AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9541		
Aircraft Registration	**ZS-OBJ**	**Date of Accident**	15 April 2016		**Time of Accident**	1105Z	
Type of Aircraft	Robinson R22 Beta II (Helicopter)		**Type of Operation**		Part 127		
Pilot-in-command Licence Type		Commercial (CPL)	**Age**	28	**Licence Valid**	Yes	
Pilot-in-command Flying Experience		Total Flying Hours	803.6		Hours on Type	385.6	
Last point of departure	Rand aerodrome (FAGM): Gauteng province						
Next point of intended landing	Private farm located west of Lanseria airport (FALA): Gauteng province						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
Privately owned farm located west of Lanseria (FALA) airport, Krugersdorp area at GPS co-ordinates determined to be S25º 56. 291″ E027º 46. 543″ at an elevation determined to be 5 032 feet AMSL.							
Meteorological Information	Temperature, 25°C: Visibility, 10 km: Wind direction, North Easterly: Wind speed, 5 knots.						
Number of people on board	1 + 1	**No. of people injured**	1	**No. of people killed**	0		

Synopsis

On Friday 15 April 2016, a commercial pilot licence holder accompanied by a passenger was conducting a game darting operation on a privately owned farm located west of Lanseria (FALA) airport, Krugersdorp area when the accident occurred. According to the pilot, the problem started after a low rotor RPM warning came into play whilst darting springboks at low altitude {about 10 feet above ground level (AGL)}. The pilot further indicated that ahead of him was a three (3) metres perimeter fence. In an attempt to avoid crashing onto it, he opened the throttle and instantly raised the collective lever intending to clear and recover the helicopter from the condition, but it didn't work out as per his plan. A few seconds after clearing the fence, the helicopter entered an uncontrolled descend after which it impacted the ground heavily on the skids gear. The main rotor blade severed the tail-boom but the helicopter remained upright. The pilot sustained head injuries but the passenger was unharmed. The helicopter was substantially damaged during the accident sequence. The investigation concluded that the helicopter's loss of rotor RPM was the result of pilot's failure to continually monitor the rotor RPM. Pilot was pre occupied with darting and saw the fence too late and did not have time to recover.

Probable Cause

The loss of control and subsequent hard landing due to the pilot's failure to maintain rotor RPM.

SRP Date	08 November 2016	Release Date	

AIRCRAFT ACCIDENT REPORT

Name of Owner/Operator	**:** T M Crane & Transportation Projects CC
Manufacturer	**:** Robinson Helicopter Company
Model	**:** Robinson R22 Beta II
Nationality	**:** South African
Registration Marks	**:** ZS-OBJ
Place	**:** Privately owned farm located west of FALA
Date	**:** 15 April 2016
Time	**:** 1105Z

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Purpose of the Investigation:

*In terms of Regulation 12.03.1 of the Civil Aviation Regulations (2011) this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and **not to establish legal liability**.*

Disclaimer:

This report is given without prejudice to the rights of the CAA, which are reserved.

1. FACTUAL INFORMATION:

1.1 History of Flight:

1.1.1 On Friday 15 April 2016, a commercial pilot licence holder accompanied by the passenger “veterinarian” was conducting a game darting operation on a privately owned farm located west of Lanseria (FALA) airport, Krugersdorp area when the accident occurred. Visual meteorological conditions prevailed in the area and the flight was conducted under visual flight rules (VFR) condition. According to the pilot’s account regarding the accident, he met with the passenger at Rand aerodrome (FAGM) early in the morning upon which they briefed for the flight. The pilot then conducted a pre-flight inspection on the helicopter and all was normal. The helicopter had a total of 28.2 litres (main fuel tank 18.01 and the auxiliary fuel tank 10.01) of Avgas LL 100 fuel, free from water and sediments. The pilot and the passenger boarded the helicopter after which the engine was started. Engine start and run up were normal and the temperature was normal with variable winds at about seven (7) knots from the south. The pilot communicated his intensions to FAGM air traffic controller (ATC), upon which he was cleared for departure. The helicopter lifted off and headed in a north westerly direction towards the game farm, about nine nautical miles (NM) west of FALA. The pilot confirmed that the wind was still from the south, and flew at about 500 feet above ground level (AGL), at about 75 knots.

1.1.2 On approach to the farm, he began a descent while turning towards the farm and maintained a descent rate of about 300 feet per minute (fpm). At about 30 feet AGL, he began to flare the helicopter by moving the cyclic aft, before initiating a turn to the right into wind facing south westerly in preparation for animals “springboks” darting. After about 4 to 5 seconds at about 10 feet AGL, the low rotor RPM annunciator horn sounded and the low rotor RPM amber red warning light illuminated. At a look at the RPM gauge, the pilot recalled seeing the main rotor RPM needle at about 88%, which was unexpectedly low. Attached below is the photograph showing the helicopter’s instrument panel, with the red low rotor warning light and the tachometer visible.

Figure 1: The helicopter’s low rotor RPM/blade stall warning light and the tachometer

1.1.3 The pilot reported that, ahead of the helicopter was a farm perimeter fence, about three (3) meters high. According to the pilot’s written statement submitted to the investigator in charge (IIC), he avoided crashing the helicopter onto the fence by raising the collective and instantly opened the throttle intending to clear it and recover the helicopter from the condition, but things didn’t work out as per his plan. The pilot was able to clear the fence, but within seconds the helicopter entered an uncontrolled descent upon which it hit the ground heavily on the skids gear. The pilot sustained minor head injuries but the passenger was unharmed. The pilot instantly shut-down the electrics and informed his superiors before reporting the occurrence to accident and incident investigation division (AIID). The helicopter was substantially damaged during the accident sequence.

1.1.4 The accident happened in day light at GPS co-ordinates determined to be S25º 56. 291″ E027º 46. 543″, at an elevation of 5 032 feet AMSL. Below is the Google Earth map showing the accident site.

Figure 2: Google Earth map showing the accident site on a privately owned farm located west of FALA

1.2 Injuries to Persons:

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	1	-	-	-
None	-	-	1	-

1.1 Damage to Aircraft:

1.1.1 The helicopter sustained substantial damage to the instrument panel, the tail-boom, the tail-rotor, the main rotor blades and the skid gear.

The fence on the helicopters flight path

Figure 3: The helicopter as found at the accident site with the farm fence visible

Figure 4: Closer shot of the helicopter at the accident site

1.2 Other Damage:

1.2.1 No other damage was caused.

1.5 Personnel Information:

Nationality	South African	Gender	Male	Age	28

Licence Number	0272441700	Licence Type	Commercial (CPL)
Licence valid	Yes	Type Endorsed	Yes
Ratings	Night and Game/livestock culling ratings		
Medical Expiry Date	31 December 2016		
Restrictions	Nil		
Previous Incidents	Nil		

Flying experience:

Total Hours	803.6
Total Past 90 Days	134.4
Total on Type Past 90 Days	31.7
Total on Type	385.6

*NOTE: The pilot, aged 28, was a South African citizen who completed his helicopter training in South Africa. He held a helicopter commercial pilot's license (CPL) and also a medical certificate (Class 1) which was valid until 31 December 2016. His pilot's profile at SA CAA showed no enforcement actions, rating failure, or retest history. The pilot's licence was valid and he was rated on Robinson helicopter series including a Bell 407 helicopter. His log book had also been endorsed by his flight instructor during his initial training, certifying that he had satisfactorily completed Robinson's helicopter safety awareness training as mandated by the limitations section of the R22 flight manual.

1.6 **Aircraft Information:**

1.6.1 General description:

The Robinson R22 Beta is a two-seat light helicopter powered by a four-cylinder carbureted Lycoming O-360-J2A piston engine. It has a standard mechanical collective and cyclic control system with no hydraulic assistance. The main rotor gearbox is driven by the engine via a sheave and belt system and the main rotor consists of two all-metal main rotor blades connected to the main rotor hub by coning bolts at coning hinges. The main rotor hub is mounted to the main rotor shaft with a teeter hinge located above the coning hinges and blade pitch is controlled by pitch links which connect the pitch horns to the rotating swash plate. The rotating swash plate is moved by the fixed swash plate, which is connected via push-pull tubes to the cyclic and collective controls in the cockpit. Attached below are the photographs showing ZS-OBJ helicopter and the Robinson R22 main rotor hub and assembly.

Figure 5: ZS-OBJ, Beta II helicopter photograph

The R22's flight control system is similar to those in other conventional helicopters in directional, lift, and maneuvering controls. The R22 uses a standard tail rotor system and tail rotor pedals for directional control. The collective and cyclic control mechanisms are also standard for controlling lift, steady flight, and maneuvers. However, the cyclic control is shaped differently from those in other helicopters. The R22's cyclic control is T shaped with a vertical component between the pilot seats. The top part of the "T" is angled slightly upwards from the center to the outboard ends to provide leg to handle clearance for the non-flying pilot. The handles are attached vertically to the outboard ends of the "T" for each pilot. The top part is hinged to the vertical component to allow the vertical position of the handles to vary. The main rotor system utilizes a two blade, rigid design. The rotor blades are connected to the main rotor hub through individual flapping hinges. The flapping hinges are part of a teetering main rotor hub that is hinged to the main rotor mast. In most two bladed semi rigid systems, the advancing blade flaps up, causing the retreating blade to flap down; however, the R22 main rotor blades are individually hinge pinned and therefore can flap independently of each other. The total diameter of the R22 main rotor disc (two opposite blades connected by the hub) measures 25 feet, 2 inches, and each blade weighs approximately 26 pounds. The R22 uses main rotor blades designed according to National Advisory Committee for Aeronautics (NACA) 63-015 airfoil specifications.

The R22 main rotor blades are constructed at the RHC's manufacturing facility with a 7.2-inch chord (width of blade) and are each 12.58 feet long. The R22 is operated at close to its maximum gross weight (1,370 pounds) with two people on board and a full tank of fuel, resulting in operations routinely conducted near the upper limit of the helicopter's operating envelope. This condition requires that the helicopter be operated near the maximum design lift capability of the main rotor system. To gain the needed lift, the R22's main rotor blade angle of attack will on occasions be near the stall angle of attack during normal operations.

Airframe:

Type	Robinson R22 Beta II	
Serial Number	4066	
Manufacturer	Robinson Helicopter Company	
Maximum take-off weight	1 370 lb	
Empty weight	880 lb	
Date of Manufacture	2006	
Total Airframe Hours (At time of accident)	2 851.5	
Last MPI (Hours & Date)	2 799.0	17 November 2015
Total Hours Flown	52.5	
Certificate of Airworthiness (Issue Date)	07 February 2007	
Certificate of Airworthiness (Expiry Date)	06 February 2017	
C of R (Issue Date) (Present owner)	22 August 2013	
Airworthiness Directive Status	Complied with	
Operating Categories	Standard Part 127	

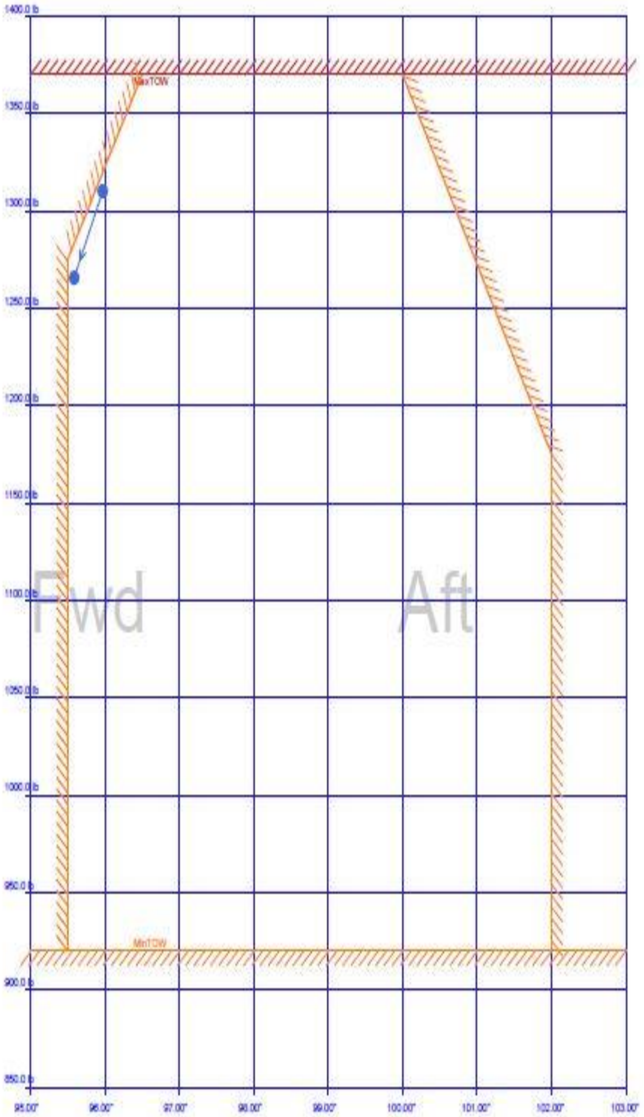
*NOTE: The operating categories and conditions for the helicopter were indicated as commercial, allowing forest and wildlife conservation activities. A review of the helicopter’s log books indicated that the helicopter had been maintained in accordance with the Robinson helicopter company, R22 maintenance schedule. The helicopter had a current certificate of registration (C of R) and certificate of airworthiness (C of A). The current maintenance work pack showed that there were no outstanding maintenance items or defects identified. The helicopter was maintained to a day visual flight rules (VFR) standard. The last mandatory periodic inspection (MPI) carried out on the helicopter prior to the accident was certified at 2799.0 hours on 17 November 2015 by an approved aircraft maintenance organisation (AMO) No 1266.

Engine:

Type	Lycoming O-360-J2A
Serial Number	L-40421-36A
Hours since New	850.60
Hours since Overhaul	TBO Not reached

ZS-OBJ weight and balance calculation at departure from FAGM:

Item	Weight (lbs)	Arm (inches)	Moment (in.lb)
A/C empty weight	880.0	103.30	90 904
Right front pilot (90kg)	198.4	78.00	15 474
Left front passenger (85kg)	187.4	78.00	14 617
Removable controls	0.0	66.80	0
Right door	0.0	77.50	0
Left door	0.0	77.50	0
Left pod	0.0	99.00	0
Right pod	0.0	99.00	0
Zero fuel	1 265.8	95.59	120 997
Main fuel tank (18.01L)	28.6	108.60	3103
Aux fuel tank (10.01L)	15.9	103.80	1648
All up Weight	**1 310.3**	**95.35**	**125 748**



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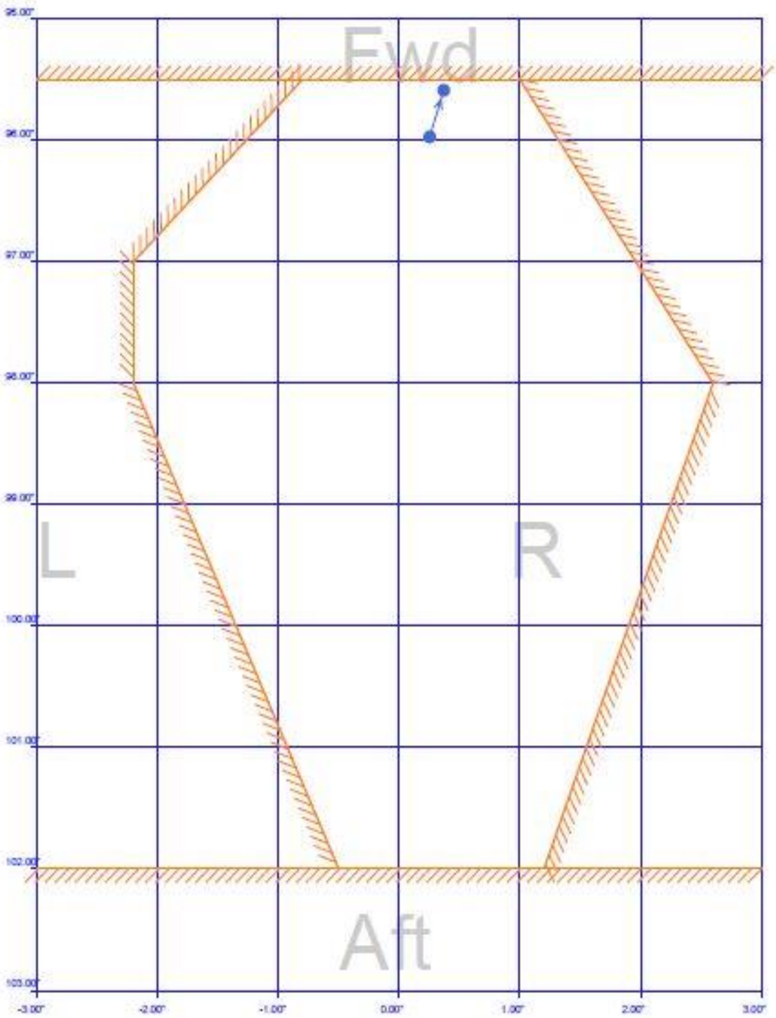


1.1.5 *NOTE: When the helicopter took-off from FAGM, the weight was estimated to have been 1,310.3 lbs and the position of the center of gravity was estimated to have been 95.50 inches “long forward limit”; aft of the reference point and 101.07 inches; left of the center line, all of which are estimated to have been within the allowable limits (i.e., maximum take-off weight of 1,370 lbs and allowable center of gravity ranges of 95.5 – 101.0 inches. This calculation had indicated that the helicopter was operated within its allowable envelope as indicated on the graphs above.

1.7 Meteorological Information:

1.7.1 Weather information as obtained from the pilot’s questionnaire:

Wind direction	North Easterly	Wind speed	05 knots	Visibility	10 km
Temperature	25°C	Cloud cover	Few	Cloud base	Nil
Dew point	Nil				

1.8 Aids to Navigation:

1.8.1 The helicopter was fitted with standard navigation equipment as approved at the time of certification.

1.9 Communications:

1.9.1 No difficulties with communications were known or reported prior to the accident.

1.10 Aerodrome Information:

1.10.1 The accident occurred outside airport boundaries.

1.10.2 The accident happened in day light at GPS co-ordinates determined to be South 25º 56. 291″ East 027º 46. 543″, at an elevation of 5 032 feet AMSL.

1.11 Flight Recorders:

1.11.1 The helicopter was not fitted with a flight data recorder (FDR) or a cockpit voice recorder (CVR), neither were this required in terms of the South African Civil Regulations to be fitted to this helicopter type.

1.12 Wreckage and Impact Information:

1.12.1 The accident happed on a farm west of FALA. The helicopter came to rest in an upright position with the instrument panel/centre console damaged and the skid gear deformed and bowed outwards. The wreckage, including pieces of the tail boom skin, tail rotor driveshaft and tail rotor, was dispersed over a distance of about 50 m radius. The tail boom, including the fin, tail rotor/blades and tail rotor gearbox were located to the east of the main wreckage. Attached below are the photographs.

Figure 7: A photograph of a severed instrument panel

Figures 8: The skid gears as found (bowed out) and the severed tail boom

Figure 9: Photographs showing the wreckage lay-out and the closer shot of the tail rotor/fin

1.12.2 Examination of the wreckage at the accident scene showed the following: The helicopter had about 28.2 litres total fuel. One main rotor blade tip was severed. The engine drive V-belts were off their sheave grooves, but not broken. The engine was found still secured to its mounting points. Both sheaves were in good condition and the free running clutch within the upper sheave responded appropriately to manual rotation in both directions. Both pitch change links exhibited slight bending overload failures. In the cockpit, the clutch was still selected to engage and the clutch circuit breaker was in the normal (un-pulled) position. The clutch caution light and actuator overload fuse were both intact. The flex plate was intact/no cracks observed on the bolt holes. MIL-H5606 hydraulic fluid leak was observed on the main rotor hub and assembly. The distribution of the wreckage around the helicopter was consistent with the main rotor blade No 1 striking the tail boom. Attached below is the photograph showing a severed rotor blade.

Figure 10: A photograph displaying of a severed rotor blade

1.13 Medical and Pathological Information:

1.13.1 Not applicable.

1.14 Fire:

1.14.1 No pre or post impact fire was reported.

1.15 Survival Aspects:

1.15.1 The accident was considered survivable.

1.16 Tests and Research:

1.16.1 Logbooks and maintenance records showed that the helicopter had been certified, equipped, and maintained in accordance with existing regulations and approved procedures. Inspection of the helicopter fuel system revealed no anomalies. Sufficient fuel for the planned trip was carried on board. No evidence of water contamination was observed. The helicopter had no known deficiencies before the flight and was operating within its load and centre of gravity limits. The wreckage was thoroughly examined during post-accident investigation. Based on the observation by the investigators, together with Robinson helicopter experts, it was determined that there had been flight control continuity before the accident. Continuity with the engine, transmission and tail rotor assembly was verified. No teardown examination of the engine was considered or done as the engine was not seen as the cause of the accident. In overall, the helicopter was considered airworthy prior to the accident and the investigation revealed that the pilot had allowed the rotor RPM to drop, to the point that it could not recover.

*NOTE: The main rotor blade system of the Robinson R22 helicopter is considered a low inertia rotor system. The term refers to the tendency for the rotor to deplete its stored energy quickly, leading to the decay of main rotor rpm and therefore an aerodynamic stall of the rotor system. The Robinson helicopter company issued safety notices S/n 24 (see Appendices), “Low rpm rotor stall can be fatal”, in September 1986. The notice states that a very high percentage of accidents are caused by rotor stall due to low main-rotor rpm. The Robinson R22 pilot operating handbook (POH) states that a warning horn and an illuminated amber caution light indicate that rotor rpm is below safe limits. The horn stops and the amber caution light extinguishes when rotor rpm is increased to safe limits or the collective control is full down. The “green arc” for safe operation of main-rotor rpm is between 97% and 104%. The warning horn and the amber light activate at 97% rpm. The “danger” area on the rpm gauge is 90% rpm and is indicated by a red line. The danger of low rotor rpm leading to a main-rotor aerodynamic stall during autorotation is covered during ground school but is not required as a review item during pre-flight briefing. Rotor stall due to low rpm has resulted in many helicopter accidents. At the stalling angle, usually around 15°, the airflow over the rotor blades would abruptly separate, causing a sudden loss of lift and a large increase in drag. A rotor stall occurs because of low rotor rpm. As the rotor rpm decreases, the angle of attack of the rotor blades must be increased “by the pilot flying” to generate the lift required to support the helicopter, else the helicopter will descend. Once the rotor blades reach the stalling angle of attack, lift suddenly decreases and drag greatly increases. This increased drag acts like a huge rotor brake, causing the rotor rpm to decrease further, accentuating the effect of the rotor stall. Once the rotor rpm has decayed significantly, recovery is unlikely because, as the helicopter begins to descend, the upward rushing air further increases the angle of attack of the slowly rotating blades. A tail boom cut often accompanies a low rotor rpm stall because of asymmetrical rotor stall, that is, the tendency for the helicopter to pitch nose down due to the upward airflow under the tail surfaces and the application of aft cyclic by the pilot in an attempt to keep the nose from dropping.

1.17 Organisational and Management Information:

1.17.1 This was a commercial flight.

1.17.2 The aircraft maintenance organisation (AMO) that performed the last mandatory periodic inspection (MPI) on the helicopter was in possession of a valid AMO approval certificate No 1266.

1.18 Additional Information:

1.18.1 Rotor Stall:

Reference: *Principles of helicopter flight, "Page 164", Wagtendonk WJ.*

According to the investigation, the helicopter may have experienced what is known as a rotor stall. When the helicopter is engaged in a powered descent, it experiences a rate of descent flow in opposition to the induced flow across the disc. Inflow angles are reduced and the blades' angles of attack increase. The root sections of the blades historically have the weakest induced flow. During a powered descent, the rotor sections may find their angles of attack increased such that they stall. The early rotor stall acts like the early stages of a vortex ring state. Provided the pilot keeps enough power to maintain rotor RPM and provided the aircraft is flown in a manner that avoids the development of vortex ring state, the descent continues normally. An inexperienced pilot may pull more collective pitch to counteract the rate of descent, not noticing or responding to the lowering of rotor RPM. If the pilot fails to identify and react to the early rotor stall's most prominent symptom, decaying rotor RPM, then trouble is just around the corner. The correct response to a development rotor stall is to increase the throttle to maintain rotor RPM and lower collective simultaneously. Pilots flying helicopters equipped with high-inertia rotors have more time to react than pilots flying low-inertia rotor systems such as the Robinson R22. The decaying rotor RPM, brought on by the blade roots' stalling, results in less total rotor thrust, which increases the helicopter's rate of descent. This in turn increases the rate of descent flow and decreases the induced flow and inflow angles further. The consequence is that the stalled region at the blade roots spreads out towards the tips. Slower blade rotation means that centrifugal force drops off sharply. Eventually, a complete rotor stall leads to a loss of directional control, severe blade flapping, possible blade failure from the coning angles, as well as nose-down pitch as the longitudinal stability aligns the fuselage with the rate of descent flow.

1.18.2 Safety notices from the Pilot's Operating Handbook (POH), Section 10, SN-10 deal with fatal accidents caused by low RPM rotor stall:

A primary cause of fatal accidents in light helicopters is failure to maintain rotor RPM. To avoid this, every pilot must have his reflexes conditioned so he will instantly add throttle and lower collective to maintain RPM in any emergency. The R22 and R44 have demonstrated excellent crashworthiness as long as the pilot flies the aircraft all the way to the ground and executes a flare at the bottom to reduce his airspeed and rate of descent. Even when going down into rough terrain, trees, wires or water, he must force himself to lower the collective to maintain RPM until just before impact. The aircraft may roll over and be severely damaged, but the occupants have an excellent chance of walking away without injury. Power available from the engine is directly proportional to RPM. If the RPM drops 10%, there is 10% less power. With less power, the helicopter will start to settle, and if the collective is raised to stop it from settling, the RPM will be pulled down even lower, causing the aircraft to settle even faster. If the pilot not only fails to lower the collective, but instead pulls up on the collective to keep the aircraft from going down, the rotor will stall almost immediately. When it stalls, the blades will either 'blow back' or cut off the tail cone or it will just stop flying, allowing the helicopter to fall at an extreme rate. In either case, the resulting crash is likely to be fatal. No matter what causes the low rotor RPM, the pilot must first roll on throttle and lower the collective simultaneously to recover RPM **before** investigating the problem. This must be a conditioned reflex. In forward flight, applying aft cyclic to bleed off airspeed will also help to recover lost RPM. A vertical descent or steep approach downwind can result in 'settling with power'. This happens when the rotor is settling in its own downwash and additional power won't stop the descent. Should this occur, reduce collective and lower the nose to increase airspeed. This can be very dangerous near the ground as the recovery results in a substantial loss of altitude.

1.19 Useful or Effective Investigation Techniques:

1.19.1 None.

2. ANALYSIS:

2.1 Logbooks and maintenance records showed that the helicopter had been maintained in accordance with Robinsons airworthiness requirements and that there were no apparent defects which had a bearing on the accident. Nothing was found to indicate that any mechanical malfunction initiated or contributed to the accident sequence, and there was usable fuel on board; therefore, this analysis focuses on the operational aspects of the flight. No evidence was found of any pre-accident defects or restrictions in the flying control systems or the main and tail rotor drive trains. The information from the pilot's questionnaire showed that fine weather conditions prevailed at the time of the accident. The pilot held a valid commercial helicopter pilot's license and was proficient to perform the task at hand. Available information indicated that the pilot had flown a total of 803.6 hours preceding the accident; of which 385.6 total flight hours was on the Robinson R22 type. It must be noted that the rotor of a helicopter with a low inertia rotor system loses energy quickly as the collective is raised and the engine is not producing adequate power. The accident happened on a farm after the pilot experienced the rotor RPM decay at low altitude. The helicopter entered an uncontrolled descent after clearing the fence upon which it hit the ground on the skid gear very hard. This was of course as a result of loss of forward speed and lift because the main rotor was already stalled. The investigation concluded that the helicopter's loss of rotor RPM was a result of the pilot's failure to continually monitor the rotor RPM, probably because his attention was diverted or distracted by animals "springboks". It is very easy to recover from low rpm. But when the helicopter is operated close to the ground that is when things get a little bit problematic. Had the helicopter been operated at a safer altitude, lowering the nose to increase forward speed would have helped, as that would have increased the air flow over the rotor disc. The investigation also noticed that the pilot's actions were consistent with someone who lost awareness of the situation.

3. CONCLUSION:

3.1 Findings:

3.1.1 The pilot was a holder of a valid commercial pilot's licence and had the helicopter type endorsed in his logbook.

3.1.2 The pilot's medical certificate was valid without restrictions.

3.1.3 Fine weather conditions prevailed at the time and were not considered to have had bearing on the occurrence.

3.1.4 The AMO that performed the last inspection on the helicopter prior to the occurrence was in possession of a valid AMO approval certificate No 1266.

3.1.5 The helicopter had enough LL 100 Avgas fuel, free from water and sediments.

3.1.6 The helicopter was in possession of a valid certificate of airworthiness at the time of the incident.

3.1.7 The accident was regarded as survivable.

3.1 Probable Cause/s:

3.1.1 The loss of control and subsequent hard landing due to the pilot's failure to maintain rotor RPM.

4. SAFETY RECOMMENDATIONS:

4.1 None.

5. Appendices:

5.1 Helicopter manufacturer's safety notices:

ROBINSON
HELICOPTER COMPANY

Safety Notice SN-24

Issued: Sep 86 Rev: Jun 94

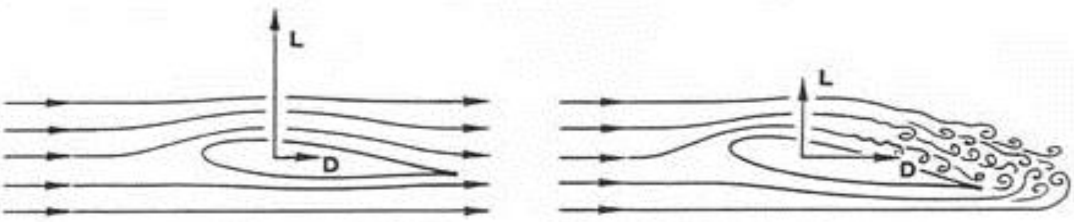
LOW RPM ROTOR STALL CAN BE FATAL

Rotor stall due to low RPM causes a very high percentage of helicopter accidents, both fatal and non-fatal. Frequently misunderstood, rotor stall is not to be confused with retreating tip stall which occurs only at high forward speeds when stall occurs over a small portion of the retreating blade tip. Retreating tip stall causes vibration and control problems, but the rotor is still very capable of providing sufficient lift to support the weight of the helicopter.

Rotor stall, on the other hand, can occur at any airspeed and when it does, the rotor stops producing the lift required to support the helicopter and the aircraft literally falls out of the sky. Fortunately, rotor stall accidents most often occur close to the ground during takeoff or landing and the helicopter falls only four or five feet. The helicopter is wrecked but the occupants survive. However, rotor stall also occurs at higher altitudes and when it happens at heights above 40 or 50 feet AGL it is most likely to be fatal.

Rotor stall is very similar to the stall of an airplane wing at low airspeeds. As the airspeed of an airplane gets lower, the nose-up angle, or angle-of-attack, of the wing must be higher for the wing to produce the lift required to support the weight of the airplane. At a critical angle (about 15 degrees), the airflow over the wing will separate and stall, causing a sudden loss of lift and a very large increase in drag. The airplane pilot recovers by lowering the nose of the airplane to reduce the wing angle-of-attack below stall and adds power to recover the lost airspeed.

The same thing happens during rotor stall with a helicopter except it occurs due to low rotor RPM instead of low airspeed. As the RPM of the rotor gets lower, the angle-of-attack of the rotor blades must be higher to generate the lift required to support the weight of the helicopter. Even if the collective is not raised by the pilot to provide the higher blade angle, the helicopter will start to descend until the



UNSTALLED STALLED

Wing or rotor blade unstalled and stalled.

upward movement of air to the rotor provides the necessary increase in blade angle-of-attack. As with the airplane wing, the blade airfoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increased drag on the blades acts like a huge rotor brake causing the rotor RPM to rapidly decrease, 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 airspeed of the helicopter will produce a higher airflow 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 resulting low aft blade and high forward blade become a rapid aft tilting of the rotor disc sometimes referred to as "rotor blow-back". Also, as the helicopter begins to fall, the upward flow of air under the tail surfaces tends to pitch 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 tailboom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of rotor blades, rotor teeter stops will not prevent the boom chop. The resulting boom chop, however, is academic, as the aircraft and its occupants are already doomed by the stalled rotor before the chop occurs.

END