AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	**CA18/2/3/10075**		
Helicopter Registration	**ZS-REH**	**Date of Accident**	13 November 2021	**Time of Accident**	1445Z		
Type of Helicopter	Robinson 22	**Type of Operation**	Training (Part 141)				
Pilot-in-command Licence Type	Student Pilot Licence (SPL)	**Age**	35	**Licence Valid**	Yes		
Pilot-in-command Flying Experience	**Total Flying Hours**	36.4	**Hours on Type**	36.4			
Last Point of Departure	Virginia Aerodrome (FAVG), KwaZulu-Natal Province						
Next Point of Intended Landing	Virginia Aerodrome (FAVG), KwaZulu-Natal Province						
Damage to Helicopter	Substantial						
Location of the accident site with reference to easily defined geographical points (GPS readings if possible)							
On the flat top of Maphephetha Mountain at Inanda GFA (GPS position: 29˚38’16.37” South 030˚51’22.28” East), at an elevation of 2192 feet (ft).							
Meteorological Information	Surface wind: 070º/11 kts, temperature: 27ºC; dew point: 17ºC; CAVOK QNH: 1010hPa						
Number of People On-board	1+0	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0
Synopsis							
On Saturday afternoon, 13 November 2021, a student pilot on-board a Robinson R22 helicopter with registration ZS-REH departed Virginia Aerodrome (FAVG) on a training flight to the general flying area (GFA), north of the Inanda Dam in KwaZulu-Natal. The intention was to conduct circuit training exercises. The flight was conducted under visual flight rules (VFR) by day and under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended. According to the student pilot, the flight to the GFA proceeded as planned; he landed on an open piece of land at the top of Maphephetha Mountain. He then planned to conduct the circuit training before he carried out the pre-take-off checks. Thereafter, he lifted off into a hover, during which he felt the helicopter leaning towards the left-side and, as a result, he lost control and crashed. The helicopter came to rest in an upright position. The student pilot was not injured during the accident sequence; however, he was taken to the hospital for a medical assessment. The helicopter was substantially damaged.							
Probable Cause							
It is likely that the heel of the right skid got stuck in the soft soil, which led to loss of control and a dynamic roll over.							
SRP Date	13 December 2022	Publication Date	19 December 2022				

Occurrence Details

Reference Number	**:** CA18/2/3/10075
Occurrence Category	**:** Category 1
Type of Operation	**:** Training (Part 141)
Name of Operator	**:** Starlite Aviation
Helicopter Registration	**:** ZS-REH
Helicopter Make and Model	**:** Robinson 22
Nationality	**:** South African
Place	**:** Maphephetha Mountain, KwaZulu-Natal Province
Date and Time	**:** 13 November 2021 1445Z
Injuries	**:** None
Damage	**:** Substantial

Purpose of the Investigation

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 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 apportion blame or liability.

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.

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence on 13 November 2021 at 1500Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and ICAO STD Annex 13 definitions. Notifications were sent to the State of Registry, Operator, Design and Manufacturer in accordance with CAR 2011 Part 12 and ICAO Annex 13 Chapter 4. Investigators were dispatched to the accident site for this accident.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Helicopter — the Robinson 22 Beta 2 involved in this accident
   Investigation — the investigation into the circumstances of this accident
   Pilot — the pilot involved in this accident
   Report — this accident report

2. *Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

This report is produced without prejudice to the rights of the AIID, which are reserved.

Table of Contents

Abbreviation	Description
°	Degrees
°C	Degrees Celsius
AGL	Above Ground Level
AIID	Accident and Incident Investigations Division
AMO	Aircraft Maintenance Organisation
ATC	Air Traffic Control
CAR	Civil Aviation Regulations
CVR	Cockpit Voice Recorder
C of A	Certificate of Airworthiness
C of R	Certificate of Registration
CRS	Certificate of Release to Service
FAVG	Virginia Airport
ft	Feet
GFA	General Flying Area
GPS	Global Positioning System
hPa	Hectopascal
kt	Knots
kt	Knots
m	Metres
METAR	Meteorological Routine Aerodrome Report
MP	Manifold Pressure
MPI	Mandatory Periodic Inspection
MHz	Megahertz
Nm	Nautical Mile
PIC	Pilot-in-command
QNH	Altitude Above Mean Sea Level
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
TBO	Time Between Overhaul
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Metrological Conditions
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Saturday afternoon, 13 November 2021, an instructor and a student pilot on-board a Robinson R22 helicopter with registration ZS-REH took off on a circuit training flight from Virginia Aerodrome (FAVG) to the general flying area (GFA), north of the Inanda Dam in KwaZulu-Natal province. Prior to take-off, the instructor conducted briefings with the student pilot, followed by pre-take-off flight checks. Upon reaching the GFA flat top at Maphephetha Mountain, the instructor briefed the student pilot before continuing with the training exercises. The flight was conducted under the provisions of Part 141 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.2. During training, the student pilot demonstrated the ability to conduct the circuits. The duo then routed back to FAVG where the instructor debriefed the student pilot. Thereafter, the student pilot prepared for a flight back to Inanda GFA to conduct his solo training circuits. The student pilot took off to FAVG through Umgeni River Corridor, which is a reporting station. A clearance was granted by air traffic control (ATC) to route to the GFA at a height of 800 feet (ft) above ground level (AGL).

1.1.3. According to the student pilot, the flight to the GFA proceeded as planned. He landed on an open piece of land at the flat top of the mountain. He then planned how he was going to conduct his circuit training. Thereafter, he carried out his pre-take-off checks. During lift-off into the hover, he felt the helicopter lean towards the left-side and he lost control and crashed. The helicopter came to rest in an upright position. The student pilot then shut down the engine and exited the helicopter before he informed his instructor about the accident using his mobile phone.

1.1.4. The student pilot was wearing an action camera on his chest during the accident flight. The investigators replayed the video footage frame-by-frame to analyse the sequence of events. On the video footage, *the helicopter becomes lighter on the skids at 18 inches manifold pressure (MP) as it starts to yaw to the right with the nose in a pitch-up attitude and without any intervention/input from the student pilot on the controls. The student pilot then makes an abrupt left cyclic input which results in the helicopter swinging to the left-side first, and then to the right-side until the helicopter is greater than 45° angle of bank.* This was evidenced by the instrument panel cutting through the horizon at an angle. *The student pilot's inputs to correct the helicopter angle are all in vain. Thereafter, the helicopter completes a full 360° roll to the right-side before it comes to a stop on its skids in an upright position. During loss of control, there are no visible warning lights on the instrument panel and the MP is at 25 inches. The engine and the rotor revolutions per minute (RPM) are in sync at the time of loss* *of control. After impact, the sound of the engine running at high rpm is heard. Post-accident, the student pilot walks away from the helicopter; and the video ends.*

Figure 1: A still picture of the video footage during the accident. (Source: Pilot)

1.1.5. The accident occurred during day light on the flat top of Maphephetha Mountain at Inanda GFA at Global Positioning System (GPS) co-ordinates determined to be 29˚38'16.37" South 030˚51'22.28" East, at an elevation of 2192ft.

Figure 2: Overlay showing the accident site. (Source: Google Earth)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	1	-	-	1	-
Total	**1**	**-**	**-**	**1**	**-**

Note: Other means people on the ground.

1.3. Damage to Helicopter

1.3.1. The aircraft sustained substantial damage during the accident sequence.

Figure 3: The helicopter as it came to rest at the accident site.

1.4. Other Damage

1.4.1. None.

1.5. Personnel Information

Nationality	South African	Gender	Male	Age	35
Licence Type	Student Pilot Licence				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	None				
Medical Class & Expiry Date	31 December 2022				
Restrictions	None				
Previous Accidents	None				

Note: Previous accidents refer to past accidents the pilot was involved in, when relevant to this accident.

Flying Experience:

Total Hours	36.4
Total Past 24 Hours	1.35
Total Past 7 Days	2.2
Total Past 90 Days	5.55
Total on Type Past 90 Days	5.55
Total on Type	36.4

1.5.1. The student pilot was initially issued a Student Pilot Licence on 2 February 2018. According to the logbook, the student pilot had not flown an aircraft in 12 months due to medical reasons. His last competency test was carried out on 14 August 2021 after which a licence was issued with an expiry date of 13 August 2022.

1.5.2. The student pilot had a Class 2 medical certificate that was issued on 6 December 2017 with an expiry date of 31 December 2022 and with no restrictions.

1.5.3. The student pilot's training report briefing sheets were inconsistently completed with some blocks/sections not populated. Exercise 17, which is the solo consolidation, was not signed out by the chief flight instructor (CFI). The student pilot's training summary hours sheet was not completed fully as well, whilst Exercise 12, which is the crosswind and downwind transitions, was not recorded.

1.5.4. The aircraft maintenance engineer (AME) who performed the last mandatory periodic inspection (MPI) on the aircraft prior to the accident flight was in possession of a valid AME licence which was initially issued on 7 July 2008. The latest renewed licence had an expiry date of 7 June 2022. According to the reviewed records, the helicopter type was endorsed on his licence, and he was also rated on this helicopter type.

1.6. Helicopter Information (Source: https://robinsonheli.com/r22)

1.6.1. *The R22 has a two-bladed rotor system which requires minimum hangar space, T-bar cyclic for easy entry and exit, and a crashworthy fuel system. An aluminium monocoque and powder-coated steel tube structure provides a lightweight, yet robust airframe while the aerodynamic fuselage optimises airspeed and fuel economy. The R22 is powered by Lycoming's proven O-360 engine that is de-rated to provide reserve power and better performance at high altitudes and in hot weather.*

Figure 4: The file picture of the R22 helicopter.
(Source: https://abpic.co.uk/pictures/registration/ZS-REH)

Airframe:

Manufacturer/Model	Robinson 22 Beta 2	
Serial Number	2401	
Year of Manufacture	1979	
Total Airframe Hours (At Time of Accident)	4 163.58	
Last Inspection (Date & Hours)	26 May 2021	4 096.58
Airframe Hours Since Last Inspection	67.06	
CRS Issue Date	26 May 2021	
C of A (Issue Date & Expiry Date)	11 January 2017	31 January 2022
C of R (Issue Date) (Present Owner)	18 January 2018	
Operating Category	Training (Part 141)	
Type of Fuel Used	Avgas	
Previous Accidents	None	

Note: Previous accidents refer to past accidents the helicopter was involved in, when relevant to this accident.

Engine:

Manufacturer/Model	Lycoming 0320 B2C
Serial Number	L-17928-39A
Hours Since New	4 096.5
Hours Since Overhaul	2 097.7

Main Rotor Blades:

Number of blades	1	2
Part Number	A016-6	A016-6
Serial Number/s	1571	1424
Hours Since New	1 800.28	1 800.28
Hours Since Overhaul	0	0

Tail Rotor Blades:

Number of blades	1	2
Part Number	A029-2	A029-2
Serial Number/s	6714	6715
Hours Since New	1 126.98	1 126.98
Hours Since Overhaul	0	0

1.6.2. The last maintenance inspection prior to the accident flight was carried out on 26 May 2021 at 4096.52 airframe hours. The aircraft was issued a Certificate of Release to Service (CRS) on 26 May 2021 with an expiry date of 25 May 2022 or at 4196.52 hours, whichever occurs first.

1.6.3. The aircraft was issued a Certificate of Airworthiness (C of A) on 11 January 2017 with an expiry date of 31 January 2022. The aircraft's Certificate of Registration (C of R) was issued to the new owner on 18 January 2018.

1.7. Meteorological Information

1.7.1. The weather information below was obtained from the Meteorological Aerodrome Report (METAR) that was issued by the South African Weather Service (SAWS), recorded at Virginia Aerodrome (FAVG) in KwaZulu-Natal on 13 November 2021 at 1445Z.

Wind Direction	070°	Wind Speed	11kt	Visibility	9999m
Temperature	27°C	Cloud Cover	CAVOK	Cloud Base	CAVOK
Dew Point	17°C	QNH	1010hPa		

1.8. Aids to Navigation

1.8.1. The helicopter was equipped with standard navigational equipment as approved by the Regulator (SACAA). There were no records indicating that the navigation system was unserviceable prior to the accident flight.

1.9. Communication

1.9.1. The helicopter was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system prior to the accident flight.

1.10. Aerodrome Information

1.10.1. The helicopter accident did not occur near an aerodrome; the closest aerodrome, which is FAVG, is located 13.2 nautical miles (nm) from the accident site.

1.11. Flight Recorders

1.11.1. The helicopter was neither equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to the helicopter type.

1.12. Wreckage and Impact Information

1.12.1. The wreckage was recovered on the same day due to the accident area/site being hostile, as well as lack of security at the site. The wreckage was stored and quarantined at the aircraft maintenance organisation's (AMO's) hangar at FAVG. According to the AMO, the helicopter was found in an upright position, facing a northerly direction. The fuselage structure was disturbed. The middle bar came off from the top and both windshields were shattered. The doors were removed prior to the accident flight. Both seats were still in place; the pilot's seat did not collapse. The skid gears broke off due to impact. Both skid shoes and heels also broke off.

1.12.2. The main rotor blade that had detached from the helicopter was located 70.9 metres (m) from the helicopter (Figure 5). The other main rotor blade was found wrapped around the helicopter anti-clockwise (direction). The main rotor hub was still intact; however, the bumpers had sheared off in the middle, indicative of excessive mast bumping. The swashplate was still intact, whilst the scissor link sustained damage on its attachment point. The pitch link of the detached blade was still intact; however, the pitch link of the other blade had sheared off at the upper rod end; it was found hanging loose on the lower rod end. The attachment hardware of the upper rod end was not located at the accident site. The mast was still attached, and the main rotor gearbox exhibited damage on the attachment points. The control tubes were still intact with the middle tube slightly bent. The continuity of the control tubes was not verified due to the jammed flight controls bell crank. The position of the collective control stick was in a raised position almost three-quarters (¾) of full travel (from the video footage), and was jammed in that position. The throttle was also stuck in position, and it was hard to rotate. Both anti-torque pedals were still in position and were not damaged.

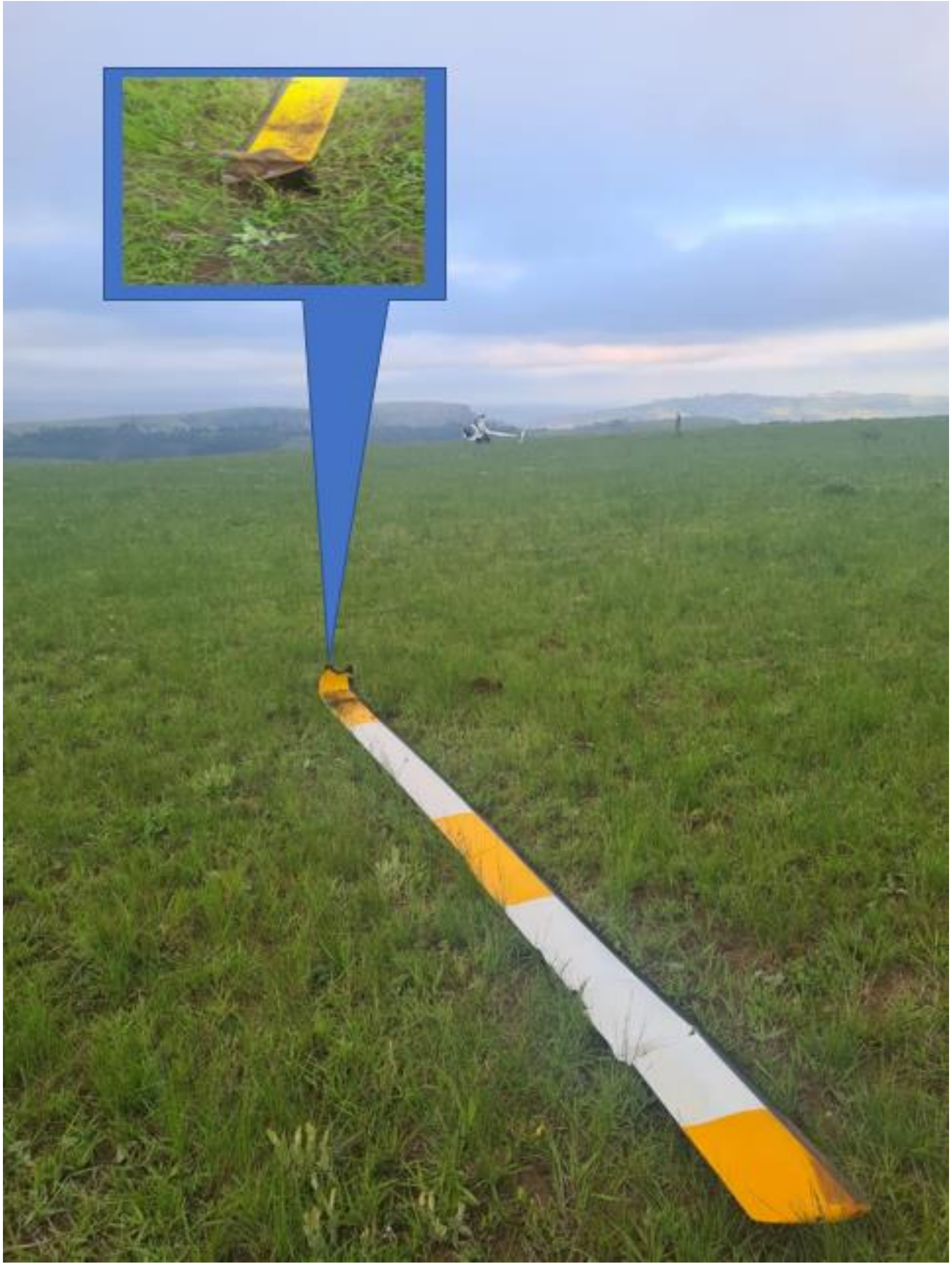

Figure 5: The detached main rotor blade. (Source: AMO)

Figure 6: The broken pitch change link.

1.12.3 The tail boom section was still attached to the mountings with evidence of compression load and buckling on the left-side; a puncture on the skin surface indicated tail rotor blade impact. One of the tail rotor blades broke off at the root as a result of impact. The tail gearbox was still intact, and the 90° drive was still positive. The tail rotor pitch was checked, and the pitch link assemblies were found operational. The teller temperature indicator was at 66°C, indicative of normal operation; the oil level was full. The vertical fin was still intact except for the compression damage (which had bent) towards the bottom end. The vertical fin had traces of blades of grass and dirt at the top, an indication of contact with the ground, whilst the lower fin had a 90° bend to the left. The tail rotor guard had dirt and blades of grass, indicative of contact with the ground. The tail drive shaft was still attached to its bearings, but the flex plate had fractured. The shaft was broken and had disconnected from the yoke assembly.

Figure 7: Damage sustained by the tail boom and the right skid. (Source: ATO)

Figure 8: The sleeve showing where the blade had detached.

1.12.4 The engine was still secured in the cradle, although damage was seen on the left lower side of it (cradle). The oil level indicated five (5) quarts; no oil leak was visible. The throttle tube was wedged into the skin surface and movement could not be confirmed. The V-belts had detached from the sheath and one of the belts was not accounted for. The tele-temperature of the lower bearing indicated 56°C, which is normal operation. The nut securing the cooling fan to the engine was misaligned, indicative of the engine producing power at impact. The alternator belt was still connected to the alternator. The firewall had buckling damage. Battery attachment points and terminals were found broken as a result of the impact.

Figure 9: The upper sheath and belt.

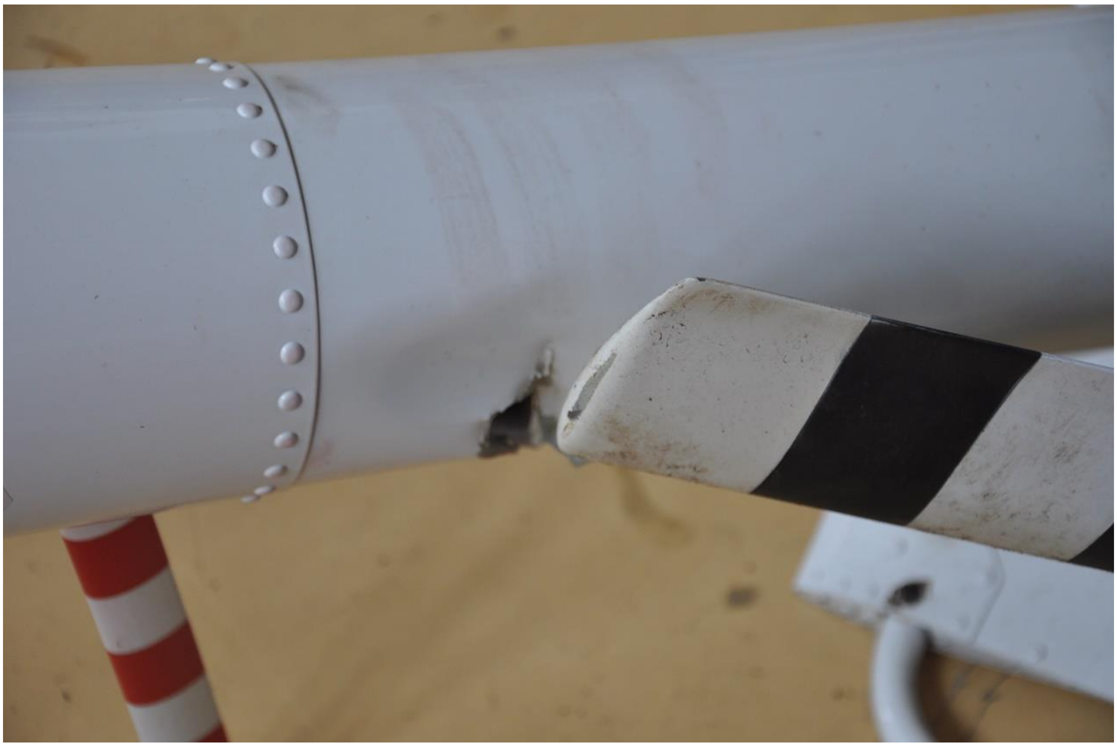

Figure 10: The punctured boom.

1.13. Medical and Pathological Information

1.13.1. Not applicable.

1.14. Fire

1.14.1. There was no evidence of post-impact fire.

1.15. Survival Aspects

1.15.1. The accident was considered survivable due to the cabin structure that was not damaged. Furthermore, the student pilot was wearing the helicopter-fitted safety harness.

1.16. Tests and Research

1.16.1. The lock nuts on the control pitch change links revealed extensive corrosion damage. The failed components were recovered and sent to the University of Pretoria for metallurgical analysis. The cause of this corrosion was due to the breakdown of the painted protective layer coating which exposed the steel-based nuts to the operation environment, as well as the galvanic action between the nut and the more inert steel adjuster body. The evidence suggested that the corrosion damage was present for a long time and should have been detected during the walk-around inspections, the mandatory periodic inspections (MPI) and the pre-flight checks.

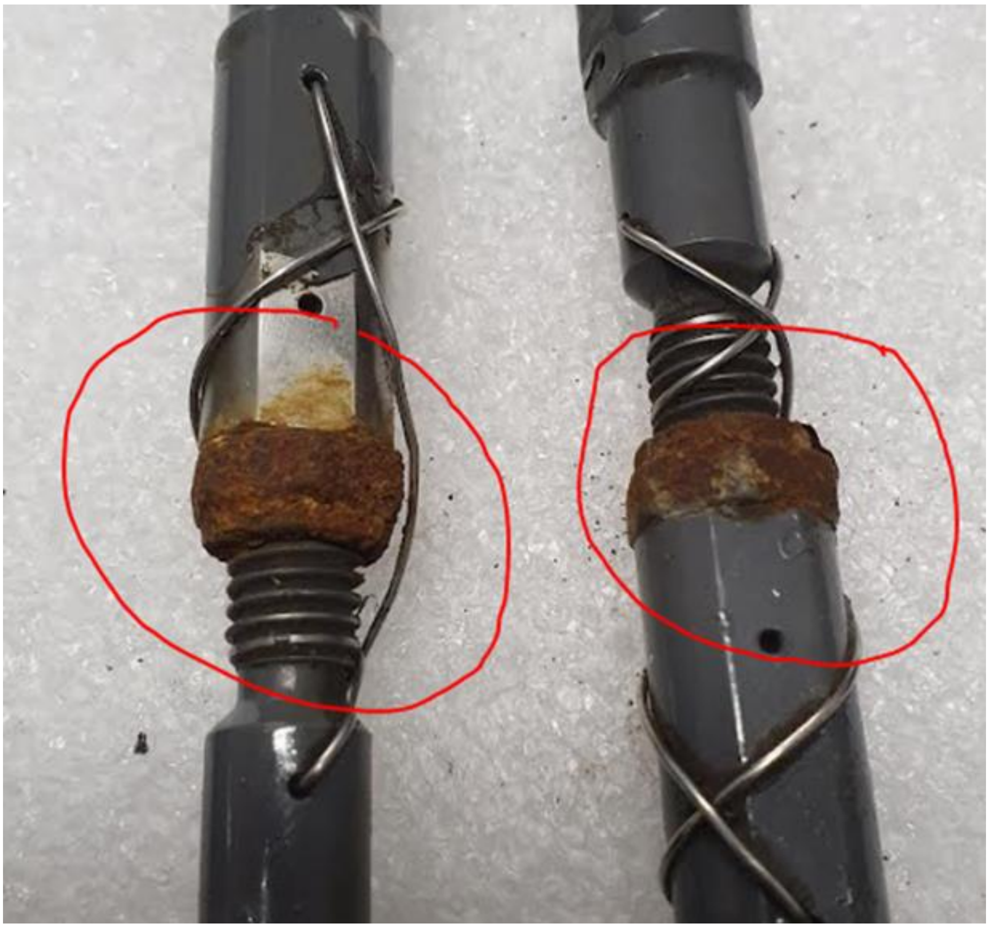

Figure 11: Corroded pitch change links. (Source: University of Pretoria)

1.16.2 The threaded section of the eye-end revealed some bending deformation at the vicinity of the primary fracture. No clear indication of a pre-existing fracture was noticed at the initiation point, i.e. fatigue, corrosion or other material discrepancies. The fractured surface morphology corresponded with a steel-based exposure to an overload condition which showed ductile, microvoid coalescence features with indications of shear. (Figures 12 and 13).

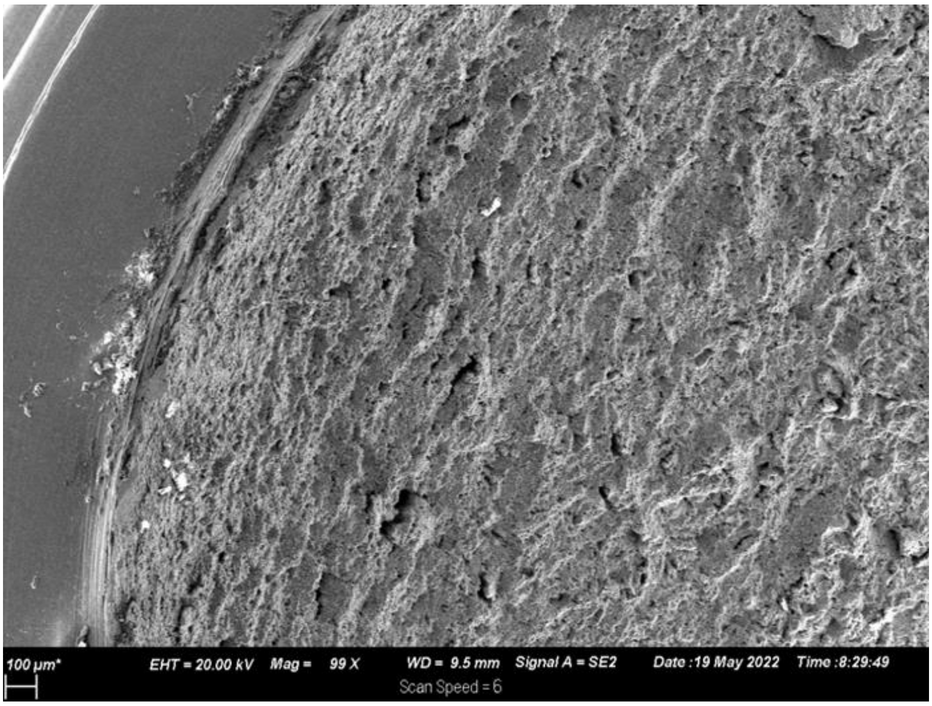

Figure 12: Sheered bolt under microscope. (Source: University of Pretoria)

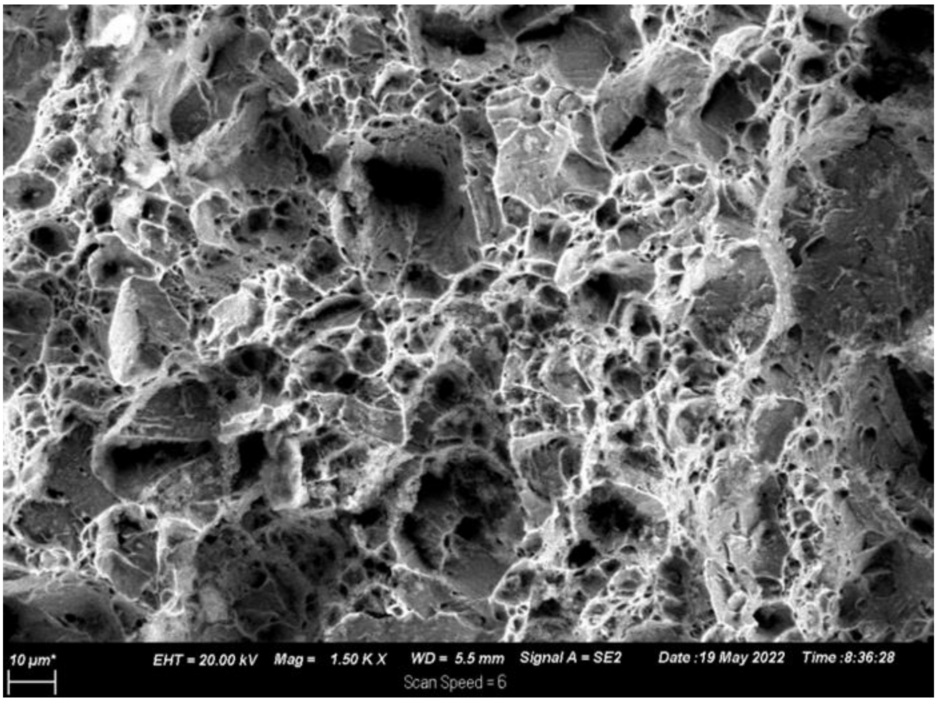

Figure 13: Magnified sheered bolt. (Source: University of Pretoria)

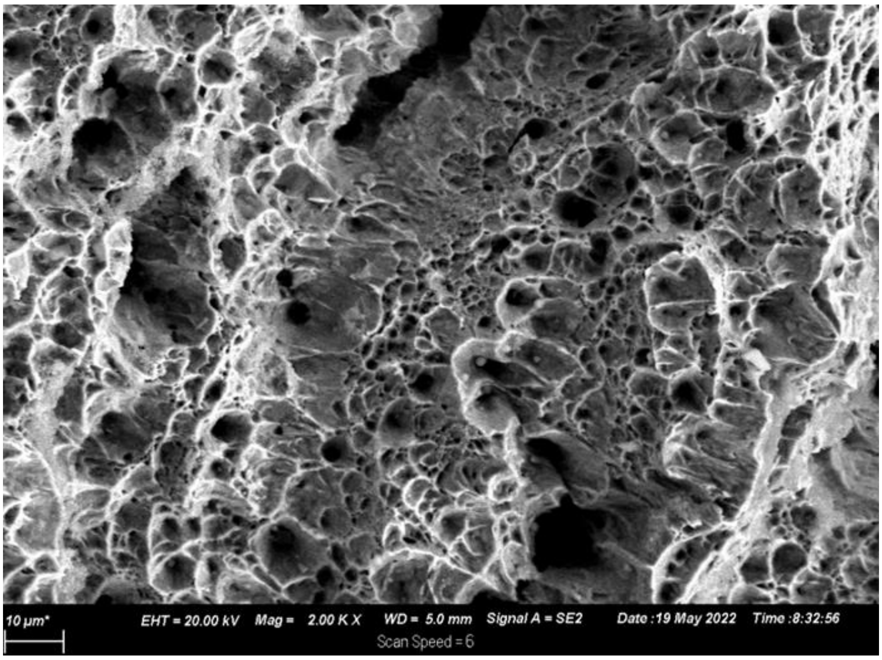

Figure 14: Enlarged magnified sheered bolt. (Source: University of Pretoria)

Figure 15: Sheered bolt. (Source: University of Pretoria)

1.16.3 Considering the above, the fractured surface morphology corresponded with the steel-based wrought alloy exposed to a single overload operation.

1.17. Organisational and Management Information

1.17.1. The aircraft was maintained by Starlite Aviation Academy in accordance with Part 145 of the Civil Aviation Regulations (CAR) 2011 as amended, as well as aircraft maintenance manuals.

1.17.2. The AMO that certified the inspection had an AMO approval certificate that was issued by the Regulator (SACAA) on 19 November 2021 with an expiry date of 31 October 2022. At the time of the accident, the AMO recertification by the Regulator (SACAA) was still underway.

1.17.3. The operator was issued an Approved Training Organisation (ATO) certificate on 30 June 2021 with an expiry date of 30 June 2026.

1.18. Additional Information

1.18.1. DYNAMIC ROLLOVER (Source: FAA Helicopter Handbook)

A helicopter is susceptible to a lateral rolling tendency, called dynamic rollover, when lifting off the surface. For dynamic rollover to occur, some factor has to first cause the helicopter to roll or pivot around a skid, or landing gear wheel, until its critical rollover angle is reached. Then, beyond this point, main rotor thrust continues the roll and recovery is impossible. If the critical rollover angle is exceeded, the helicopter rolls on its side regardless of the cyclic corrections made. Dynamic rollover begins when the helicopter starts to pivot around its skid or wheel. This can occur for a variety of reasons, including the failure to remove a tiedown or skid securing device, or if the skid or wheel contacts a fixed object while hovering sideward, or if the gear is stuck in ice, soft asphalt, or mud. Dynamic rollover may also occur if you do not use the proper landing or take-off technique or while performing slope operations. Whatever the cause, if the gear or skid becomes a pivot point, dynamic rollover is possible if you do not use the proper corrective technique. Once started, dynamic rollover cannot be stopped by application of opposite cyclic control alone. For example, the right skid contacts an object and becomes the pivot point while the helicopter starts rolling to the right. Even with full left cyclic applied, the main rotor thrust vector and its moment follows the aircraft as it continues rolling to the right. Quickly applying down collective is the most effective way to stop dynamic rollover from developing. Dynamic rollover can occur in both skid and wheel equipped helicopters, and all types of rotor systems.

CRITICAL CONDITIONS

Certain conditions reduce the critical rollover angle, thus increasing the possibility for dynamic rollover and reducing the chance for recovery. The rate of rolling motion is also a consideration, because as the roll rate increases, the critical rollover angle at which recovery is still possible, is reduced. Other critical conditions include operating at high gross weights with thrust (lift) approximately equal to the weight. Refer to figure 15. The following conditions are most critical for helicopters with counter-clockwise rotor rotation: 1. right side skid/wheel down, since translating tendency adds to the rollover force. 2. right lateral centre of gravity. When performing slope take-off and landing manoeuvres, follow the published procedures *and keep the roll rates small. Slowly raise the downslope skid or wheel to bring the helicopter level, and then lift off. During landing, first touchdown on the upslope skid or wheel, then slowly lower the downslope skid or wheel using combined movements of cyclic and collective. If the helicopter rolls approximately 5 to 8° to the upslope side, decrease collective to correct the bank angle and return to level attitude, then start the landing procedure again.*

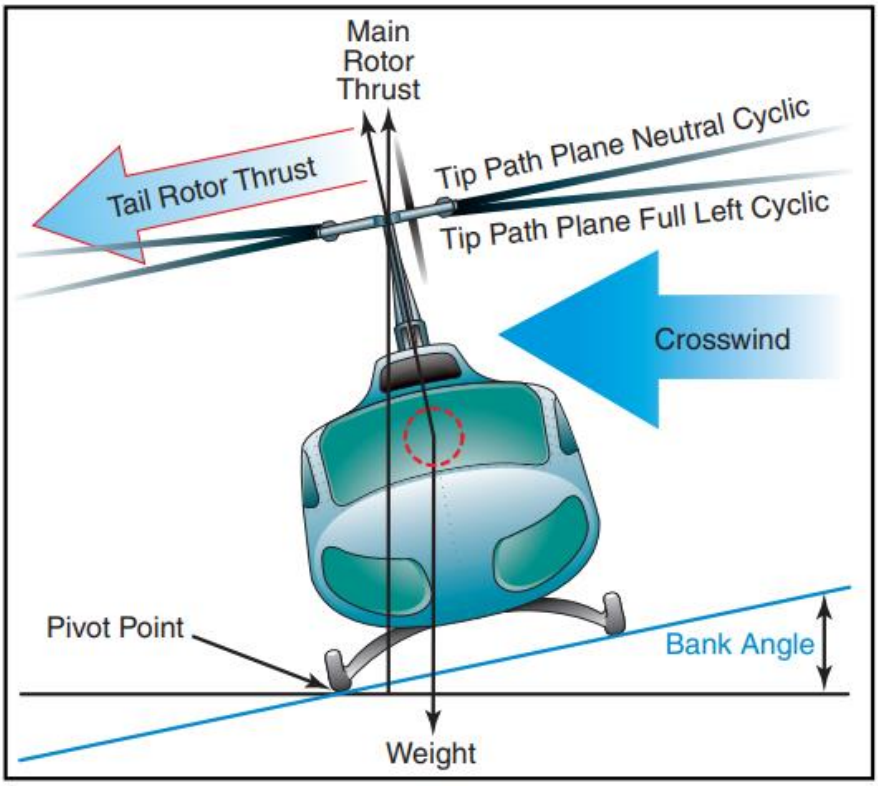

Figure 16: Forces acting on a helicopter with the right skid on the ground.
(Source: FAA Helicopter handbook)

1.18.2 PRECAUTIONS

The following list presents several measures to help avoid a dynamic rollover:

1. Always practice hovering autorotation's into the wind, but never when the wind is gusty or over 10 knots.

2. When hovering close to fences, sprinklers, bushes, runway/taxi lights, or other obstacles that could catch a skid, use extreme caution.

3. Always use a two-step lift off. Pull in just enough collective pitch control to be light on the skids and feel for equilibrium, then gently lift the helicopter into the air.

4. When practising hovering manoeuvres close to the ground, make sure you hover high enough to have adequate skid clearance with any obstacles, especially when practising sideways or rearward flight.

5. When the wind is coming from the upslope direction, less lateral cyclic control will be available.

6. Tailwind conditions should be avoided when conducting slope operations.

7. When the left skid/wheel is upslope, less lateral cyclic control is available due to the translating tendency of the tail rotor. (This is true for counter-rotating rotor systems)
8. If passengers or cargo are loaded or unloaded, the lateral cyclic requirement changes.
9. If the helicopter utilises interconnecting fuel lines that allow fuel to automatically transfer from one side of the helicopter to the other, the gravitational flow of fuel to the downslope tank could change the centre of gravity, resulting in a different amount of cyclic control application to obtain the same lateral result.
10. Do not allow the cyclic limits to be reached. If the cyclic control limit is reached, further lowering of the collective may cause mast bumping. If this occurs, return to a hover and select a landing point with a lesser degree of slope.
11. During a take-off from a slope, if the upslope skid/wheel starts to leave the ground before the downslope skid/wheel, smoothly and gently lower the collective and check to see if the downslope skid/wheel is caught on something. Under these conditions vertical ascent is the only acceptable method of lift off.
12. During flight operations on a floating platform, if the platform is pitching/rolling while attempting to land or take-off, the result could be dynamic rollover.

1.18.3 Safety Notice SN-9 (Source: Robinson POH)

Many Accidents Involve Dynamic Rollover
A dynamic rollover can occur whenever the landing gear contacts a fixed object forcing the aircraft to pivot about the object instead of about its own centre of gravity. The fixed object can be any obstacle or surface which prevents the skid from moving sideways. Once started, dynamic rollover cannot be stopped by applying of opposite cyclic alone. For example, assume the right skid contacts an object and becomes the pivot point while the helicopter starts rolling to the right. Even with full left cyclic applied, the main rotor thrust vector will still pass on the left side of the pivot point and produce a rolling moment to the right instead of to the left. The thrust vector and its moment will follow the aircraft as it continues rolling to the right. Quickly applying down collective is the most effective way to stop a dynamic rollover.

To avoid a dynamic rollover:

1) *Always practise hovering autorotations into the wind and never when the wind is gusty or over 10 knots.*
2) *Never hover close to fences, sprinklers, bushes, runway lights or other obstacles a skid could catch on.*
3) *Always use a two-step lift off. Pull in just enough collective to be light on the skids and feel for equilibrium, then gently lift the helicopter into the air*
4) *Do not practise hovering manoeuvres close to the ground. Keep the skids at least five feet above the ground when practising sideward or rearward flight*

1.18.4 The longitudinal centre of gravity shifts reward (Source: Helicopter flight training by Kim Carter-Watchurst and Lucy Erasmus)

The weight in the front of the helicopter will be much lighter without the instructor on-board. As a result of the heavier weight of fuel behind the pilot, the nose of the helicopter will sit higher than normal. The effect that it has as you lift off into the hover is that the front of the skids will lift off the ground first. This will need to be compensated for with cyclic. Apply forward cyclic to keep the rotor disc in line for vertical lift off into the hover.

1.18.5 Lateral centre of gravity shifts right (Source: Helicopter flight training by Kim Carter-Watchurst and Lucy Erasmus)

With no instructor in the left seat, the helicopter is now lighter on the left-hand side and the weight of you, in the pilot's seat, makes it heavier on the right. As opposed to the left skid low position as previously felt in the lift-off and hover during dual training, the helicopter may well hang right skid low. The left skid, being on the lighter side, will want to lift off the ground first. Quite a change from when the instructor was in the helicopter and the right skid wanted to lift first. Lifting into the hover you will need to apply left cyclic to keep the rotor disc positioned for a vertical lift-off into the hover.

1.18.6 SLOPE OPERATIONS (Source: FAA Helicopter Handbook)

Prior to conducting any slope operations, you should be thoroughly familiar with the characteristics of dynamic rollover and mast bumping, which are discussed in Chapter 11—Helicopter Emergencies. The approach to a slope is similar to the approach to any other landing area. During slope operations, make allowances for wind, barriers, and forced landing sites in case of engine failure. Since the slope may constitute an obstruction to wind passage, you should anticipate turbulence and downdrafts.

1.18.7 SLOPE LANDING

You usually land a helicopter across the slope rather than with the slope. Landing with the helicopter facing down the slope or downhill is not recommended because of the possibility of striking the tail rotor on the surface.

TECHNIQUE (Refer to Figure 17)

At the termination of the approach, move the helicopter slowly toward the slope, being careful not to turn the tail upslope. Position the helicopter across the slope at a stabilised hover headed into the wind over the spot of intended landing (frame 1). Downward pressure on the collective starts the helicopter descending. As the upslope skid touches the ground, hesitate momentarily in a level attitude, then apply lateral cyclic in the direction of the slope (frame 2). This holds the skid against the slope while you continue lowering the downslope skid with the collective. As you lower the collective, continue to move the cyclic toward the slope to *maintain a fixed position (frame 3). The slope must be shallow enough so you can hold the helicopter against it with the cyclic during the entire landing. A slope of 5° is considered maximum for normal operation of most helicopters. You should be aware of any abnormal vibration or mast bumping that signal maximum cyclic deflection. If this occurs, abandon the landing because the slope is too steep. In most helicopters with a counter clockwise rotor system, landings can be made on steeper slopes when you are holding the cyclic to the right. When landing on slopes using left cyclic, some cyclic input must be used to overcome the translating tendency. If wind is not a factor, you should consider the drifting tendency when determining landing direction. After the downslope skid is on the surface, reduce the collective to full down, and neutralise the cyclic and pedals (frame 4). Normal operating r.p.m. should be maintained until the full weight of the helicopter is on the landing gear. This ensures adequate r.p.m. for immediate take-off in case the helicopter starts sliding down the slope. Use antitorque pedals as necessary throughout the landing for heading control. Before reducing the r.p.m., move the cyclic control as necessary to check that the helicopter is firmly on the ground.*

COMMON ERRORS

1. Failure to consider wind effects during the approach and landing.
2. Failure to maintain proper r.p.m. throughout the entire manoeuvre.
3. Turning the tail of the helicopter into the slope.
4. Lowering the downslope skid or wheel too rapidly.
5. Applying excessive cyclic control into the slope, causing mast bumping.

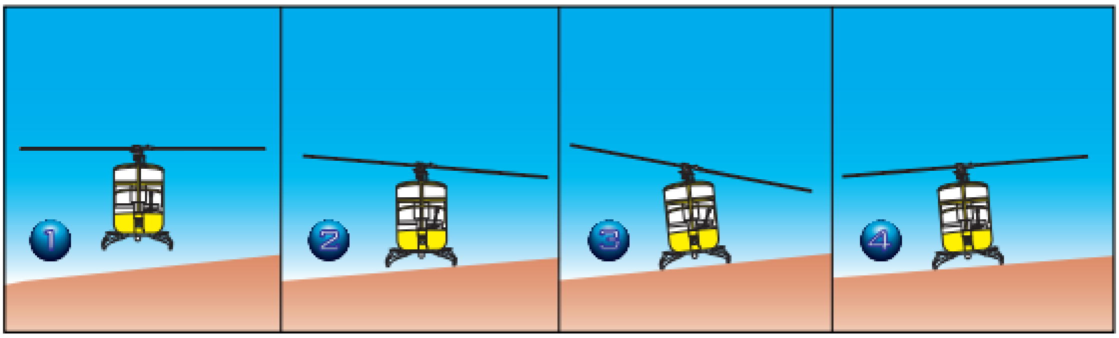

Figure 17: Slope landing.

SLOPE TAKE-OFF

A slope take-off (Figure 18) is basically the reverse of a slope landing (Figure 17). Conditions that may be associated with the slope, such as turbulence and obstacles, must be considered during the take-off. Planning should include suitable forced landing areas.

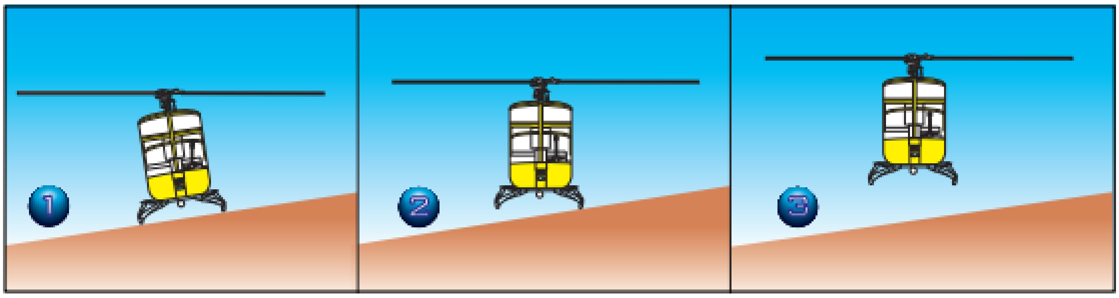

Figure 18: Slope take-off.

TECHNIQUE

Begin the take-off by increasing r.p.m. to the normal range with the collective full down. Then, move the cyclic toward the slope (frame 1). Holding cyclic toward the slope causes the downslope skid to rise as you slowly raise the collective (frame 2). As the skid comes up, move the cyclic toward the neutral position. If properly coordinated, the helicopter should attain a level attitude as the cyclic reaches the neutral position. At the same time, use antitorque pedal pressure to maintain heading and throttle to maintain r.p.m. With the helicopter level and the cyclic centred, pause momentarily to verify everything is correct, and then gradually raise the collective to complete the lift-off (frame 3). After reaching a hover, take care to avoid hitting the ground with the tail rotor. If an upslope wind exists, execute a crosswind take-off and then make a turn into the wind after clearing the ground with the tail rotor.

COMMON ERRORS

1. Failure to adjust cyclic control to keep the helicopter from sliding downslope.

2. Failure to maintain proper r.p.m.

3. Holding excessive cyclic into the slope as the downslope skid is raised.

4. Turning the tail of the helicopter into the slope during take-off.

1.19. Useful or Effective Investigation Techniques

1.19.1. None.

2. ANALYSIS

2.1. General

From the available evidence, the following analysis was made with respect to this accident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2. Analysis

Pilot

2.2.1. The student pilot was initially issued a Student Pilot Licence on 2 February 2018. His last competency test was conducted on 14 August 2021, after which a licence was reissued with an expiry date of 13 August 2022. The pilot had a Class 2 medical certificate which was issued on 6 December 2017 with an expiry date of 31 December 2022, and with no restrictions.

2.2.2. The student training report briefing sheets in the student pilot's file were inconsistently completed with some blocks/sections not populated.

2.2.3. Exercise 17, which is the solo consolidation, was not signed out by the CFI in the student pilot's training file.

2.2.4. The student pilot's AB-initio summary hours sheet was not completed fully; Exercise 12, which is the crosswind and downwind transitions, was not recorded.

Aircraft

2.2.5 The aircraft was issued the Certificate of Airworthiness (C of A) on 11 January 2017. The latest C of A had an expiry date of 31 January 2022.

2.2.6 The aircraft's Certificate of Registration (C of R) was issued to the present owner on 18 August 2018.

2.2.7 The last maintenance inspection prior to the accident flight was carried out on 26 May 2021 at 4 096.52 airframe hours. The aircraft was issued the Certificate of Release to Service (CRS) on 26 May 2021 with an expiry date of 25 May 2022 or at 4 196.52 hours, whichever occurs first.

2.2.8 The video footage showed that the aircraft rolled 360° to the right.

Environment

2.2.9 The weather was reported to be as follows: wind direction: 070° with wind speed of 11 knots; temperature: 27°C; dew point: 17°C; and visibility of more than 10 kilometres. There was no cloud cover, therefore, the weather was not a factor to this accident. The terrain where the accident occurred was soft and sloping.

3. CONCLUSION

3.1. General

From the available evidence, the following findings, causes and contributing factors were made with respect to this accident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events, or circumstances in this accident. The findings are significant steps in this accident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this accident.
- **Contributing factors —** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident occurring, or would have mitigated the severity of the consequences of the accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

3.2. Findings

<u>Pilot</u>

3.2.1. The student pilot was initially issued a Student Pilot Licence on 2 February 2018. His last competency test was conducted on 14 August 2021, after which a licence was re-issued with an expiry date of 13 August 2022. The pilot had a Class 2 medical certificate which was issued on 6 December 2017 with an expiry date of 31 December 2022, and with no restrictions.

3.2.2. The student training report briefing sheets in the student pilot's file were inconsistently completed with some blocks/sections not populated. Also, Exercise 17, which is the solo consolidation, was not signed out by the CFI.

3.2.3. The student pilot's AB-initio summary hours sheet was not completed fully; Exercise 12, which is the crosswind and downwind transitions, was not recorded.

<u>Aircraft</u>

3.2.4. The aircraft was issued a Certificate of Airworthiness (C of A) on 11 January 2017. The latest C of A had an expiry date of 31 January 2022. The aircraft's Certificate of Registration (C of R) was issued to the present owner on 18 August 2018.

3.2.5. The last maintenance inspection prior to the accident flight was carried out on 26 May 2021 at 4 096.52 airframe hours. The aircraft was issued a Certificate of Release to Service (CRS) on 26 May 2021 with an expiry date of 25 May 2022 or at 4 196.52 hours, whichever occurs first.

3.2.6. The video footage showed that the aircraft rolled 360° to the right.

Environment

3.2.7. The weather was reported to be as follows: wind direction: 070° with wind speed of 11 knots; temperature: 27°C; dew point: 17°C; and visibility of more than 10 kilometres. There was no cloud cover, therefore, the weather at the time of the flight was not a factor. The terrain where the accident occurred was soft and sloping.

3.3. Probable Cause

3.3.1. It is likely that the heel of the right skid got stuck in the soft soil, which led to loss of control and a dynamic roll over.

3.4. Contributory Factor

3.4.1. Incorrect technique during lift-off.

4. SAFETY RECOMMENDATIONS

4.1. General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2. Safety Recommendation/s

4.2.1. None.

5. APPENDICES

5.1. None.

This report is issued by:

Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa