Robinson R22 Beta, G-BOEY

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Aircraft Type and Registration:	Robinson R22 Beta, G-BOEY
No & Type of Engines:	1 Lycoming O-320-B2C piston engine
Year of Manufacture:	1988
Date & Time (UTC):	16 January 1997 at 1806 hrs
Location:	Redhill Aerodrome, Surrey
Type of Flight:	Training
Persons on Board:	Crew - 1 - Passengers - None
Injuries:	Crew - 1 fatal - Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Student pilot
Commander's Age:	29 years
Commander's Flying Experience:	130 hours (of which 118 were on type)
	Last 90 days - 46 hours
	Last 28 days - 17 hours
Information Source:	AAIB Field Investigation

History of flight

The student pilot, a Nigerian national, was undergoing the nightflying phase of a formal course for the award of a United KingdomCommercial Pilot's Licence (Helicopter), (CPL(H)). He had beenbriefed for a solo circuit detail. The surface wind was calm,the visibility was 4,000 metres in haze, the temperature was +2°C and the QFE was 1006 mb. An aftercast gave the dew pointas +2°C.

Shortly before 1800 hrs, the pilot took over the aircraft on a'rotors running change' and called for permission to hover taxito the holding point of Runway 08. At 1804:30 hrs, he was givenclearance to line up; permission to take off was given about oneminute later. The Duty Instructor reported that the helicoptercarried out a 'normal night towering take off' to about 75 feetagl; his attention was then drawn away from 'EY'.

The evidence of two witnesses, who were just to the north of thetake-off flight path, indicated that the helicopter was only about100 feet agl as it approached the M23 motorway; it should havebeen at least 400 feet agl at this point. It was in a level attitudeand appeared to be flying normally, in an easterly direction. As it crossed the motorway, it turned right and began to descend. It then pitched steeply nose down and they heard the sound ofan impact shortly afterwards. One of the witnesses noted a regularand, to her, unusual sound from the helicopter which continuedto the point of impact; another witness also reported hearinga similar unusual sound.

Another witness, who was travelling south on the motorway, sawa helicopter pass from right to left across the path of the carin which he was travelling. He was mainly aware of the whiteand red lights but was able to say that it appeared to be flyinghorizontally. Once it had crossed the motorway, it started amanoeuvre which looked like a turn to the right, however, it immediatelypitched forward, 'cockpit down and tail in the air', and thendisappeared from view.

Radar data

Three primary returns from the Gatwick Watchman radar, were recordedin the area of the accident; the first at 1806:16 hrs and thelast at 1806:24 hrs. From these the track of the helicopter wasestimated to be about 090° and the ground speed about 51kt. The minimum height at which the Gatwick Watchman will 'see'an aircraft in this area is about 100 feet agl; the returns wereall from the area where the witnesses saw the helicopter at aheight which was visually estimated to be about 100 feet agl.

Examination of the wreckage

The helicopter had struck the ground in a level field immediatelyto the east of the M23 Motorway whilst travelling in a directionof about 130° magnetic; the ground was part frozen and fairlyhard. At impact, the aircraft had been steeply nose down andthe forward ends of both skids had broken off and remained embeddedat the point of impact. The angles of entry and remainder ofthe skid ends indicated that the aircraft had struck the groundabout 25° nose down, with a roll attitude about 20°to the right and slightly yawed to the right. As a result ofthe impact, it had yawed further to the right and rapidly pitchedfurther nose down. The forward part of the cabin was shatteredcompletely at initial impact and the pilot was thrown out. Apartfrom the fragments of the cabin, the only significant componentwhich had become detached and remained close to the initial pointof impact was the outer two feet of one main rotor blade.

Each of the main rotor blades had struck the ground to the rightof the aircraft, the two strikes almost overlaying each other. Their position, relative to the first mark of impact of the rotorhub, indicated that they had occurred before the rotor head hadstruck the ground. These two strikes were the only evidence ofmain rotor ground strikes.

After initial impact, the ground marks indicated that the aircrafthad then tumbled and rolled across the field for about 15 metresbefore coming to rest in a hedge and ditch which bounded the field. There was some smell of fuel at the accident site shortly afterit had occurred, but the fuel tank had been split open and verylittle fuel remained in it. There was no evidence of any preor post impact fire.

Examination of the wreckage on site revealed that both the mainrotor blades had bent upwards over the length between 1/3and 1/2 span, with 'crippling' of their uppersurfaces. Both blades were also slightly bowed backwards, fromjust outboard of the root to within 3 feet of the tip, with cripplingof the trailing edge. Whilst one blade had remained intact, theother had bent 90° downwards just outboard of the root end,with a failure of the upper skin at this position, and the outboardtwo feet of the blade had detached in a 'tip aft and trailingedge down' direction relative to the inboard portion of the blade. The overall damage to the main rotor was consistent with somerotation at impact but without significant energy.

Although the tail boom had been broken into three parts, the empennageand tail rotor were undamaged. Examination of the failures inthe tail rotor drive shaft showed them all to be the result ofbending, with only slight evidence of rotation of the shaft duringthe failure process. The cabin section had been completely crushedafterwards and the engine had thrown forward, distorting its mountings.

The aircraft was transported to the AAIB at Farnborough for moredetailed examination.

Detailed examination

Examination of the flying controls revealed no evidence of anypre-impact disconnection or other failure. Evidence of theirpositions at the time of impact was consistent with the collectivelever having been fully up and the cyclic control fully aft. Evidence of contact caused by impact crushing indicated that thethrottle control had been at, or very close to, the fully openposition at the moment of impact. The carburettor heat controlwas found extended to about 1/4 of its travelfrom the 'cold' setting.

Examination of the drive train did not reveal any evidence ofpre-impact failure or restriction. There was, however, littleevidence of persistent rotation of the drive train as the aircraft'sstructure had distorted at impact; this lack of evidence was particularlyapparent where the flanges of the drive shaft flexible couplingshad become trapped in the distorted structure. Similarly therewas only slight abrasion, indicative of rotation, on the enginecooling fan duct and the fan itself bore very little evidenceof post impact rotation on its vanes. The freewheel mechanismwas still functioning correctly and the main drive belts werein good condition. Comparison of the condition of the drivensurfaces of the belts with other used belts showed that therewas no significant evidence of slip against the pulleys. Becausethe clutch mounting had been severely distorted and the electricactuating mechanism disrupted, it was not possible to establishthe belt tension which had been applied by the clutch.

The fuel supply and breather systems were examined and found tobe free of pre-impact defects; the fuel selector was found inthe 'on' position.

The engine induction and exhaust systems had been severely damagedin the impact and the carburettor broken from the manifold throughthe butterfly spindle bearings. There was no damage to give conclusiveevidence of butterfly position at impact. The carburettor intaketemperature sensing system had been severely disrupted and itspre impact condition could not be established. The magnetos,although damaged, had not shifted as a result of the impact andboth were capable of generating energetic sparks at a relativelylow speed.

During strip examination of the engine it was noted that two ofthe cylinders (Nos 2 & 3) had reduced compression and a third(No 4) had virtually no compression. After the cylinders hadbeen removed from the crankcase, it could be seen that the combustionspaces all had encrustation consistent with prolonged lean mixturerunning. It was also noted that the piston crowns had the appearanceof having been operating at higher temperatures than is usualin this type of engine, particularly in the areas which came closestto the valve ports.

Leak testing of the combustion spaces indicated that all threeof the cylinders with low compression had poor sealing of theinlet valves. After removal of the valves, inspection showedthat the No 4 inlet valve seat, uniquely, had a single piece offoreign matter adhered to it and the general condition of thatseat was more degraded than that of the other inlet valves. Itwas also observed that the deposits on the wall of the inlet tractto the No 4 cylinder appeared qualitatively different from thedeposits of the other three cylinders, as did the deposit adheringto the back of its inlet valve head. This latter deposit appearedvery brittle and a sizeable piece of it, from close to the stem,had detached. The No 4 cylinder and inlet valve were sent forphysical and chemical analysis of these deposits together withthose from No 3, they being considered a representative exampleof the remainder.

The foreign matter on the No 4 valve seat was analysed and comparedwith a sample of accident site mud taken from the base of theengine sump where the carburettor had broken off. This showedthem to be of very similar composition and indicated that theengine was still turning sufficiently at impact for mud to bebeen drawn up the inlet tract.

The deposits from the inlet tract walls and the backs of the valveheads from the Nos 3 & 4 cylinders were subjected to physicaland chemical analysis. This showed that the deposit on the backof the No 4 valve head could be replicated in consistencyand composition by heating some of the deposit from the No 3 valvehead. The deposits from the two inlet tracts were found to bechemically similar and softened at the same temperature when heated;the deposit from the No 3 tract, however, gave off considerablymore sublimate. This indicated that the No 3 inlet tract hadprobably been operating at a significantly lower temperature.

Pilot's flying experience

The course allowed for up to 25 hours fixed wing flying over a5 week period, the remaining hours required to achieve the minimum150 hours for the CPL(H) being flown in the R22. The studentpilot started flying the Slingsby T67 on 10 April 1996 and finishedon 17 May 1996 when he had a total of 12 hours.

He started helicopter flying on 28 May 1996 and went solo on 5July 1996, after 16:25 hours. The night flying phase of the coursestarted on 6 January 1997 and he flew again on the 13 and 14 January. His total helicopter flying before the accident flight was 117:30hours, which included 2 hours dual and 3 hours solo at night.

The pilot had been assessed as a keen, hard working student whoprepared well for each flight. His last periodic report indicatedthat he knew the required techniques and could produce good results. It was predicted that he would have successfully completed thecourse to CPL(H) standard.

Medical and pathology

The pilot had a medical examination on 25 March 1996 and met therequired standard for a Class 1 medical certificate; for a commercialpilot under 40 years this is valid for 12 months from the endof the month of issue.

Post mortem examination revealed no pre-existing medical conditionwhich would have contributed to the accident.

Analysis

The characteristics of the accident and the condition of the wreckagewere all consistent with low rotor energy and a lack of enginepower at the time of impact. The aircraft had, however, justcompleted the previous detail with no apparent engine power problemsand had been observed to have lifted off normally on the accidentflight. The possibility of mishandling was considered but thepilot's recent experience of solo night flying suggested that,in the absence of unusual circumstances, this was unlikely.

Although the witness evidence indicated that the aircraft neverachieved an altitude of more than about 100 feet, at the estimatedtake-off weight the aircraft should have been able to achievea relatively high rate of climb with the engine power normallyavailable in the prevailing conditions. This, together with theunusual and regular sound reported by two witnesses, suggestedan engine power problem. However, any loss of power must haveoccurred suddenly since an apparently normal 'towering' takeoff had been made immediately before the witnesses saw and heardthe helicopter.

The examination of the helicopter and strip of the engine didnot reveal any fundamental faults or mechanical failures.

The weather on the night of the accident (100% humidity at +2°C)was conducive to carburettor icing and the helicopter had beenrunning for some time at a low throttle setting whilst the crewchange had been taking place, shortly before this take off. Thecarburettor would be at its most vulnerable to icing in such conditions;ice build up occurring around the butterfly and affecting theengine's ability to be accelerated. However, since the enginehad been accelerated for hover taxying and then further acceleratedto achieve the towering take-off, it would not appear to haveaccumulated significant induction ice whilst in this low powerstate. It appears, therefore, unlikely that carburettor ice wouldaccumulate at a rate which could seriously affect engine powerafter about 1 minute of high power flight, particularly with asignificant amount of carburettor heat applied, as was indicatedby the position of the carburettor heat control.

However, use of hot air to the carburettor at high power is knownto carry a risk of detonation if the intake air temperature limitationsare not adhered to strictly. The use of carburettor heat at powerdemands above flight idle is sanctioned by the engine manufactureron the basis of the carburettor temperature probe system beingfitted and operative. Although it was not possible to ascertainthe pre-impact serviceability of the system, the pilot on theprevious detail reported that it seemed to him to be working correctly. The appearance of the combustion spaces indicated persistentlean mixture running which inferred that the engine was habitually,but not unusually, hot running; the carburettors for the R22 typeengines are set-up to give a leaner mixture than that used formost applications of the manufacturer's engines.

The presence of a friable deposit, with a piece missing, on theback of the head of No 4 inlet valve suggested a potential mechanismfor an abrupt decrease of engine power. It is possible that thepiece of deposit which broke away from the valve head may havebecome lodged between the inlet valve and its seat. This wouldhave allowed burnt gas into the inlet manifold and grossly affectedthe inlet mixture to all cylinders. The occurrence of the friabledeposit suggested the presence, for some time, of the deterioratedvalve seat observed during examination of the engine, which hadled to a hotter than usual inlet valve in the No 4 cylinder. The reduction of volatile matter in the inlet tract deposits ofthat one cylinder was considered consistent with significant combustiongas blow back into the inlet tract in the short term.

The radar returns indicated that the helicopter had not climbedabove about 100 feet agl until clear of the airfield, indicatingthat the power loss probably occurred shortly after the transitionfrom the apparently normal towering take off to the initial climb. If a reduced performance had been recognised at the onset, theprudent solution would have been to land immediately while thehelicopter was still over the airfield. However, this would haverequired an immediate decision; to the student pilot there wouldalmost certainly have been a period of confusion during whichhe may have wondered whether he had made an error of omission.

During this period, the aircraft would have flown beyond the airfieldboundary where the pilot would then have been confronted by agenerally featureless blackness beyond the brightly illuminatedstrip of the busy motorway. In the reduced power situation, thepilot would have had to reduce the collective pitch and, consequently,power demand, in order to maintain the rotor energy. It is notpossible to say whether he had made an unsuccessful attempt toland beyond the motorway or that the power loss had led to a decayin rotor RPM and a subsequent loss of control.