National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 22, 2011

In reply refer to: A-11-82 through -86

The Honorable J. Randolph Babbitt
Administrator
Federal Aviation Administration
Washington, DC 20591

On May 12, 2009, about 1330 Alaska daylight time, a Robinson Helicopter R44, N7196H, sustained substantial damage to the main rotor and tailboom during a hard landing, about 57 miles northwest of Iliamna, Alaska. The commercial pilot and the two passengers were not injured. The helicopter was being operated by the State of Alaska, Alaska State Troopers, Anchorage, Alaska, as a visual flight rules public flight under 14 *Code of Federal Regulations* (CFR) Part 91. Visual meteorological conditions prevailed, and company flight-following procedures were in effect.[1]

In a written statement, the pilot reported that, about 1.5 minutes into the flight, he felt a vibration he had not felt before. He said the vibration was mostly in the pedals, then a slight yawing motion developed. The pilot said the vibrations became oscillations, in both yaw and pitch, to the point he felt the helicopter was going to come apart. He said an emergency landing was his only option. He reported that he fought to maintain control of the helicopter and that his only concern was to get the helicopter on the ground in one piece. The helicopter subsequently touched down with 5 to 10 knots of forward airspeed. During the hard landing, the main rotor contacted the tailboom, resulting in substantial damage. The pilot indicated that, after the accident, he recalculated the helicopter's weight and balance and determined that it was loaded under the gross weight limit but approximately 1.1 inch forward of the forward center of gravity (CG) limit.

On May 15, 2009, the helicopter was examined by the National Transportation Safety Board (NTSB) investigator-in-charge (IIC), accompanied by representatives from the Federal Aviation Administration (FAA) and the Alaska State Troopers. No preaccident mechanical anomalies were discovered, and a review of the helicopter's logbooks disclosed no mechanical discrepancies. Small dents were noted in the cabin top, fore and aft of the main rotor mast fairings.

[1] More information about this accident, National Transportation Safety Board (NTSB) case number ANC09GA040, is available from the NTSB's website at <http://www.ntsb.gov/aviationquery/index.aspx>.

During a telephone conversation on May 27, 2009, an accident investigator for Robinson Helicopter told the NTSB IIC that he was familiar with the anomaly reported by the pilot, which the manufacturer referred to as mast rocking.[2] He stated that the oscillation was more of a "bucking" motion due to the fore-and-aft movement of the rotor mast and that the manufacturer had found the onset of the oscillation regime was exacerbated by a forward CG (although still within the CG envelope) and a 30º banked turn to the left; he indicated that the helicopter may also begin to oscillate in a right turn but entered the oscillation regime more readily in a left turn.

The Robinson Helicopter investigator also stated that the manufacturer determined that the oscillation is not divergent (that is, the main rotor blades do not diverge from their normal plane of rotation) and can be mitigated by adding power. Pilots can then land the helicopter safely. The investigator stated that he had seen damage to the test helicopter only on one occasion, when the pilot landed while the main rotor mast was still oscillating and that the damage manifested as dents on the cabin top as a result of the fore-and-aft movement of the main rotor shaft fairings. According to this investigator, the manufacturer attributes the oscillation to the lack of firmness of the forward main rotor transmission mounts and installs stiffer mounts on helicopters that exhibit mast rocking during post-manufacturing test flights. He indicated that he did not know the standard by which mount firmness was measured and that he believed approved helicopter service centers were aware of mast rocking, although no service alerts or bulletins currently reference it. The Robinson Helicopter investigator said that, to his knowledge, no manufacturer-provided alerts, bulletins, or pilot training, or pilot operating handbook (POH) entries address mast rocking or actions that can be taken to resolve it. The NTSB's investigation revealed that the manufacturer does not have a formal mechanism to track reports of this anomaly.

The NTSB determined that the probable cause of the Iliamna 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 to the accident was 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."

At least three similar events preceded the Iliamna accident. On December 16, 2006, the pilot of a Robinson Helicopter R44, United Kingdom registration, G-CEFR, experienced a mast-rocking vibration and performed an emergency landing near Ballymena, Ireland. No occupants were injured, and the helicopter sustained minor damage.[3] On March 15, 2007, a Robinson Helicopter R44 pilot made an emergency landing on unsuitable terrain near Opa Locka, Florida, after experiencing a mast-rocking vibration. The helicopter landed hard, resulting in separation of the tailboom. The two helicopter occupants were not injured. On September 30, 2007, the pilot of a Robinson Helicopter R44 made an emergency landing near Jackson Center,

[2] Conversations between an NTSB IIC and R44 operators, as well as an Internet search of helicopter blog sites, revealed that operators and pilots had encountered the anomaly to an extent that they commonly refer to it as "chugging."

[3] The United Kingdom Air Accidents Investigation Branch conducted the investigation of this incident.

Ohio, after experiencing a mast-rocking vibration, resulting in substantial damage to the tail rotor boom and the landing gear. The pilot was the only occupant on board and was uninjured.[4]

During the investigation of the Iliamna, Alaska, accident, the NTSB obtained a copy of a December 2006 flight test report prepared by an FAA flight test engineer who participated in flight tests with Robinson Helicopter to explore in-flight mast-rocking vibrations.[5] The report, titled *Investigation of Unusual In-flight Vibrations of Robinson R44 II Helicopters*, noted that mast rocking was 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. For example, after inducing the vibration by increasing normal acceleration in a level turn (both left and right), the flight test engineer varied G loading[6] and determined that the vibration stopped when he reduced loading. The vibration was also induced during a straight-in autorotation with a forward CG (the CG having moved beyond the forward limit with normal fuel burn) and during a turning autorotation. The report noted that returning the helicopter to level flight from a turning autorotation did not stop the vibration. In both instances, the only way to stop the vibration in autorotation was to add power. A second R44, with the same type of aft mounts as the first helicopter but stiffer forward mounts, was also evaluated; the vibration was not induced with any maneuver.

The flight test report concluded that the vibration exceeded criteria provided at 14 CFR 27.251, "Vibration." The regulation states, in part, that "each part of the rotorcraft must be free from excessive vibration under each appropriate speed and power condition." The report indicated that the test pilots and manufacturer examined various transmission mounts and vibration isolators before and after the test flights and found certain combinations that preclude mast rocking. According to the manufacturer and the FAA test pilot, no standard configuration was established because each helicopter responded differently during testing.

The FAA flight test report stated that Robinson Helicopter planned to revise its R44 production flight test procedure to require that helicopters be flown at forward CG in the defined inducement maneuvers and, if necessary, to install stiffer main rotor transmission mounts and retest any aircraft found to exhibit mast rocking. The manufacturer and the FAA also planned to publish and distribute a service letter and safety notice describing the mast-rocking vibration, the maneuvers that induce the vibration at full forward CG, and, if necessary, the installation of stiffer transmission mounts, as well as insert a caution note and safety tip in the Robinson Helicopter R44 POH. To date, only the change to the R44 flight test procedure has been accomplished. The United Kingdom Air Accidents Investigation Branch (AAIB) final report of the Ballymena, Ireland, event indicates Robinson Helicopter informed the AAIB on August 28, 2007, that it was no longer encountering the vibration problem during production flight tests and had not received further reports of vibration incidents from in-service aircraft; therefore, the

[4] Additional information about these accidents, NTSB case numbers MIA07LA059 and CHI07LA309, is available at <http://www.ntsb.gov/aviationquery/index.aspx>.

[5] An FAA letter of authorization, dated December 18, 2006, states that the flight tests were conducted in response to reports of in-flight vibrations by R44 operators in New Zealand.

[6] The FAA *Pilot's Handbook of Aeronautical Knowledge* defines load factor as "the ratio of the maximum load an aircraft can sustain to the gross weight of the aircraft."

manufacturer did not intend to issue a service letter about the condition but would reconsider if it received new reports of vibration.

Despite Robinson Helicopter's change to the R44 flight test procedure, including the procedure to install stiffer transmission mounts if necessary, to resolve mast-rocking vibration in new production helicopters, the NTSB is concerned about the lack of a specific solution for all affected helicopters. As evidenced by the Jackson Center, Ohio, and Iliamna accidents, helicopters in service before the revised test procedure continue to exhibit this condition. Moreover, for those helicopters tested post-manufacture and found not to exhibit the mast-rocking vibration, it is not known if the condition will manifest as the helicopters age, even with stiffer transmission mounts installed. It also is not known how frequently mast rocking may occur in the fleet because Robinson Helicopter does not track reports of the condition.

The NTSB concludes that 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 NTSB also concludes that a manufacturer-maintained database of reports of mast rocking would provide a valuable tool for research to detect the root cause. Therefore, the NTSB recommends 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, as required by 14 CFR 27.251. The NTSB also recommends that the FAA require Robinson Helicopter to maintain a database of all reported incidents of mast rocking in the main rotor assembly of R44 helicopters.

Until the underlying cause of this condition is identified and resolved, R44 service centers need to be informed of mast rocking so that personnel can consult the manufacturer for a solution. Therefore, the NTSB recommends that the FAA require Robinson Helicopter to issue a service letter to all approved service centers describing the mast-rocking vibration that can occur in the main rotor assembly of R44 helicopters and instructing service centers to report all incidents of mast rocking to the manufacturer.

The Robinson Helicopter R44 flight manual, section 1, indicates that pilots are responsible for determining whether their helicopter is safe for flight, noting that pilots should study the entire manual and be familiar with the limitations, performance, procedures and operational handling characteristics of the helicopter before flight. The NTSB's review of the flight manual found no mention of the term "mast rocking" nor is the condition or its operational remedy noted in any associated Robinson Helicopter R44 publications. The manufacturer provides, however, specific guidance concerning main rotor vibration as a result of blade fatigue failure in R44 helicopters. Helicopter Safety Notice SN-39, dated July 2003, states, "if main rotor vibration rapidly increases or becomes severe during flight, make an immediate safe landing. Do not attempt to continue flight to a convenient destination." The NTSB is concerned that, without specific training or guidance from the manufacturer regarding mast rocking and how to safely stop it, R44 pilots may believe the condition is a result of blade fatigue failure and inadvertently exacerbate the vibration by reducing power or initiating an unwarranted emergency landing on what may be the only available, but potentially unsuitable, terrain.

The NTSB concludes that, given the various flight conditions in which mast rocking can be induced and the limited remedies available depending on the flight condition at the time of

inducement, R44 pilots should be alerted to the potential for mast-rocking vibrations in the main rotor assembly in certain flight conditions and trained in recognizing and mitigating these vibrations. Therefore, the NTSB recommends that the FAA require Robinson Helicopter to amend the R44 helicopter flight manual to inform pilots of the potential for mast-rocking vibration in the main rotor assembly and how to safely exit the condition. The NTSB also recommends that the FAA require that the Robinson Helicopter R44 pilot training program be revised to provide pilot instruction in the recognition and mitigation of in-flight mast-rocking vibrations in the main rotor assembly.

Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> 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, as required by 14 *Code of Federal Regulations* Section 27.251, "Vibration." (A-11-82)
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> Require Robinson Helicopter to maintain a database of all reported incidents of mast rocking in the main rotor assembly of R44 helicopters. (A-11-83)
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> Require Robinson Helicopter to issue a service letter to all approved service centers describing the mast-rocking vibration that can occur in the main rotor assembly of R44 helicopters and instructing service centers to report all incidents of mast rocking to the manufacturer. (A-11-84)
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> Require Robinson Helicopter to amend the R44 helicopter flight manual to inform pilots of the potential for mast-rocking vibration in the main rotor assembly and how to safely exit the condition. (A-11-85)
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> Require that the Robinson Helicopter R44 pilot training program be revised to provide pilot instruction in the recognition and mitigation of in-flight mast-rocking vibrations in the main rotor assembly. (A-11-86)

In response to the recommendations in this letter, please refer to Safety Recommendations A-11-82 through -86. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman