



AIRCRAFT ACCIDENT REPORT

No. 91-001

ROBINSON R22 BETA ZK-HDC

Near Hukerenui, North Auckland Province

4 January 1991

**Transport Accident Investigation Commission
Wellington - New Zealand**

Transport Accident Investigation Commission
Wellington

Chief Commissioner
Transport Accident Investigation Commission

The attached report summarises the circumstances surrounding the accident involving Robinson R22 Beta ZK-HDC near Hukerenui on 4 January 1991 and includes suggested findings and safety recommendations.

This report is submitted pursuant to Section 8(2) of the Transport Accident Investigation Commission Act 1990 for the Commission to review the facts and endorse or amend the findings and recommendations as to the contributing factors and causes of the accident.

23 July 1991

R CHIPPINDALE
Acting Chief Executive

APPROVED FOR RELEASE AS A PUBLIC DOCUMENT

22 August 1991

M F DUNPHY
Chief Commissioner

AIRCRAFT: Robinson R22 Beta		OPERATOR: Helicarr Limited													
REGISTRATION: ZK-HDC		PILOT: Mr K.E. Willmot													
PLACE OF ACCIDENT: 1500 m west-north-west of Hukerenui North Auckland Province		OTHER CREW: Nil													
DATE AND TIME: 4 January 1991, 1233 hours		PASSENGERS: One													
SYNOPSIS: The helicopter's main rotor was seen to separate from the aircraft while it was cruising at low level. Both occupants were killed in the subsequent collision with the terrain. Mr R Chippindale was the investigator in charge of the investigation.															
1.1 HISTORY OF THE FLIGHT: See page 4.	1.2 INJURIES TO PERSONS: Pilot: 1 Fatal Pax: 1 Fatal	1.3 DAMAGE TO AIRCRAFT: Destroyed	1.4 OTHER DAMAGE Nil												
1.5 PERSONNEL INFORMATION: <table border="1" style="float: right; margin-top: 10px;"> <thead> <tr> <th colspan="3">Flight Times</th> </tr> <tr> <th></th> <th>Last 90 days</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>All Types</td> <td>12</td> <td>213</td> </tr> <tr> <td>On Type</td> <td>5</td> <td>47</td> </tr> </tbody> </table> See page 4.				Flight Times				Last 90 days	Total	All Types	12	213	On Type	5	47
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	Last 90 days	Total													
All Types	12	213													
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1.6 AIRCRAFT INFORMATION: See page 5.															
1.7 METEOROLOGICAL INFORMATION: See page 5.		1.8 AIDS TO NAVIGATION: Not applicable.	1.9 COMMUNICATION: Not applicable.												
1.10 AERODROME: Not Applicable	1.11 FLIGHT RECORDERS: Not applicable.	1.12 WRECKAGE AND IMPACT INFORMATION: See page 6.													
1.13 MEDICAL AND PATHOLOGICAL INFORMATION: See page 7.		1.14 FIRE: See page 8.	1.15 SURVIVAL ASPECTS: See page 8.												
1.16 TESTS AND RESEARCH: See page 8.	1.17 ADDITIONAL INFORMATION: See page 8.	1.18 USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES: Nil.													
2. ANALYSIS: See page 10.	3. FINDINGS: See page 11.														
4. SAFETY RECOMMENDATIONS: See page 12.			5. REGULATORY: See page 12.												

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

1. FACTUAL INFORMATION

1.1 History of the Flight

1.1.1 Although he completed the first 42 hours of his initial helicopter flying training on the Robinson R22 the pilot had not flown this aircraft type for over 12 months apart from a 1 hour 10 minute cross country on 14 April 1990 and a 50 minute local flight on 10 June 1990. Therefore he had a 30 minute dual check flight before he hired the aircraft on 2 January.

1.1.2 Following this check he was joined by his passenger and flew to Kaeo where he parked the aircraft on a private farm after giving another friend a 10 minute local flight.

1.1.3 No further flying of the aircraft took place that day. Next day the pilot was seen to carry out a careful pre-flight inspection after which he flew the aircraft to Kerikeri and filled its tanks for the flight to Auckland.

1.1.4 At Kerikeri he telephoned the operator and requested a one day extension to the flight but this was declined as the owner intended to fly the aircraft to Taupo that day.

1.1.5 No reports were received of the aircraft being seen during its flight from Kerikeri southwards until it was sighted immediately before the accident.

1.1.6 Several groups of motorists were parked, in a rest area over which the aircraft passed, some 150 m prior to the point where the aircraft wreckage came to rest. From their evidence and that of local residents it was established that the aircraft was flying normally, between 50 and 100 feet above ground level as it passed overhead. Immediately after this a loud noise occurred and several items including the aircraft's main rotor, separated from the aircraft. The aircraft then rolled onto its side, descended to the ground and caught fire on impact.

1.1.7 The accident occurred at 1233 hours in daylight. The accident site was 1500 m west-north-west of Hukerenui at 110 m amsl. National Grid Reference 182313 (NZMS 260 Sheet Q06 "Hukerenui"). Latitude 35°31'10"S, longitude 174°11'15"E.

1.5 Personnel information

1.5.1 Kenneth Eardley Willmot, aged 31, commenced his flying training on 27 March 1987 in a Cessna 152 and completed 19 hours flying in that type including 5 hours solo, by October of that year. He did no further flying until January 1989 when he recommenced a course of instruction on PA 38 aircraft which he last flew on 18 December 1990. He had not qualified for a Private Pilot Licence - Aeroplane (PPL A) but in the interim he had concentrated on helicopter flying.

1.5.2 He commenced helicopter flying in a Robinson R22 aircraft on 4 July 1989 and made his first solo helicopter flight in that type on 6 August 1989 after 19 hours dual instruction.

1.5.3 On 28 August 1989 a 1.1 hour dual flight was recorded as "Low G recognition and recovery".

1.5.4 He flew the Robinson R22 regularly until November 1989 by which time he had 42.3 hours on type. He then continued his flying training on a Hughes 269C aircraft of which he was a part owner. He flew that aircraft regularly until 25 November 1989 and accumulated 104 hours on that type. He also obtained his Private Pilot Licence - Helicopter (PPL H) number 21174, during this time and an aircraft type rating on the Hughes 269 and Robinson R22 on 6 December 1989. The type rating on the R22 aircraft was issued without a specific flight test on the basis of his ability to fly the aircraft after his earlier 34 hours dual training.

1.5.5 On 14 November 1990 he obtained a Type Rating on the Bell 206 after a 60 minute flight in that aircraft and subsequently flew one hour solo in the aircraft to accumulate a total of two hours on that type.

1.5.6 He underwent his last medical examination for the renewal of his PPL H and Student Pilot Licence - Aeroplane (SPL A) on 26 June 1989 and was passed as fit to exercise the privileges of these licences for two years.

1.5.7 Each licence was valid to 3 July 1991 and his PPL H was endorsed:

“Restricted to student pilot licence privileges by night. Not valid for sling load operation.”

1.6 Aircraft information

1.6.1 The Robinson R22 Beta aircraft, Serial number 1535 was manufactured in September 1990. It flew 8.6 hours in the United States before being shipped to New Zealand and reassembled on 31 October 1990. Apart from its initial test and delivery flying on 1 and 2 November 1990 it did not fly again until 1 January 1991 when Mr Wilmot flew it for 3.7 hours. On 2 January it flew 3.3 hours and approximately 1 hour on 4 January giving a total time for the airframe and engine of 17.5 hours since new.

1.6.2 There were no outstanding defects recorded.

1.6.3 The pilot had mentioned to his friends that the low rpm audio warning had operated during the approach to one landing and that he was puzzled by this as he believed there to be no cause for it.

1.6.4 An experienced instructor advised that it was not unusual for a low rpm warning to sound during an approach by inexperienced pilots but this warning was well in advance of any serious situation developing and enabled the pilot to make the necessary corrections in the type of situation faced by Mr Willmot.

1.6.5 Its Lycoming O-320-B2C engine had flown 17.5 hours since new.

1.7 Meteorological information

1.7.1 An anticyclone was centred over the North Tasman Sea and a south-westerly airstream covered North Island. Average wind speeds near ground level were about 20 knots.

1.7.2 The most interesting feature was a very strong inversion layer between about 3000 and 8000 feet. The temperature at the lower height was unusually low for the time of the year and the temperature at the top unusually high. It is thought that a stronger inversion would occur rarely.

1.7.3 The inversion was well above the altitudes generally used by helicopters but it would have had some controlling influence on the weather beneath it. The wind flow over the hills below the inversion would have given rise to frequent light or moderate turbulence. Cloud was variable scattered to broken thin stratocumulus with a base 2500 to 3000 feet.

1.7.4 The atmosphere below the inversion was hazy but visibilities were reported in excess of 30 km.

1.7.5 A steady south-westerly surface wind of some 20 and 25 knots prevailed at the accident site. As this was flowing across an upsloping but even area towards a stand of trees there was likely to be an upflow beneath the aircraft's flightpath to windward of the trees .

1.7.6 The aircraft appeared to witnesses to be flying steadily and there were no obvious obstructions which might have caused mechanical turbulence.

1.7.7 The sky was clear.

1.12 Wreckage and impact information

1.12.1 The wreckage of ZK-HDC was located in a flat paddock on the western side of and adjacent to, State Highway 1 approximately 1500 m west-north-west of Hukerenui.

1.12.2 The helicopter came to rest on its left side on a heading of 180 degrees magnetic. The accident site was to the windward side of a row of tall pine trees and downwind of an unobstructed expanse of rolling pastureland.

1.12.3 The main rotor blades, still attached to the rotorhead assembly, lay approximately 50 m to the north of the fuselage. The upper section of the main rotor drive shaft had a fracture allowing the whole rotorhead and blade assembly to separate from the remaining structure. The mast had a torsional overload failure and showed no deformation due to the mast bumping which was evident on the stops.

1.12.4 Damage to the main rotor blades was consistent with an in-flight strike on the main canopy and left door frame and low rotational energy at the time of ground impact. There was no significant damage to the leading edge of either of the main rotor blades. One blade had evidence of striking the cockpit canopy along a line between a point immediately above the right door's forward upper corner to a mid point on the forward edge of the left door's transparency. The second blade had rotated through some 180° in pitch before it too struck the canopy area with its trailing edge.

1.12.5 The left door, pieces of the canopy, the aircraft's magnetic compass, the passenger's handbag, landing light fragments and a metal clip used to retain the rubber boot on the root of the main rotor blade which struck the cockpit area with its leading edge, were among the debris which had fallen from the aircraft prior to its ground impact.

1.12.6 Impact marks in the turf and the fracture of the aircraft's skid indicated that the aircraft had impacted in a dive, with the right side down, on a heading of 098° magnetic. It was in a nose down attitude of between 20 and 30 degrees with the aircraft rolled some 45° to the right. The impact angle was approximately 25° on the level grass surface. The amount of compression of

the structure was not established owing to the subsequent damage which resulted from a sustained and fierce post-impact fire.

1.12.7 Most of the instruments had separated from the panel and together with the panel had been thrown up to 65 m in an easterly direction.

1.12.8 The surface marks and wreckage distribution indicated that the helicopter had collided with the ground on an easterly heading and then fallen almost inverted onto its upper left side while pivoting onto a heading of due south.

1.12.9 Damage to the rear sections of the tailboom was consistent with the impact that had occurred. The right hand door was about one metre to the north of the rear end of the tailboom.

1.12.10 The tail rotor drive shaft had failed under an overload at the rear end and adjacent damage indicated that it had been operating normally when the impact occurred. The tail rotor blades had been bent symmetrically at right angles close to their hubs with no significant damage to their leading edges indicating that they did not strike the ground or any other object before the failure of the tail rotor drive shaft.

1.12.11 Most of the instruments had been damaged in the impact and some by the ensuing fire. The rotor and engine combined tachometer had a captured main rotor speed indication of 100%. The engine rpm indication was beyond the upper range of the gauge. This instrument had been subject to substantial heating. The rotor rpm reading was captured by mechanical damage. The airspeed indicator had a captured reading of 52 knots.

1.12.12 The position of the collective lever and throttle at the time of the impact could not be established as most of the structure in the cockpit area was destroyed by fire.

1.12.13 Examination of the main rotor hub indicated that the blades had flapped downwards in excess of 50 degrees from the horizontal and mast bumping had occurred in flight.

1.12.14 The blade pitch had been forced to a high negative angle due to the leading edge pitch horns being pulled downwards as the main rotor shaft failed prior to the tensile failure of the pitch control rods.

1.12.15 The pieces of debris collected from beneath the aircraft's flight path confirmed that the cockpit area had been entered by at least one main rotor blade in flight some 150 m prior to the aircraft's ground impact point.

1.12.16 Remains of the aircraft's fuel filter bowl assembly were found in a position which indicated that they had broken away prior to the aircraft falling onto its side. The duration and intensity of the fire indicated a significant quantity of fuel was on board at the time of the impact.

1.13 Medical and pathological information

1.13.1 Nothing was revealed in the pathological and toxicological examinations to suggest that the pilot was other than fit to conduct the flight.

1.14 Fire

1.14.1 The aircraft impacted heavily in a nose down attitude mainly on its right side. The engine was probably operating before it was brought to an abrupt halt by the impact, therefore ignition of fuel from the disrupted tank by contact with the hot exhaust, or sparks from metal contacts or electrical arcing were all possibilities. From whatever cause a fire erupted on impact and continued to burn until the arrival of the Towai Volunteer Fire Service 12 minutes after the emergency services were alerted by a passer-by on his cellular phone.

1.15 Survival aspects

1.15.1 The occupants were probably incapacitated, before the aircraft collided with the ground, by the main rotor blade which passed through the canopy. Even if they were not seriously injured at this point the severity of the impact and the rapid onset of the post-impact fire rendered this an unsurvivable accident.

1.15.2 The pilot was flying ZK-HDC from the right hand seat. Both he and the passenger were wearing a lap and diagonal upper torso restraint provided as standard equipment in the helicopter. The pilot was wearing a safety helmet which was damaged by the fire.

1.15.3 The intensity of the fire rendered the emergency locator transmitter unserviceable almost immediately after the aircraft's impact.

1.16 Tests and research

1.16.1 The aircraft's engine and transmission were examined in a bulk strip. These inspections revealed no defects or maladjustments which were likely to have lead to an engine malfunction but were subject to the limitations imposed by exposure to the post accident fire which destroyed much of the surrounding structure.

1.17 Additional information

1.17.1 The Robinson R22 Pilot's Operating Handbook and FAA Approved Rotorcraft Flight Manual, contained the following "Caution" in Section 2 Limitations:

"CAUTION

Avoid abrupt pull-ups in forward flight. When a pull-up (aft cyclic) is followed by a push-over (forward cyclic), a weightless (low G) condition may occur. If the aircraft starts to roll during this condition, **gently apply aft cyclic** to reduce the weightless feeling **before** using lateral cyclic to stop the roll."

1.17.2 Section 10 of the Robinson R22 Pilot's Operating Handbook entitled "Safety Tips" contained the following Safety Notice SN-11:

"R22 HELICOPTER SAFETY NOTICE SN-11

TO: All R22 Owners, Dealers and Pilot's Operating Handbook Subscribers

DATE: 18 October 1982

Abrupt pull-ups and push-overs can be catastrophic. A recent fatal accident was caused by a student pilot putting the helicopter into a low-G (weightless) flight condition. While he attempted to manoeuvre the helicopter with full cyclic inputs during the low-G condition, the rotor flapping at the teeter hinge exceeded design limits, causing extreme "mast bumping" and a fracture of the main rotor shaft.

CAUTION

In forward flight, when a pull-up (aft cyclic) is followed by a push-over (forward cyclic), a weightless (low-G) condition will occur. If the aircraft starts to roll during this condition, gently apply aft cyclic to reduce the weightless feeling **before** using lateral cyclic to stop the roll.

For cyclic control, light helicopters depend primarily on tilting the main rotor thrust vector to produce control moments about the aircraft centre of gravity (CG), so the helicopter will roll or pitch in the desired direction. In forward flight, when a pull-up is followed by a push-over, the angle of attack and thrust of the rotor is reduced, causing the low-G or weightless flight condition. During the low-G condition, the lateral cyclic has little, if any, effect because the rotor thrust has been reduced. Also, there is no main rotor thrust component to the left to counteract the tail rotor thrust to the right, and, since the tail rotor is above the CG, the tail rotor thrust will cause the helicopter to roll rapidly to the right. If the pilot attempts to stop the right roll by applying full left cyclic before regaining main rotor thrust, the rotor can exceed its flapping limits and cause structural failure of the rotor shaft.

The best way to prevent mast bumping is to avoid abrupt cyclic pull-ups or push-overs during forward flight. Always use gentle and sensitive cyclic control inputs and if you do have a feeling of weightlessness during a manoeuvre, gently bring the cyclic aft to regain main rotor thrust before lateral cyclic is applied."

1.17.3 A further Safety Notice (SN-17) in the same section, included the following paragraph:

"1.0 Do not experiment with low-G manoeuvres. Do not practice or experiment with low-G push-overs. Whenever any manoeuvres results in a feeling of weightlessness, immediately apply gentle aft cyclic to reload the rotor. Remember the low-G push-over can lead to mast bumping and in-flight failure of the main rotor shaft. **Don't play with it.**

The careful demonstration of a slight feeling of weightlessness followed by gentle aft cyclic is as far as a flight instructor should go during a safety checkout."

1.17.4 Civil Aviation Regulations 38, "Minimum Safe Heights" stated:

- "1. Subject to the provisions of these regulations, no aircraft shall be flown over any city, town or populous area except at such altitude as will enable the aircraft to complete a safe landing should engine failure or other cause necessitate a forced landing.
 2. Without limiting the provision of subclause (1) hereof, no aircraft shall be flown over —
- ... (b) Any other area at a lower height above the area than 500 feet."

2. ANALYSIS

2.1 Mr Willmot had advised the operator that his flight north from Auckland to Kaero had been routine even though he had commented to a friend that he was puzzled by a low rotor rpm warning on one approach to land. He had parked the aircraft in a secure location and carried out a careful pre-flight inspection prior to flying the aircraft to Kerikeri to refuel it for the flight to Auckland. No mention had been made of any problem to the person who assisted him with the refuel or to the operator when he telephoned him to request an extension of his period of hire of the helicopter, so he appeared satisfied that the aircraft was airworthy.

2.2 The pilot was aware that two of his friends would be travelling southwards by car at approximately the same time as he was transiting the route and may have flown the aircraft at a lower altitude than the approved minimum in an endeavour to spot them on the road and greet them as he passed. Alternatively as there was a 20 to 25 knot crosswind on his track he may have flown as low as practicable in an endeavour to minimise the headwind component to reduce the flying time. For whatever reason the aircraft was flown at between 50 and 100 feet agl as it crossed the rest area just prior to the accident.

2.3 The rest area was on the crest of a ridge which ran across the aircraft's track and rose some 100 feet above the general ground level to either side. Mr Willmot may have climbed the aircraft as he approached the ridge and then endeavoured to descend to his former altitude as soon as he had passed over the crest and/or he may have encountered an updraught created by the upward slope of the ground beneath the aircraft in relation to the prevailing wind and eased the cyclic forwards to regain his selected height above ground level.

2.4 While neither of these hypotheses was established it was known that if the main rotor of this aircraft was unloaded, as it would have been if the pilot used abrupt forward cyclic stick to pitch the aircraft forward, then the main rotor blades could flap downward and strike the cabin area as occurred in this case. There was clear evidence that the blades had struck the canopy in flight, that they had flapped in excess of 50 degrees down from the horizontal, that the blade hub had bumped the mast and that the main rotor head assembly with a section of shaft had separated in flight over a point immediately past the rest area on the crest of the ridge.

2.5 Mr Willmot had some experience on the Robinson R22 helicopter. He had a type rating for the aircraft, had gained his first 40 hours of helicopter

flying experience on the type and been checked out on the type before undertaking the flying in connection with his visit to Kaeo. However he had not flown the aircraft regularly since November 1989 and since that time had flown only two flights prior to his check flight so his experience on the type was not recent.

2.6 Nevertheless he had flown other types of helicopter in the interim and was in practice for helicopter flying techniques. His last period of instruction relating to low "G" recognition and recovery was flown on 28 August 1989, therefore in the event of the helicopter rolling it would be instinctive for him to attempt to return the aircraft to an even keel using cyclic stick. In the Robinson R22 it was essential to avoid this response if the roll was due to the tail rotor thrust combined with an unloaded main rotor as it would lead to excessive flapping of the main rotor blades.

2.7 As the aircraft was at a low level when the incident occurred the need to subdue the instinctive reaction and identify the cause of the roll to make the appropriate but unnatural corrective action with aft cyclic may have been beyond the inexperienced pilot.

2.8 The operator who conducted Mr Willmot's check flight, personally, three days before the accident stated that he had reminded the pilot of the dangers of unloading the main rotor of this aircraft by forward pressure on the cyclic during the cruise. The recognition and recovery from this situation had been taught to Mr Willmot during his training in August 1989. However the effect and the corrective measures to be taken to prevent such a situation were not demonstrated again.

2.9 The information in the Robinson R22 Pilot's Operating Handbook and FAA Approved Rotorcraft Flight Manual indicated that mast bumping would result in a failure of the main rotor shaft. While mast bumping was evident in this case the shaft had failed at a position on the shaft 53 mm below the point at which damage from the bumping had occurred. In this case the overload failure of the shaft was caused by the shock loading from the main rotor blade striking the cabin during the course of the mast bumping as there was no evidence of material failure but a continuous trail of debris confirming the inflight strike by the main rotor blades on the cabin side.

2.10 The manufacturer referred to the hazard associated with low g flight in the aircraft owners' operating manual and the erstwhile Office of Air Accidents Investigation had drawn the attention of New Zealand operators to this hazard following an accident in 1987 but these actions were, evidently, insufficient to prevent further mishaps.

2.11 Once the main rotor blade struck the cabin there was nothing the pilot could have done to avoid the accident or to increase the occupants' chances of survival.

3. FINDINGS

3.1 The aircraft was correctly maintained and airworthy prior to the main rotor blades striking the aircraft's canopy

- 3.2 The pilot was properly qualified to conduct the flight
- 3.3 The pilot flew the aircraft below the minimum height approved by Civil Aviation Regulations for such flights
- 3.4 The operator had stated that he reminded the pilot of the hazards of low g or negative g flight
- 3.5 The operator was entitled to complete the pilot's type rating flight test report form without completing the appropriate flight test.
- 3.6 The probable cause of this accident was that the pilot failed to recognise that he had inadvertently entered a low g flight regime which caused the aircraft to roll. Consequently he endeavoured to right the aircraft by applying left cyclic without first restoring positive loading to the main rotor blades. Other factors were the pilot's inexperience on type and a lack of awareness of the helicopter's vulnerability to low g flight.

4. SAFETY RECOMMENDATIONS

4.1 It was recommended to the Air Transport Division of the Ministry of Transport that:

They review the flight test requirements for ratings on the R22 aircraft to ensure appropriate knowledge of this peculiarity of the Robinson R22 aircraft's behaviour and the appropriate recovery technique is understood by all applicants.

5. REGULATORY

5.1 Pursuant to Section 14(5) of the Transport Accident Investigation Commission Act 1990 the operator and the legal personal representatives of the pilot in command were invited to avail themselves of the opportunities afforded to them thereunder.

5.2 As a result of representations received the report was amended and amplified to clarify some of the points raised.

5.3 The representations made to the undersigned are not to be taken as an admission of liability on the part of the parties concerned and their statements are without prejudice to their right to act in any way they may consider fit in any proceedings or action which may be based on the events to which this report refers.

22 August 1991

M F DUNPHY
Chief Commissioner