No: 12/91 **Ref: EW/C91/9/2** **Category: 2c**

Aircraft Type and Registration:	Robinson R22 Beta, G-BSHF
No & Type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1990
Date & Time (UTC):	8 September 1991 at 1600 hrs
Location:	Welford-on-Avon, Warwickshire
Type of Flight:	Private (training)
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - Fatal Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence (Aeroplanes) Commercial Pilot's Licence (Helicopters) - lapsed
Commander's Age:	30 years
Commander's Flying Experience:	Total flying : 2,473 hours Fixed Wing : 2,198 hours Rotary Wing : 275 hours (of which 2 were on type)
Information Source:	AAIB Field Investigation

History of Flight

The pilot had completed his initial training on helicopters in the Royal Navy but left the service after two years, having flown some 109 hours, to pursue a career in civil aviation. With his CPL (H) training complete, he joined a company operating helicopters for North Sea oil support but, after two months and having flown 108 hrs, he was made redundant. He then decided to concentrate on fixed wing flying, eventually becoming a Flying Instructor Course instructor.

On the day before the accident the pilot had been briefed on the Robinson R22 and its differences from other helicopters. He flew the helicopter for two hours five minutes (of which one hour 35 minutes was with an instructor). During the dual instruction he was shown and practiced steep turns, vortex ring, practice forced landings and autorotation exercises. He was assessed by his instructor as being "an unusually able student who's airmanship and checks were immaculate. He handled the controls unaided from and including the first take off".

On the 8 September 1991 the pilot was given a preflight briefing prior to carrying out a dual training flight taking off at 1510 hrs. Having revised autorotations, practice forced landings and emergencies, he landed back at Wellesbourne at 1544 hrs. The pilot was then briefed to return to the area of Stratford disused airfield to carry out "a couple of autorotations from 2000 feet to recover no lower than 1000 feet and to return to land at Wellesbourne no later than 1610 hrs". With the engine still running, the instructor secured the passenger harness and vacated the helicopter. The pilot departed at 1545 hrs for the 25 minute solo flight. The weather at the time, confirmed by an aftercast obtained from the Meteorological Office at Bracknell, was clear skies, good visibility, surface temperature 22°C with light and variable winds.

At 1559 hrs the helicopter was seen by several witnesses travelling in straight and level flight, with the engine sounding normal, at a height estimated to be between 1500 feet and 2000 feet approximately from northeast to southwest over the village of Weston-on-Avon. The helicopter was then seen to yaw suddenly, first to the right through 30° then back to the left 60°. A loud noise was heard, described by some witnesses as a bang, crack or pop followed by a clattering or spluttering. The helicopter was then seen to pitch nose down as the tail rotor assembly and sections of the tail boom fragmented from the main body. The main rotor blades were seen to flail and cease rotation with them stopping both together behind the helicopter cabin. One rotor blade was then seen to separate from the machine as it entered a vertical dive, rotating as it descended. Witnesses stated that there was no sound from the engine during this descent. At approximately 200 to 300 feet above the ground the pilot was seen to fall out of the cabin landing some 15 metres from the main wreckage. The aircraft cabin and engine came to rest in an upright position and there was no subsequent fire. The accident, which occurred at 1600 hrs, was seen by more than a dozen witnesses several of whom proceeded to the crash site to render assistance but the pilot had received fatal injuries. The emergency services were notified and were in attendance within 19 minutes.

Engineering Investigation

The wreckage of the helicopter was spread across some 200 metres in stubble, predominantly in an east to west direction. Most of the wreckage trail consisted of pieces of tail boom structure. The main wreckage was slightly to the south of the major axis of the wreckage trail, as was one rotor blade which had become detached.

The main wreckage had impacted tail first, but essentially upright. The rotor mast had failed in a rearwards direction, due to impact forces. A large degree of vertical crushing was evident. Examination of the helicopter on-site and later at the AAIB facility at Farnborough did not reveal any pre-existing technical defect in the structure, flying controls, engine or transmission.

It was found that the engine had been stopped at impact. This is consistent with the witness reports of the rotor being stopped which in turn had stalled the engine. The droop stops, which normally bear against pads attached to the rotor mast, had been distorted due to downward bending of the blades. Analysis of the indicator warning lamps on the panel showed that the low rotor warning lamp and the alternator lamp had been illuminated. It was not possible to examine the oil lamp or the clutch engaged lamp due to damage and the others were not illuminated. At impact the carburettor heat was in the "cold" position and the mixture was set to full rich. Deformation of the cruise trim control indicated that it was probably in the "cruise" position. The pilot's three point harness was found to be undone and undamaged. It showed no evidence of overstress or of any malfunction or defect likely to have caused the latch to open accidentally.

Several strikes of the tail boom by the main rotor were apparent. The initial strike was in the region of the warning arrows decal DANGER at the rear of the boom. Subsequent high energy strikes had occurred with the blade going through and under the boom, separating the tail assembly at an early stage in the sequence. As the tail assembly left the aircraft it had withdrawn the tail rotor drive shaft and tail rotor pitch control shaft from the boom. Further strikes on the boom occurred, with the blades bending downwards through about 45°. During this sequence a low energy blade strike occurred on the left hand canopy.

Safety Notices

The Robinson Helicopter Company issues, from time to time, Safety Notices arising as a result of previous accidents and incidents to the Robinson R22. These Safety Notices are included in the Pilots Operating Handbook to acquaint pilots new to the Robinson R22 with potential problems. Extracts of the relevant Notices are reproduced below:

Safety Notice SN-10 (Issued on 4 December 1981 and reissued on 4 October 1982).

The primary cause of fatal accidents in light helicopters, including the R22, is failure to maintain rotor rpm and airspeed. To avoid this, every pilot (including students and instructors) must have his reflexes conditioned so he will instantly add throttle and lower the collective lever to maintain rpm in any emergency.

When the pilot fails to add throttle and lower the collective lever, the rotor rpm rapidly decays, and the rotor stalls. If the pilot not only fails to lower collective, but instead pulls up on the collective to keep the helicopter from going down, the rotor will stall almost immediately.

When it stalls, the blades will either "Blow Back" and cut off the tail cone, or, it will just stop flying allowing the helicopter to fall at an extreme rate.

Rotor stall can occur at any airspeed. It is very similar to the stall of an aircraft wing at low speeds. As the airspeed of an aircraft reduces the angle of attack of the wings must be increased to produce the required lift to support the weight of the aircraft. At a critical angle, (around 15°) the airflow over the wing will separate and stall causing sudden loss of lift and a very large increase in drag. The same thing happens in a helicopter except it occurs due to low rotor rpm. As the rotor rpm gets lower and lower, the nose up angle of attack of the rotor blades must be higher and higher to generate the lift required to support the helicopter. Even if the collective lever it not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until the upward movement of the air through the rotor provides the necessary increase in blade angle of attack. Again at the critical angle the blade will stall resulting in the sudden loss of lift and a large increase in drag. The increase in drag acts like a huge rotor brake causing the rotor rpm to reduce even more, further increasing the rotor stall. As the helicopter begins to fall, the upward rushing air continues to increase the angle of attack on the slowly rotating blades making recovery virtually impossible even with full down collective.

When the rotor stalls it does not do so symmetrically because any forward speed of the helicopter will produce a higher air flow on the advancing blade than on the retreating blade. This causes the retreating blade to stall first allowing it to dive as it goes aft while the advancing blade is still climbing as it goes forward. The result is a rapid aft tilting of the rotor disc sometimes referred to as "rotor blowback". As the helicopter begins to fall, the upward flow of air under the tail surfaces tends to pitch the the aircraft nose down. These two effects, combined with aft cyclic by the pilot attempting to keep the nose from dropping will frequently allow the rotor blades to "blow back" and chop off the tail boom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of the rotor blades, hub flapping stops will not prevent the boom chop. The power on low rpm recovery procedure of simultaneously rolling on throttle while lowering the collective must become an automatic reaction to any indication of low rpm.

Safety Notice SN-11 (issued on 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 maneuver 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 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 a 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 "mast bumping" resulting in structural failure of the rotor shaft.