Bell 206B Jet Ranger III, G-BAML

AAIB Bulletin No: 1/2004	Ref: EW/C2003/05/07	Category: 2.3
Aircraft Type and Registration:	Bell 206B Jet Ranger III, G-BAML	
No & Type of Engines:	1 Allison 250-C20 turboshaft engine	
Year of Manufacture:	1967	
Date & Time (UTC):	30 May 2003 at 1515 hrs	
Location:	Crag Lough, 4 miles North East of Haltwhistle, Northumberland	
Type of Flight:	Aerial Work	
Persons on Board:	Crew - 3	Passengers - None
Injuries:	Crew - 3 (Minor)	Passengers - N/A
Nature of Damage:	Helicopter destroyed	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	39 years	
Commander's Flying Experience:	993 hours (of which 538 were on type)	
	Last 90 days - 75 hours	
	Last 28 days - 25 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The helicopter was involved in relatively slow speed, low level aerial photography that involved it flying a straight track before turning right around a fixed structure of significant historical interest. The pilot carried out one practice run that was judged to be slightly too fast and too close to the structure. The second attempt proceeded without incident until, when half way around the turn, the helicopter began to yaw to the right. Application of corrective left pedal was ineffective and as the helicopter continued yawing right it descended. The rotation continued through several complete revolutions and it struck sloping ground at low forward speed rolling on to its right side. All three occupants were able to vacate the aircraft with only minor injuries. An engineering investigation failed to find any technical fault that could have accounted for the accident. There was evidence, however, that the helicopter may have been operating in a part of the flight envelope where the susceptibility to loss of tail rotor effectiveness was possible. Two safety recommendations, promoting the dissemination of literature relating to the loss of tail rotor effectiveness, have been made.

History of the flight

The operator had been contracted by a film company to provide a helicopter to support the filming of a TV series. On the day of the accident the helicopter departed Blackpool Airport, Lancashire and flew north to Grange-over-Sands where an engineer removed the right rear door and fitted an

approved camera mount. The fitting of the mount involved removing the helicopter's rear seats and providing a separate seat and harness arrangement in the rear seat foot well area for a cameraman. An airflow deflector was also fitted to the right rear door hinge to prevent buffeting of the camera in flight. During filming the cameraman was seated facing to the right of the helicopter with his legs over the door sill and feet resting on a footrest attached to the landing skids.

After installation of the camera mount the pilot and a cameraman flew from Grange-over-Sands to 'Milecastle 39' on Hadrian's Wall where the filming was to take place. By mid afternoon the pilot and cameraman had flown several filming sorties and flown to Carlisle to refuel. At approximately 1445 hrs the helicopter landed at 'Milecastle 39' to discuss the requirements for the filming of the next shot. This shot involved flying from west to east along Hadrian's Wall and then, on a call from the cameraman, flying a slow speed turn to the right around 'Milecastle 39'.

When the helicopter took off to carry out the task the weather was fine with a surface wind of approximately 140°/10kt, but there were thunderstorms and showers in the area some distance from the site. The pilot positioned the helicopter to the west of 'Milecastle 39' and commenced a practice run at about 40 kt and 300 feet agl to the north of the Wall. This area is 150 feet below the escarpment upon which the Wall stands. As the helicopter tracked from west to east the pilot applied left pedal and intentionally put the helicopter into a right sideslip to allow the cameraman to film straight ahead from the right rear door. At a point called by the cameraman, the pilot commenced a right turn around the Milecastle by neutralising the pedals and applying a small amount of right bank. During the turn the pilot aimed to maintain a constant aspect on the Milecastle to provide maximum stability for the cameraman. To achieve this he maintained a constant 'picture' in his right side window and used the pedals to adjust for the varying effect of the wind in the turn.

The practice run was completed without incident, but there were some vehicles on the ground that intruded into the shot and the film crew was asked to move them. The cameraman recalled that the turn around the Milecastle had been slightly too close and too fast. While the vehicles were moved, the pilot positioned for a second run. The run proceeded without incident until, about a half way around the turn, the helicopter yawed to the right. The pilot applied corrective left pedal but this was ineffective and the helicopter continued to rotate to the right. At this stage the pilot considered that the helicopter had suffered a tail rotor failure. He neutralised the pedals and then re-applied full left pedal, but the helicopter continued to rotate to the right. Realising that the helicopter was now out of control, he looked for a suitable place to carry out a crash landing. The top of the escarpment was slightly flatter than the area beneath him so he aimed the helicopter for the ridge. At a height of approximately 5 feet above the ground the pilot timed a cyclic movement with the helicopter's rotation to reduce the impact. When the cameraman realised that the helicopter was out of control he grasped the camera to prevent it causing damage to the other occupants during impact. The helicopter struck the ground at slow speed in a right banked attitude and rolled on to its right side. When it finally came to rest, the right side of the fuselage remained slightly elevated above the ground and the cameraman was able to exit beneath the helicopter fuselage. The occupant of the left front seat was able to open the left forward door and he and the pilot exited the helicopter.

During air-to-ground filming the pilot's attention is focussed largely on achieving the correct sight picture for the cameraman. Control movements tend to be instinctive to achieve the best possible results. After the accident the pilot considered that he might have had some right pedal applied when the helicopter initially started to yaw to the right. The cameraman felt that the second practice run was proceeding normally until the right yaw commenced. He noted however, that the speed on the second run seemed slightly slower than the first and he recalled a feeling that the helicopter was skidding during the turn with the nose pointing into the turn.

Meteorology

An aftercast provided by the Meteorological Office indicates that the surface wind in the area of the accident would have been 140°/10 kt varying to 150°/12 kt at 500 feet agl. There was cumulonimbus activity in the area during the period which produced rain showers and reduced visibility. With this

type of activity present there was a possibility of a gust front affecting the area. Although the Meteorological Office was unable to detect any charted evidence, the possibility of such a front affecting the area at the time of the accident could not be dismissed.

Wreckage examination

From photographs of the site taken by the police showing the location of the wreckage and ground impact marks, it appeared that the helicopter had hit the ground in a tail low attitude with low forward speed. The aft section of the tail boom together with the tail rotor gearbox and tail rotor had become detached. The helicopter had then rolled over coming to rest on its right side.

Examination of the wreckage by the AAIB was limited to the tail rotor system. There was evidence of rotation on the tail rotor drive shaft where it had been crushed as the aft section had detached. The drive shaft sections upstream and downstream of the fracture were still free to rotate. Tail rotor control is achieved by means of yaw pedals which are connected via push pull tubes and bell cranks to an hydraulic servo actuator in the rear fuselage. An additional push-pull tube connects the servo to the tail rotor pitch control mechanism. This control mechanism was still connected and functional from the pedals to the actuator. The push-pull output from the actuator was broken, which is consistent with the detachment of the aft section on impact. The tail rotor pitch mechanism was free to move. The hydraulic contents had been lost and no testing of the hydraulic system was possible.

It was possible to conclude that there was no evidence of any pre-impact failure in the tail rotor pitch control system, and the tail rotor drive shaft had been rotating at impact.

Loss of tail rotor effectiveness

In 1983 and 1984 Bell Helicopters issued an Operations Safety Notice (OSN 206-83-10) for the Bell 206 and two Information Letters on the subject of Low Speed Flight Characteristics Which Can Result in Unanticipated Right Yaw (referred to hereafter as loss of tail rotor effectiveness (LTE)). In July 1984, as a result of an accident to a Bell 206B, the National Transportation Safety Board recommended that the FAA should require Bell to include the contents of the OSN in the FAA approved flight manual for the Bell 206. The NTSB further recommended that a review should be carried out of Bell 206 compliance with the controllability requirements of the certification regulations of 14 CFR 27.143.

The FAA did not accept either NTSB recommendation. The FAA considered that the LTE phenomenon was '*generally applicable to all single main rotor/anti-torque rotor types'*, and that the information should be provided to all helicopter pilots and not just those flying the Bell 206. Accordingly, the FAA took steps to advise all US holders of helicopter pilot certificates of the potential for LTE on helicopters of similar design to the Bell 206. On the question of controllability, the FAA took the view that there was no need to carry out further checks on Bell 206 controllability since this had been done '*numerous times over the period 1963 and 1977'*. The FAA also stated that '*the OSN 206-83-10 and Information Letter 206-84-41 were not intended to imply that the existing tail rotor control margin is inadequate'*.

The important message to be extracted from these exchanges is that, notwithstanding the fact that a helicopter is in compliance with the controllability requirements of Part 27, there may remain parts of the flight envelope where there could be insufficient tail rotor effectiveness to maintain directional control.

In 1995, and in response to a number of helicopter accidents in the USA involving LTE, the FAA issued Advisory Circular (AC) 90-95 (see Appendix 1) on the Subject of 'Unanticipated Right Yaw in (US Manufactured) Helicopters'. The AC was based largely on previous Bell publications but also contained data from various military publications.

Most of the 'mishaps' to which the AC referred had occurred during low altitude, low speed flight while manoeuvring, and the AC identified typical operations during which the accidents occurred.

Pipeline inspection, agricultural spraying, traffic watch and movie and TV support flights were among the operations listed. In particular, flights at low altitude and low speed, during which the pilot may have been distracted from the dynamic conditions affecting control of the helicopter, seemed most susceptible. In most incidents, inappropriate or late corrective action may have resulted in the development of uncontrollable yaw.

The report identifies four possible relative wind directions and resultant aircraft characteristics that can, either singularly or in combination, create an environment conducive to LTE:

1. *Main rotor disc vortex interference occurs with a relative wind of 285° to 315° and involves changes in tail rotor thrust as the airflow experienced at the tail rotor is affected by the main rotor disc vortex.*

2. *Tailwinds from a relative wind direction of 120° to 240° will cause the helicopter to yaw into wind and may accelerate an established rate of yaw.*

3. *Tail rotor vortex ring state can occur with a relative wind of 210° to 330°. With the relative wind in this region, vortex ring state can cause tail rotor thrust variations.*

4. *Loss of translational lift with the relative wind in all azimuths results in an increased power demand and consequent increase in anti-torque demand from the tail rotor.*

The recommended recovery technique, if a sudden unanticipated yaw occurs, is to apply full pedal to oppose the yaw whilst simultaneously moving the cyclic forward to increase speed. If altitude permits, power should be reduced. The AC also makes the point that the tail rotor is not stalled and full pedal to oppose the yaw should be maintained until rotation stops.

Finally, the AC makes several recommendations on how to avoid the onset of LTE. In particular it advises that when manoeuvring at forward speeds between the hover and 30 kt, out of ground effect and with a high power demand, downwind turns should be avoided.

Although the Bell OSN was issued to all Bell 206 owners worldwide, the focus of LTE awareness has been largely in the USA. In the UK there has been little emphasis on the phenomenon, but most of the factors that can lead to LTE should be known by most UK helicopter pilots. However, the relationship of the various factors to the performance capability of Part 27 helicopters is probably less widely known. The pilot involved in this accident had been trained to cope with tail rotor failures, but he had not received training nor was he aware of the LTE phenomenon.

Discussion

The investigation found no evidence of mechanical failure in the tail rotor system. However, the pilot's evidence indicates that he lost control in yaw and was unable to prevent the helicopter from completing several revolutions before impacting the ground.

In the absence of any technical reason for this loss of control, it would appear possible that the pilot experienced LTE as described in the Bell Operational Safety Notice and highlighted by the FAA in their AC. A number of the criteria that can lead to LTE were present during the accident flight, but other factors may have been present, and in particular, it is impossible to rule out that the area may have been affected by gusts associated with thunderstorm activity.

Safety Recommendations

The generally USA based focus of previous LTE awareness efforts has meant that the phenomenon is not widely known in the UK and it is therefore recommended that the CAA take action to publicise information on LTE as widely as possible within the UK helicopter industry. However, the inherent drawback of such publicity efforts is that as time goes by, and new generations of pilots become qualified, the safety message can be lost. It is therefore recommended that the CAA should approach

the European Aviation Safety Agency (EASA) with a view to having information on LTE included in helicopter pilot training syllabi.

The following safety recommendations are made:

Safety Recommendation 2003-126

The CAA should publish, as widely as possible within the UK, information on the Loss of Tail Rotor Effectiveness (LTE).

Safety Recommendation 2003-127

The European Aviation Safety Agency (EASA) should ensure that information on Loss of Tail Rotor Effectiveness (LTE) is included in helicopter pilot training syllabi.