main rotor to a degree that precluded recovery. It is considered most likely that the engine stopped as a result of the over pitching and the main rotor blade striking the cabin, rather than from any other cause.
- 2.9 The need to react promptly in a low-rpm situation is an important component of the Robinson safety awareness training. A strong emphasis is also placed on this in various parts of the Flight Manual, and the associated Safety Notices. Practical training further reinforces the point.

- 2.10 In view of the existing mandatory safety awareness training, reinforced by the Flight Manual material, no new safety recommendations were made as a result of this investigation.

3. Conclusions

- 3.1 The pilot was appropriately licensed and experienced for the flight being conducted.
- 3.2 The helicopter was airworthy and properly maintained in accordance with the rules currently in force.
- 3.3 The helicopter had been operating normally prior to the accident.
- 3.4 The accident sequence was consistent with over pitching of the main rotor, resulting in loss of control and the striking of the airframe by one main rotor blade.
- 3.5 The initiating factor was unlikely to have been an engine failure.
- 3.6 The helicopter had a tendency to increase collective pitch when flown hands off if insufficient collective friction was applied.
- 3.7 The pilot may have reacted too slowly, or inappropriately, to a low rotor rpm situation.
- 3.8 The pilot had received theoretical and practical training in the required recovery actions.
- 3.9 The accident was not survivable.

Report written by:

(Signed)

Richard White
Manager Safety Investigation
Date 03/ 02/ 2004