MAST rocking

The NTSB says intensified efforts are needed to find the cause of incidents of severe vibration in R44s.

BY LINDA WERFELMAN

The U.S. National Transportation Safety Board (NTSB), citing a 2009 accident involving severe vibration known as "mast rocking" in a Robinson R44, says the manufacturer should be required to identify the cause of the phenomenon and develop steps to avoid it.

Robinson Helicopter told NTSB accident investigators that, even before the agency issued its recommendations, it has begun flight tests to evaluate the problem, sometimes called "chugging."

The pilot of the accident helicopter — operated by the state of Alaska and being flown in visual meteorological conditions on May 12, 2009, by the Alaska State Troopers–Fish and Wildlife Protection on a game-management patrol — said that about 90 seconds after departure from a site 57 nm (106 km) northwest of Iliamna, Alaska, he felt an unusual vibration, mostly in the pedals, followed by a slight yaw.

"The pilot said the vibrations became oscillations, in both yaw and pitch, to the point he felt the helicopter was going to come apart," the NTSB said in a safety recommendation letter to the U.S. Federal Aviation Administration (FAA). "He said an emergency landing was his only option."

The pilot said he "fought to maintain control" of the helicopter during the emergency landing, and the helicopter touched down with a forward airspeed of 5 to 10 kt. The main rotor blades contacted the tail boom during the hard landing, causing substantial

damage to the helicopter, the NTSB said. The pilot and his two passengers were not injured.

The pilot's post-accident calculations indicated that the helicopter's weight had been below the gross weight limit but the center of gravity (CG) had been about 1.1 in (2.8 cm) forward of the forward limit.

The NTSB said the probable cause of the accident was "the main rotor transmission mount design, which resulted in an in-flight vibration/oscillation and damage to the helicopter during the subsequent emergency descent and hard landing." Contributing factors were "the lack of information from the manufacturer regarding this known flight oscillation, and loading the helicopter beyond the forward center of gravity limit by the pilot."

In both the safety recommendation letter to the FAA and in its report on the accident,[1] the NTSB quoted a Robinson Helicopter accident investigator as saying that the company already had begun flight tests to learn more about mast rocking.

"The tests determined that an oscillation may develop at high gross weight, [at] about 90 to 100 kt, and that the oscillation was more of a 'bucking' movement due to the fore-and-aft movement of the rotor mast," the NTSB said.

"According to the manufacturer, the tests determined that chugging could occur within the normal CG range, most typically at or near a gross weight with a CG near the forward limit."

The NTSB said that the manufacturer believed that the oscillation is "not destructive to the helicopter," that it can be attributed to "the degree of firmness of the transmission mounts" and that it can be mitigated when the pilot increases power to make possible a safe landing.

The Robinson Helicopter investigator said that he was aware of one mast-rocking event in which the helicopter was damaged. In that case, the helicopter was landed before the main rotor mast oscillations stopped; as a result, the top of the cabin was dented by "the fore-and-aft movement of the main rotor shaft fairings," the NTSB said.

The NTSB also quoted the manufacturer's investigator as saying that he was unaware of information provided by the manufacturer — in the form of alerts, bulletins, pilot training and a pilot operating handbook — that discusses mast rocking.

The manufacturer's tests had followed a Dec. 16, 2006, accident in which the pilot of an "almost new" R44 conducted an emergency landing near Ballymena, Ireland, because of severe vibration. The pilot and his three passengers were not injured, and the only damage to the helicopter was the distortion of an aluminum rib in the mast fairing assembly.[2]

The U.K. Air Accidents Investigation Branch (AAIB) said that the vibration was caused by "new, softer, main rotor gearbox mounts allowing excessive fore-and-aft rocking of the gearbox."

During the investigation, the pilot told the AAIB that as he flew a downwind leg in preparation for landing, and the helicopter descended through 700 ft above ground level at 75 to 80 kt, it "suddenly started to oscillate in pitch" and he felt "high vibrating control forces through the cyclic control." The oscillations and vibration increased "to the point where the pilot was concerned about the helicopter's structural integrity," the AAIB report said.

He conducted a run-on landing, with the vibration continuing during engine shutdown.

The AAIB accident report quoted Robinson Helicopter as saying that the company became aware of the vibration problem during test flights in 1993 when the CG was forward of the main rotor gearbox. In test flights, the vibration ceased when the pilot increased power. Robinson began installing stiffer gearbox mounts, which appeared to prevent the vibration.

After the 2006 incident in Ireland, Robinson determined that the gearbox mounts were softer than those manufactured in previous years, the AAIB said, adding, "The manufacturer believes that this softening of the mounts resulted in a recurrence of the vibration problem."

The AAIB said, in a report published in October 2007, that the manufacturer had again begun installing stiffer mounts and that the manufacturer had told the AAIB in August 2007 that "they were no longer encountering the vibration

The NTSB says Robinson Helicopter should maintain a database of mast-rocking events involving R44s.

problem during production flight test and … had not received any further reports of vibration incidents from in-service aircraft."

As a result, the manufacturer had no plans to issue a service letter, the AAIB added, "although this situation would be reconsidered if new reports of vibration were received."

The NTSB safety recommendation letter cited two events involving mast rocking, including one that occurred after the manufacturer's statement to the AAIB:

- On March 15, 2007, an R44 pilot conducted an emergency autorotative landing in Miami after experiencing a "huge vibration." Neither of the two people in the helicopter was injured, but the helicopter was substantially damaged. The NTSB said the probable cause of the accident was "the pilot's failure to maintain sufficient rotor rpm during an autorotative landing, which resulted in a hard landing and separation of the tail boom."[3]

- On Sept. 30, 2007, the pilot of another R44 conducted an emergency landing in a cornfield near Jackson Center, Ohio, U.S., after he experienced a severe vibration during approach to the landing zone. The pilot — the only person in the helicopter — was not injured, but the helicopter was substantially damaged when the tail rotor struck tall corn and the tail rotor gearbox separated. The NTSB cited as the probable cause "the reported vibration in the helicopter during an approach for landing."[4]

The NTSB safety recommendation letter cited a December 2006 report by an FAA flight test engineer who had participated in Robinson's flight tests and who noted that mast rocking had been induced "in various flight regimes and stopped under certain conditions using an R44 with aft and forward main rotor transmission mounts designed to react with upward and downward movement of the transmission."

The FAA test pilot's report noted that some combinations of transmission mounts and vibration isolators precluded mast rocking. Nevertheless, the manufacturer and the FAA test pilot agreed that each helicopter behaved differently during testing, so "no standard configuration was established," the NTSB said.

The NTSB added, "The lack of a specific solution for the mast-rocking vibration in all affected R44 helicopters suggests that the manufacturer has not identified the underlying cause of the vibration."

The agency recommended that the FAA "require Robinson Helicopter to resolve the root cause of the mast-rocking vibration in the main rotor assembly to ensure that all applicable R44 helicopters are free of excessive vibrations in all flight regimes."

Other recommendations called on the FAA to require the manufacturer to maintain a database of reported mast-rocking events in R44s, to add information to the R44 flight manual to inform pilots of the potential for mast rocking and to require that the R44 pilot training program be revised to include instruction in the recognition and mitigation of mast rocking vibrations in the main rotor assembly.

A final recommendation said the FAA should "issue a service letter to all approved service centers describing the mast-rocking vibration that can occur in the main rotor assembly" of R44s and "instructing service centers to report all incidents of mast rocking to the manufacturer."

Robinson R44

The Robinson R44 is a four-seat light helicopter developed in the late 1980s and first flown in 1990. It incorporates some elements of the two-seat R22 — including a tri-hinge underslung rotor head designed to limit blade-flexing and rotor vibration — but has a larger cabin.

The R44 has one Textron Lycoming O-540 six-cylinder reciprocating engine. Its empty weight is 1,442 lb (654 kg) and maximum takeoff and landing weight is 2,400 lb (1,089 kg). Standard fuel capacity is 31 U.S. gal (116 L).

Cruising speed at maximum takeoff weight and 75 percent power is 113 kt. Maximum rate of climb at sea level is 1,000 fpm. Service ceiling is 14,000 ft, hovering ceiling in ground effect is 6,100 ft, and hovering ceiling out of ground effect is 4,500 ft. Maximum range, with no fuel reserve, is about 347 nm (643 km).

Source: *Jane's All the World's Aircraft*

Notes

1. NTSB. Accident report no. ANC09GA040. May 12, 2009.
2. AAIB. Accident report no. EW/G2006/12/08. *AAIB Bulletin 10/2007*.
3. NTSB. Accident report no. MIA07LA059. March 15, 2007.
4. NTSB. Accident report no. CHI07LA309. Sept. 30, 2007.