CIVIL AVIATION AUTHORITY
OF NEW ZEALAND

AIRCRAFT ACCIDENT REPORT

OCCURRENCE NUMBER 04/39

ROBINSON R22 BETA

ZK-HXT

10km NORTH EAST OF TAUPO

10 JANUARY 2004

Glossary of abbreviations used in this report:.

AGL	Above Ground Level
AMSL	Above Mean Sea Level
CAA	Civil Aviation Authority
CAR	Civil Aviation Rule(s)
ft	foot or feet
hPa	hectopascals
kg	kilogram(s)
km	kilometre(s)
m	metre(s)
NE	North East
Nm	nautical mile(s)
NZDT	New Zealand Daylight Time
NZST	New Zealand Standard Time
PPL(H)	Private Pilot's Licence (Helicopter)
RHC	Robinson Helicopter Company
RPM	Revolutions per minute
USA	United States of America
UTC	Coordinated Universal Time
WGS 84	World Geodetic System 1984

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Aircraft type, serial number and registration:	Robinson R22 Beta ZK-HXT
Number and type of engines:	1 Lycoming O-360-J2A
Year of manufacture:	2000
Date and time:	10 January 2004, 1130 hours[1] (approx)
Location:	Near Lake Rotokawa , 12 km NE of Taupo Latitude[2]: S 37° 14.4' Longitude: E 175° 14.1'
Type of flight:	Private
Persons on board:	Crew: 1 Passengers: 1
Injuries:	Crew: 1 fatal Passengers: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot's licence:	Private Pilot Licence (Helicopter)
Pilot's age:	50 years
Pilot's total flying experience:	200.45 hours, 22 on type
Information sources:	Civil Aviation Authority field investigation
Investigator in Charge:	Mr T.P. McCready

[1] Times are NZDT (UTC + 13 hours)

[2] WGS 84 co-ordinates

Synopsis

The Civil Aviation Authority was notified of the accident at 1000 hours on 12 January 2004. The Transport Accident Investigation Commission was in turn notified, but declined to investigate. A CAA site investigation was commenced that day.

The private helicopter with two persons on board left Taupo airport at 1114 hours on 10 January and, although subsequently seen over Taupo township was not seen again after leaving the area and was reported overdue that evening. During the next two days the helicopter was the subject of an extensive aerial search operation by helicopters in the Taupo/Rotorua region.

The accident scene was discovered on 12 January by an agricultural truck driver working on a farm paddock 12km north east of Taupo. Both occupants had been fatally injured.

1. Factual information

1.1 History of the flight

1.1.1 The helicopter with its two occupants departed Taupo airport after refuelling and initially flew along the Taupo lake front, then overhead the Taupo race course, and then departed the township towards the north east.

1.1.2 Recorded radio transmissions suggested a flight to Te Puke was intended. Both the pilot and his passenger had various appointments later that afternoon and when these were not kept, the alarm was raised later that evening.

1.1.3 As no flight plan, detailed intentions, or witness sightings were available, an extensive aerial search by helicopters was necessary between Taupo and Te Puke. This proved challenging, given the large geographical area and many heavily forested areas to be searched. The search was complicated by the area having a lot of daily helicopter traffic, so a number of unrelated helicopter sightings had to be investigated. The wreckage was eventually discovered in the vicinity of high voltage power line pylons, by the truck driver 12km north east of Taupo near Lake Rotokawa.

1.1.4 Some days later a group of youths who had been swimming in the nearby Waikato River came forward with a description of loud banging and whacking sounds that they attributed to a helicopter noise which had ceased suddenly. Although they never sighted the helicopter, given the close proximity to the accident site, which was blocked from their view by a stand of pine trees, it is highly probable that they heard the accident. This indicates that the accident occurred at about 1130 hours on 10 January, when the helicopter was outbound from Taupo airport and only about 15 minutes into the flight. The late

notification was due to the youths being on holiday, not listening to the news, and therefore being unaware of the search.

1.1.5 The accident occurred in daylight, at approximately 1130 hours , near Taupo, at an elevation of 1170 feet. Latitude: S 37° 14.4', longitude: E 175° 14.1'

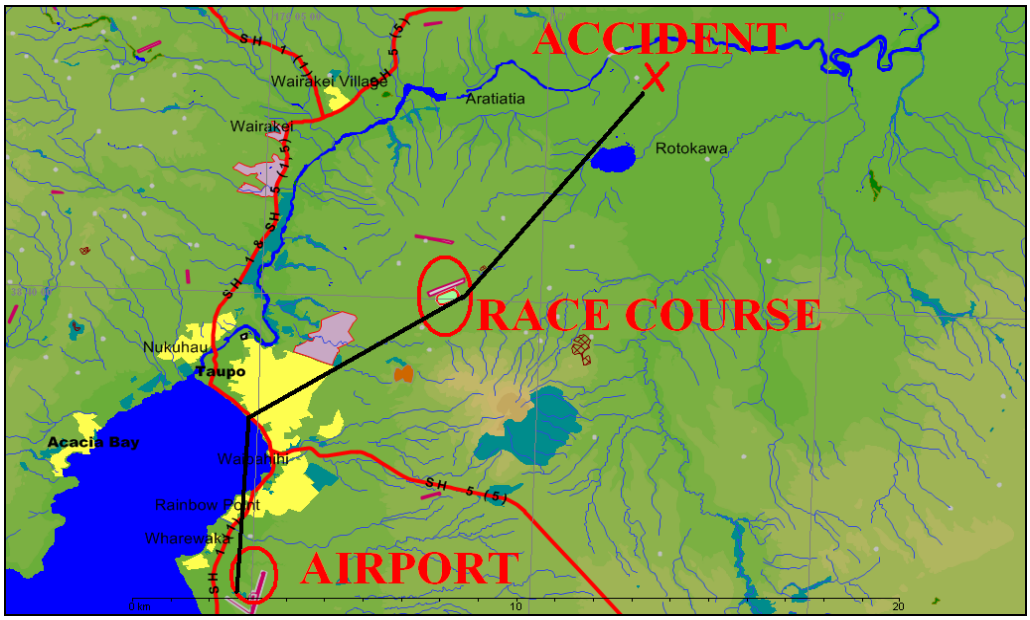

Figure 1: Flight was from runway 17 at Taupo Airport to the lake front and overhead the race course to the accident site NE of Lake Rotokawa.

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	1	1	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 Nil.

1.5 Personnel information

1.5.1 The pilot, aged 50 years, held a Private Pilot Licence (Helicopter) and a Class 2 medical certificate which is appropriate for that licence. It was valid to 15 September 2004.

1.5.2 At the time of the accident the pilot had recorded a total of 200.45 flying hours, all of which were in helicopters. The total hours were comprised of 100 dual instruction hours and 100.45 solo hours. The last recorded entry in his logbook was 6 January 2004, four days before the accident.

1.5.3 The pilot's initial helicopter training began on the Hughes 269 (commonly referred to as the Hughes 300) in 1996 where in a concentrated period between 12 February and 25 April he recorded 28.6 hours dual instruction and 5.6 hours solo. He then did no further flying for approx 15 months until 5 August 1997 when he received dual instruction on a Hughes 369 of 1.4 hours. This helicopter type is commonly referred to as Hughes 500. The pilot then again ceased flying for a lengthy period until late 2002.

1.5.4 The pilot recommenced regular training from 1 September 2002 until obtaining his Private Pilot Licence (Helicopter) 7 ½ months later on 17 April 2003, having recorded 98.2 total flying hours which included 20.4 solo hours. All of this latest phase of training was conducted on the pilot's own C and E model Hughes 369 helicopters.

1.5.5 A week after obtaining his PPL (H) the pilot was introduced to the R22 helicopter, having purchased and imported ZK-HXT. This was the first time that he had flown the R22 helicopter. The R22 training comprised of:

23 April	2.7 dual	Cross Country
25 April	0.6 dual	type rating training
2 May	0.4 dual	type rating training
14 June	0.7 dual	type rating training
TOTAL	**4.4 dual (including 1.7 type rating)**	
14 June	0.3 solo	type rating

1.5.6 No further dual instruction on the R22 was recorded and the pilot flew the R22 infrequently for the rest of the year, doing most of his flying in his larger Hughes 369E helicopter.

1.5.7 At the time of the accident the pilot's recorded R22 time (all in his own R22 Beta II helicopter) was 4.4 hours dual instruction and 17.6 hours solo. 6.2 hours of these solo hours were flown during the month preceding the accident

1.5.8 When the R22 type rating was issued, an entry in the pilot's logbook stated "Robinson R22 Safety Awareness Training carried out IAW Part 61 and R22 Flight Manual including low RPM recover in hover and forward flight low G and advanced autos." This entry was undated, but signed by the pilot's instructor.

1.6 Aircraft information

1.6.1 The Robinson R22 Beta II helicopter serial number 3060 was manufactured in March 2000 and operated in the USA until 966.1 airframe hours.

1.6.2 It was then sold to the accident pilot, imported into New Zealand in April 2003, and issued an Airworthiness Certificate. During its post shipping assembly a 500 hour inspection was carried out. In September 2003 a 100 hour inspection was completed and on 26 December 2003 a cargo hook was fitted at 1141 airframe hours.

1.6.3 The engine, Lycoming 0-360-J2A serial number L37274-36A, was manufactured in January 2000 and fitted new to the helicopter when it was manufactured in March 2000.

1.6.4 During assembly in New Zealand two cylinders were removed due to worn cylinder exhaust guides. These were repaired, but the work was regarded as routine maintenance.

1.6.5 The helicopter had flown approximately 187 hours in New Zealand over a 10 month period.

1.7 Meteorological information

1.7.1 The weather was fine with blue skies and little or no wind so weather is not considered to be a factor in this accident

1.8 Aids to navigation

1.8.1 Nil.

1.9 Communications

1.9.1 After lifting off from the Taupo Airport fuel pumps at 1114 hours the pilot made a number of position reports over Taupo township. All of these radio transmissions were recorded by the Taupo Unicom. The last call at 1121 hours recorded "now overhead race track at 2,200 feet on track through to Te Puke"

1.10 Aerodrome information

1.10.1 Nil.

1.11 Flight recorders

1.11.1 Nil.

1.12 Wreckage and impact information

1.12.1 The helicopter impacted the ground fully inverted, nose down and was compacted deeply into the freshly cultivated soil. No other impact marks were discovered on the ground.

1.12.2 A wreckage trail consisting of cabin contents and small shattered perspex pieces from the left side of the cabin led to the impact point. The pilot's windscreen, which had popped out of the airframe as one complete and intact unit, was found on the left side of the trail.

1.12.3 Examination of the aft section of the helicopter indicated that the tail rotor blades struck the ground with little or no rotation, indicated by the slight static bending of one blade. The other blade appeared undamaged. Static witness marks on the tail rotor driveshaft upper half also indicated an inverted impact with little or no driveshaft rotation. The lack of rotation remained consistent with examination of the upper pulley and flexible couplings. The engine cooling fan indicated no rotation of the engine at impact.

Figure 2 Tail section showing crushed vertical upper fin from inverted impact and no evidence of tail rotor rotation.

1.12.4 The tail boom was not struck by the main rotor blades. The blades remained with the wreckage but had suffered various bending failures as they had struck the ground first (due to the helicopter being inverted) and the fuselage impacted down into the blades. The rotor hub examination revealed that one spindle tusk, which acted on the static stop, had been broken. This allowed one main rotor blade to swing lower than normal out of the plane of rotation and cause extensive damage to the cabin area.

1.12.5 The cabin area was severely damaged initially due to blade impact and then ground impact. Examination indicated at least three separate main rotor blade strike paths. The first was at the top of the passenger roof and was indicated by the dark coloured perspex that was found early in the wreckage tail. The second strike was at the height of the instrument panel and cut the left door completely through, just above the door latch. The third strike contacted the centre line of the cabin at floor level indicated by blue paint transfer to the blade from the blue trim line going around the nose of the helicopter. The blade on this third strike line also struck the passenger's tail rotor pedals and then the left side front cross tube.

1.12.6 The fuel selector was in the OFF position.

1.12.7 The pilot's windscreen assembly was examined and rubber marks, similar to tyre marks, ran up the inside of the screen and then abruptly changed direction.

1.12.8 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.

1.13 Medical and pathological information

1.13.1 Post-mortem examination showed that both occupants died of multiple fractures and internal injuries consistent with an aircraft crash.

1.13.2 No samples were available for toxicology tests due to the length of time elapsed in finding the helicopter.

1.14 Fire

1.14.1 Fire did not occur.

1.15 Survival aspects

1.15.1 The accident was not survivable. The R22 is a light helicopter and there is no crashworthy cabin structure that is designed to assist in an inverted impact. Once the spindle tusk in the rotor head is broken, the main rotor blades are free to pass through the cabin. This requires the main rotor disc to be significantly out of plane and the teeter limit of the hub to exceed a 12 degree limit. At 530 main rotor RPM this equates to 17 blades per second passing the cabin. Striking of the cabin can occur in less than half a second once the blades are out of plane.

1.15.2 The 121.5 MHz ELT did not activate and was found smashed in the wreckage. No flight plan was lodged or flight following information available. Neither was required under the current Civil Aviation Rules.

1.16 Tests and research

1.16.1 A strip-down examination of the engine at an engine overhaul facility revealed no obvious fault with the engine. Examination of the filter, spark plugs, and internal components indicated that the engine was running normally until the start of the accident sequence.

1.16.2 The discovery of an inwardly crushed push-rod cover, which had contacted the push rod and left only static marks, confirmed that the engine was not running at the time of impact.

1.17 Organisational and management information

1.17.1 Nil

1.18 Additional information

1.18.1 The Robinson R22 is a very popular helicopter and is operated in large numbers throughout the world. During the early production years a number of accidents occurred, primarily due to inexperience with some of the helicopter's unique handling characteristics. The R22 is a light weight helicopter and highly responsive in pitch and roll to small flight control inputs. In response to the accident rate, Robinson Helicopter Company issued safety notices, introduced factory instructor training specific to the helicopter type, and conducted factory

pilot training. The company also produced a safety awareness video for use in training which outlines manoeuvres and flight profiles to avoid.

1.18.2 The CAA approved Flight Manual contains a limitation section which details safety awareness training requirements. Paragraph (c) states that "safety awareness training must cover theory and flight practice of a number of topics including :

(ii) low 'g' hazards, including the factors which can lead to mast bumping.

The section also contains a note that low 'g' hazards training shall not under any circumstances be demonstrated or practised in the air.

Section 10 of the Flight Manual contains further safety information, including safety notice number 11 which deals with "Abrupt pull ups and push overs".
This notice describes in detail the dangers of the low 'g' hazard condition and how to avoid it.
Because of the dangers associated with low 'g' manoeuvres these can only be briefed on the ground and not practised in the air.

The limitations section also specifies a total of 3 hours training before a pilot is allowed to carry passengers, unless the pilot is the holder of another Robinson Helicopter type rating.

1.19 Useful or effective investigation techniques

1.19.1 Nil.

2. Analysis

2.1 The helicopter was found lying inverted, having initially impacted the ground in that position with a high vertical descent component. The helicopter becoming inverted in flight is unusual; photographs of R22 accidents will generally show the helicopter on its side. This is because the weight distribution of the R22 is bottom heavy, with the engine mounted low in the fuselage, so it is not dissimilar to a shuttle cock which always falls heavy end first. Accordingly, a helicopter that initially impacted inverted indicates that a considerable aerodynamic upset occurred.

2.2 There was no rotational damage to the cooling fan, which is directly coupled to the engine, and the push rod cover internal crushing to the push rod showed only static interference. The tail rotor drive-train also indicated little or no rotation at impact. These facts confirm that the engine was not running at impact.

2.3 The inverted impact, combined with engine and drive-train indications, account for the lack of engine rotation. Any prolonged inverted flight will cause the float in the fuel carburettor to close off the fuel supply to the engine, stopping it.

2.4 The injuries to the occupants indicate that they were thrown to the left of the cabin. The black 'tyre' marks on the inside of the pilot's windscreen from the soles of his footwear, suggest that his feet left the tail rotor pedals, contacted the windscreen, and abruptly changed direction. This is consistent with experiencing a very low 'g' situation, followed by the helicopter rapidly rolling right and the occupants being flung to the left. The severity of such a roll is dependent on the amount of power being applied at the time. Low 'g' is characterised by a light feeling in the stomach, similar to driving a car over the crest of a hill at high speed.

Figure 3: Pilot's windscreen with footwear marks. Note abrupt change in direction.

2.5 After the rapid roll to the right the helicopter momentum would be sufficient to continue to the inverted attitude cutting off the engine fuel supply in the carburettor and in turn any driving force to the drive-train.

2.6 The rapid roll to the right (sometimes as fast as 100 degrees per second) is well presented in the Robinson Helicopter Company R22 Safety Awareness Video, which attributes this roll to encountering a low 'g' situation. The video shows that, as the main rotor becomes unloaded in the approximate horizontal plane;

the tail rotor is still being driven in the vertical plane, thrust from the tail rotor will drive the helicopter to roll to the right. This low 'g' situation is pilot-induced by abrupt pushing forward of the cyclic control, resulting in the main rotor disc becoming unloaded and unstable. The corrective action is to reload the rotor disc by applying aft cyclic. It should be noted that the speed of the roll is directly proportional to the power applied to the tail rotor, so a rapid roll is likely to be from high power being applied.

2.7 The low 'g' push over manoeuvre is prohibited in the R22 helicopter. It is well publicised by warning decals in the cabin, the Safety Awareness Video, specific training requirements and advisory service letters and Flight Manual publications from the manufacturer. This pilot was inexperienced in the R22 with only 20 hours on the type. Most of his 200 hours flying had been conducted in the Hughes 500 helicopter, in which the rotor head does not react to this low 'g' situation so readily.

2.8 The last recorded radio transmission gave a reported altitude of 2,200 feet AMSL overhead the Taupo race track, which is approximately 1,000 feet above ground level (AGL). It is likely that the helicopter descended towards Lake Rotokawa which is a scenic geothermal lake. The likelihood of the aircraft being at a lower altitude at accident initiation is supported by the narrow "footprint" of the wreckage trail. An in-flight break up from 1,000 ft AGL would have produced a much wider footprint area of wreckage distribution. The fact that the helicopter, although close in proximity to the youths at the river, was not seen by them also points to a low level approach (based on the likelihood that the noises the youths heard could be attributed to the accident).

2.9 Assuming the helicopter had descended towards Lake Rotokawa the pilot would have noted a group of high voltage transmission power line pylons in his vicinity. If he opted to climb rather than to turn away, the low 'g" push over could have been a reaction to decreasing airspeed at the top of a cyclic climb. That would be consistent with the high vertical descent to the impact as little forward speed was evident. If normal speed was present some bouncing and rolling could be expected over the flat open farmland after impact.

Figure 4: The flight path from the race course required a turn to align with the wreckage trail. Note the small "foot print" of the wreckage trail and two circuits of the paddock by the fertiliser truck.

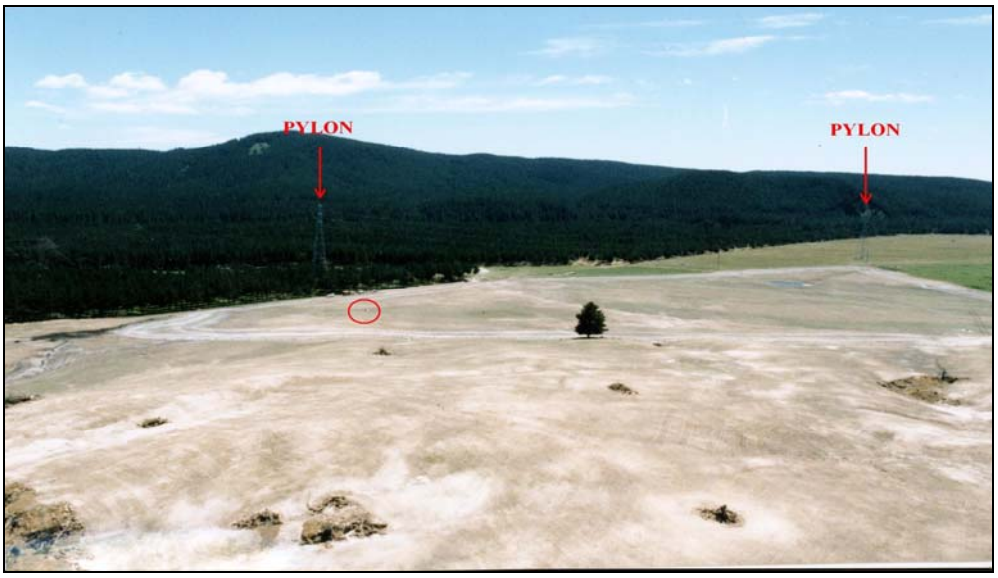

Figure 5: View along the approximate flight path of the helicopter. Note the transmission power lines. R22 accident site is circled in red.

2.10 During a helicopter accident sequence it is common for the main rotor blades to contact the tail boom. No such contact occurred during this accident, suggesting that the main rotor disc was tilted well forward. This also points to a low 'g' push over.

2.11 The main rotor head was examined in detail. The fracture of one of the main rotor droop stop tusks is consistent with an unstable main rotor allowing

excessive deflection of the blade and heavy contact between the tusk and the mast-mounted stop. The tusk broke during this sequence and, once broken, enabled the blade to move out of the normal plane of rotation and contact the cabin.

2.12 Numerous R22 helicopters have had accidents in New Zealand, and research into a number of those accidents reveals that, only one low 'g' accident was found to have occurred in New Zealand. This was near Hukerunui, south of Whangarei, on 4 January 1991 and is detailed in TAIC Report 91-001.

2.13 As part of the investigation the helicopter Flight Manual was reviewed. The limitations section of the Manual contains the following specific training requirements: *Pilots undertaking a type rating on an R22 helicopter shall not carry passengers until at least 3 hours have been logged under training, unless the pilot is the holder of another Robinson Helicopter type rating*. The intent of the requirement is to provide minimum training guidelines; however the type of training is not specified. The pilot had received the training specified in the Flight Manual and no direct link can be inferred between the type of training undertaken and factors in the accident; however, a review of the information indicates that the wording could be improved to specify in detail the type of training to be conducted.

2.14 The helicopter was fitted with dual controls. This is not a recommended practice in the R22 when flying with passengers and the Flight Manual pre flight check contains a caution to that effect. It was considered possible that the passenger may have been allowed to control the helicopter and over controlling and abrupt inputs may have led to a low 'g' situation. No definitive evidence was obtained to support this.

2.15 Finding the fuel cock in the OFF position created some concern during the initial stages of the investigation. However this was eliminated when paint transfer was found between the red fuel cock and the airframe, indicating ground impact induced airframe twisting, moving the fuel cock to the OFF position.

3. Conclusions

3.1 The pilot was appropriately licensed and rated for the flight.

3.2 The helicopter had a valid airworthiness certificate and had been maintained in accordance with CAA rules.

3.3 An uncorrected low 'g' situation is likely to have initiated the accident sequence. The reason for the low 'g' situation could not be determined.

3.4 The pilot had limited experience on the R22, having done the majority of his flying on the Hughes 500 series helicopter.

3.5 While the limitations section of the Flight Manual specifies minimum dual instruction before carrying passengers to be 3 hours, the type of instruction is not specified.

3.6 The R22 training requirements, combined with various notifications, all warn about the consequences of a low 'g' situation, and how to avoid or correct for it; these instructions are comprehensive and adequate.

3.7 Dual controls were fitted. This was not in accordance with accepted practice or the Flight Manual caution when carrying a passenger.

4. Safety actions

4.1 The CAA has begun the process of changing the wording in the Limitations section of the R22 Flight Manual.

Para 3 currently details the requirement that:

"Pilots undertaking a type rating on an R22 helicopter shall not carry passengers until 3 hours have been logged under training, unless the pilot is the holder of another Robinson Helicopter type rating."

The paragraph will be amended to read:

"Pilots undertaking a type rating on an R22 helicopter shall not carry passengers until 3 hours of dual instruction training as per AC 61-1.10 Appendix VII have been logged, **excluding cross country time**."

Authorised by

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14/5/2007

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