SOUTH AFRICAN CIVIL AVIATION AUTHORITY

Section/division **Accident and Incident Investigations Division** Form Number: CA 12-12c

HELICOPTER ACCIDENT REPORT AND EXECUTIVE SUMMARY

				Reference:	CA18/2/3/9832
Aircraft Registration	ZT-RAL	**Date of Accident**	25 October 2019	**Time of Accident**	1030Z
Type of Aircraft	Robinson R44		**Type of Operation**	Training (Part 141)	

Pilot-in-command Licence Type	Commercial Pilot Licence	**Age**	70	**Licence Valid**	Yes
Pilot-in-command Flying Experience	Total Flying Hours	7700.6		Hours on Type	134.1

Last Point of Departure	Wonderboom Aerodrome (FAWB), Gauteng Province
Next Point of Intended Landing	Wonderboom Aerodrome (FAWB), Gauteng Province

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

At position S 25º 40' 18.67" E 028º 12' 54.12" on Marjoram Ave position 0.6nm south of Runway 06 threshold

Meteorological Information	Wind: 270°/14kts, Temperature: 36°C, Dew Point: 14°C, Visibility: CAVOK, QNH: 1018hPa and Clouds: Nil

Number of People On-board	3 + 0	**No. of People Injured**	2 (minor) 1 (serious)	**No. of People Killed**	0

Synopsis

On 25 October 2019, a Robinson R44 helicopter with three pilots on-board took off from Wonderboom Aerodrome (FAWB) to conduct instrument rating revalidation in accordance with the Regulator (South African Civil Aviation Authority). On-board the helicopter were the DFE (instructor), the pilot conducting the rating revalidation, and an authorised officer (AO) from the Regulator's personnel licensing department (PEL). Both exercises were conducted simultaneously and were completed successfully. Thereafter, the helicopter headed back to FAWB with the pilot on flight controls. During landing, the instructor felt that the pilot's landing approach was not good and decided to take over controls for a go-around. During a climb at approximately 200 feet (ft) above ground level (AGL), the helicopter's low rotor revolutions per minute (RPM) warning horn went off, the instructor corrected it and maintained climb. At approximately 300ft AGL, the helicopter's low rotor RPM warning horn went off again with the low rotor rotation lighting illuminating. This time, the instructor could not recover from the low rotor RPM condition. The helicopter's height was low. Due to insufficient height and the helicopter flying over a built-up area, the pilot opted to execute a forced landing on the road (Marjoram Avenue) in Sinoville. Autorotation was not possible because of insufficient height, however, the instructor focused on guiding the helicopter to an identified landing zone to avoid impacting buildings as it was flying over a populated residential area. The main rotor first clipped some treetops, then cut through some branches before striking a streetlight pole. The helicopter was destroyed during the accident; the DFE and the pilot conducting the rating revalidation had minor injuries, while the AO sustained serious injuries.

The investigation revealed that it is likely that following the instructor's abrupt taking over controls of the helicopter, he may have rolled the throttle the wrong way or pulled more collective pitch than power available during a go-around. That resulted in the rotor RPM drop and the blades trying to maintain the same amount of lift by increasing pitch. As the pitch increased, the drag also increased, which required more power to keep the blades turning at the proper RPM. When power available was no longer sufficient to maintain RPM, and therefore lift, the helicopter began to descent; and the pilot elected to execute a forced landing, which was unsuccessful.

SRP Date	14 July 2020	Publication Date	22 July 2020

ABBREVIATION	DEFINITION
º	Degrees
ºC	Degree Celsius
'	Minutes
"	Seconds
AGL	Above Ground Level
AMSL	Above Mean Sea Level
AO	Authorised Officer
ATNS	Air Traffic Navigation Services
CAVOK	Ceiling and Visibility OK
ATPL	Airline Transport Pilot Licence
CPL	Commercial Pilot Licence
CoA	Certificate of Airworthiness
C o R	Certificate of Registration
CVR	Cockpit Voice Recorder
DFE	Designated Flight Examiner
FAWB	Wonderboom Aerodrome
FDR	Flight Data Recorder
Ft	Feet
Kt	Knots
hPa	Hectopascal
GPS	Geographical Positioning System
nm	Nautical Miles
MEP	Multi Engine Piston
MPI	Mandatory Periodic Inspection
PEL	Personnel Licencing
PIC	Pilot-in-command
QNH	Query Nautical height
RPM	Revolutions per Minute
SB	Service Bulletin
SI	Service Instruction
SEP	Single Engine Piston
TI	Technical Instructions
VOR	Very High Omnidirectional Range
TBO	Time Before Overhaul

Reference Number	**:** CA18/2/3/9832
Name of Owner/Operator	**:** Delmart (Pty) Ltd t/a Powered Flight Training Centre
Manufacturer	**:** Robinson Helicopter Company
Model	**:** R44
Nationality	**:** South African
Registration Marks	**:** ZT-RAL
Place	**:** At position S 25º 40ˈ 18.67ˮ E 028º 12ˈ 54.12ˮ on Marjoram Avenue, 0.6nm short of Runway 06 threshold
Date	**:** 25 October 2019
Time	**:** 1030Z

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 (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**.*

Investigations process:

The accident was notified to the Accident and Incident Investigations Division (AIID) on 25 October 2019 at about 1100Z. The investigator went to Sinoville, Pretoria, on 25 October 2019. The investigator co-ordinated with all authorities on site by initiating the accident investigation process according to CAR 2011 Part 12 and investigation procedures. The AIID is leading the investigation as the Republic of South Africa is the State of Occurrence.

The AIID appointed an investigator-in-charge (IIC) with an investigation team. The AIID sent notifications to the State of Registry, State of Operator (RSA) and the State of Manufacture and Design (USA). The National Transportation Safety Board (NTSB), which is representing the State of Manufacture and Design, nominated a non-travelling accredited representative.

Notes:
1. Whenever the following words are mentioned in this report, they shall mean the following:

- *Accident – this investigated accident*
- *Aircraft – the R44 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 be 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:

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FACTUAL INFORMATION

1.1. History of Flight

1.1.1 On 25 October 2019, the Robinson R44 helicopter took off from Wonderboom Aerodrome (FAWB) on a training flight which was oversighted by an inspector from the Regulator's (SACAA) office. On-board the helicopter were three occupants: the instructor, also a designated flight examiner (DFE), who was seated on the front right-hand side of the helicopter; the pilot, who was being tested for the reissuance of his instrument rating and seated on the front left-hand side of the helicopter; and the Regulator's inspector, who was seated on the rear seat of the helicopter. The helicopter's pre-flight checks were conducted and were in order. Upon take-off in front of the Operator's hangar at approximately 0930Z, the helicopter headed towards a very high omnidirectional range (VOR) antenna CZV, situated near Cullinan for a simulated instrument let-down. Thereafter, the helicopter returned to FAWB for a practise autorotation onto the training squares next to the taxiway. This was followed by a simulated confined landing onto the threshold of Runway 06.

Figure 1: View of the accident site. (Source Google Earth)

1.1.2 After completion of the exercise, the pilot initiated an approach to the landing area in front of the Operator's hangar. The instructor stated that he was not satisfied with the approach and elected to take over controls of the helicopter and initiated a climb in a south-easterly direction. During the climbing phase at approximately 200 feet (ft) above ground level (AGL) at 40 knots (kt) indicated airspeed, the low rotor revolutions per minute (RPM) warning horn briefly went off and a caution light illuminated. This was corrected accordingly by slight reduction of the collective control. At approximately 300ft AGL, the instructor initiated a turn to the right with an intention to turn towards the threshold of Runway 06 for landing at the dedicated landing spot in-front of the Operator's hangar. During the turn, the low rotor RPM warning horn went off again with the caution light indicator illuminated; and it remained on. An attempt for power recovery through reduction of collective control had no effect this time. During a forced descent, autorotation was not possible because of insufficient height. However, the instructor focused on guiding the helicopter to an identified landing zone to avoid impact with buildings as the helicopter was flying over a populated residential area.

1.1.3 The helicopter's main rotor blade clipped the treetops and cut through some branches before it struck a streetlight pole; damaging it. It then impacted the ground hard on its right landing skid; the skid broke off before collapsing and bending outwards. The left-hand skid was also bent outwards during the accident sequence, leaving the belly to make a hard contact with the ground. The helicopter then began to skid along the road for approximately 20 metres before it came to a stop; it then rolled onto its left-hand side facing a south-westerly direction. All three helicopter occupants disembarked unassisted. The DFE and the pilot conducting the rating revalidation had minor injuries, while the AO sustained serious injuries.

1.1.4 The helicopter accident occurred during daylight approximately 0.6 nautical miles (nm) south of Runway 06 threshold at Global Positioning System (GPS) co-ordinates determined to be S 25º 40ʹ 18.67ʺ, E 028º 12ʹ 54.12ʺ at a field elevation of 4092ft above mean sea level (AMSL).

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Other
Fatal	-	-	-	-
Serious	1	-	-	-
Minor	2		-	-
None	-	-	-	-

1.2.1 After the accident, the AO went for a medical check-up and was subsequently hospitalised for several days due to back injuries. The OA was booked off duty for approximately six weeks.

1.3. Damage to Aircraft

1.3.1 The helicopter was destroyed during the accident sequence.

Figure 2: The helicopter wreckage after the accident.

1.4. Other Damage

1.4.1 The helicopter struck the streetlight pole, damaging it.

Figure 3: The damaged streetlight pole.

1.5. Personnel Information

Instructor/DFE: Designated Flight Examiner

Nationality	South African	Gender	Male	Age	70
Licence Number	0270431612	Licence Type	Airline Transport Pilot Licence (Helicopters and Aeroplanes)		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Night, Instructor Grade 1, Culling, Sling-load, Winching, Instrument, Test Pilot.				
Medical Expiry Date	11 January 2020				
Restrictions	Corrective lenses				
Previous Accidents	None				

Flying Experience:

Total Hours	7700.6
Total Past 90 Days	7.1
Total on Type Past 90 Days	1.9
Total on Type	134.1

According to available information, the instructor (DFE) was rated on both fixed-wing aeroplanes and rotorcrafts. He accumulated a total of 1595.6 flying hours on aeroplanes and a total of 6105 flying hours on rotorcrafts. On the day of the flight, the instructor (DFE) was also undergoing oversight review conducted by an inspector from the regulating authority. The instructor (DFE) was contracted by the pilot for his instrument rating renewal.

Pilot

Nationality	South African	Gender	Male	Age	49
Licence Number	0271070377	Licence Type	Commercial Pilot Licence		
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Night				
Medical Expiry Date	30 April 2020				
Restrictions	None				
Previous Accidents	None				

Flying Experience:

Total Hours	3896.4
Total Past 90 Days	70.7
Total on Type Past 90 Days	5.6
Total on Type	558.1

1.6. Aircraft Information

Figure 4: The R44 Raven 1 helicopter.

The following information was extracted from the R44 Pilot Operating Handbook (POH), Section 7: System description:

1.6.1 *The R44 is a four-seater, single main rotor, single engine helicopter constructed primarily of metal and equipped with skid-type landing gear. The primary fuselage structure is welded steel tubing and riveted aluminium sheet. The tail-cone is a monocoque structure in which aluminium skins carry most primary loads. Fiberglass and thermoplastics are used in secondary cabin structure, engine cooling shrouds, and various other ducts and fairings. The cabin doors are also constructed of fiberglass and thermoplastics.*

Four right-side cowl doors provide access to the main gearbox, drive system and engine. A left-side engine cowl door provides access to the engine oil filler and dip stick. Additional access to controls and other components for maintenance is provided by removable panels and cowlings. Stainless steel firewalls are located forward of and above the engine. The four cabin doors are removable.

Airframe:

Type	R44 Raven 1	
Serial Number	1279	
Manufacturer	Robinson Helicopter Company	
Date of Manufacture	2003	
Total Airframe Hours (At time of Accident)	2089.1	
Last MPI (Date & Hours)	19 September 2019	2041.4
Hours since Last MPI	47.7	
C of A (Issue Date)	20 September 2018	
C of A (Expiry Date)	30 November 2019	
C of R (Issue Date) (Present owner)	3 February 2016	
Operating Categories	Standard Part 127	

Engine:

Type	Lycoming: LYC-0 540-FIB5
Serial Number	L-26173-40A
Hours Since New	2089.1
Hours Since Overhaul	TBO not yet reached

Main Rotor:

Type	Main Rotor Hub: P/N: C154-1(two teetering blades)			
Serial Number/s	1480			
Rotor Blades	P/N: C016-7	S/N: 9249	P/N: C016-7	SN: 9291
Hours Since New	2089.1		2089.1	
Hours Since Overhaul	TBO not yet reached	T/L: 2200	TBO not yet reached	T/L: 2200
Transmission Type	Main Rotor gearbox (P/N: C006-6)			
Serial Number/s	1543			
Hours Since New	2089.1			
Hours Since Overhaul	TBO not yet reached (Time limit (T/L) is: 2200)			

Tail Rotor:

Type	Tail Rotor Hub (TRH) P/N: D062-2 (two blades)			
Serial Number/s	TRH: 771			
Tail Rotor Blades	P/N: C029-1	TRB: 2979A	P/N: 029-1	TRB: 3053A
Hours Since New	2089.1		2089.1	
Hours Since Overhaul	TBO not yet reached		TBO not yet reached	
Transmission Type	T/R Gearset: P/N: C545-1			
Serial Number/s	1549			
Hours Since New	2089.1			
Hours Since Overhaul	TBO not yet reached (Component life retire at 2200)			

1.6.2 Rotor system:

The following information was extracted from the R44 Raven I helicopter type POH, approved by the Federal Aviation Administration (FAA): 12 October 2016 (System description, Page 7-2)

The main rotor has two all metal blades mounted to the hub by coning hinges. The hub is mounted to the shaft by a teeter hinge. The coning and teeter hinges use self-lubricated bearings. Droop *stops for the main rotor blades provide a teeter hinge friction restrain which normally prevents the rotor from teetering while starting or stopping. Pitch change bearings for each blade are enclosed in a housing at the blade root. The housing is filled with oil and sealed with an elastomeric boot. Each. blade has a thick stainless-steel spar at the leading edge which is resistant to corrosion and erosion. The skins are bonded to the spar approximately one inch aft of the leading edge. Blades must be refinished if the paint erodes to the bare metal at the skin-to-spar bond line. Bond may be damaged if bond line is exposed.*

1.6.3 A review and study of the helicopter maintenance records (such as mandatory periodic inspection [MPI] records and logbooks) was conducted. All relevant service bulletin (SB), service instructions (SI) and technical instructions (TIs) published by the helicopter manufacturer were adhered to by both the operator and the aircraft maintenance organisation (AMO). The helicopter's last mandatory periodic inspection was carried out on 29 September 2019 at airframe hours 2041.4 and was followed by a 50-hour oil change on 23 October 2019 at 2088.3 airframe hours. The helicopter was issued an Airworthiness Certificate on 3 November 2018 with an expiry date of 30 November 2019.

1.6.4 The helicopter performance reviews:

Given the meteorological conditions with the air temperature of 36ºC and the QNH of 1018hPa, (refer to 1.7), the area where the accident occurred was at approximately 4090ft AMSL. The helicopter was flying at a height of 300ft when the accident occurred. According to the helicopter's performance chat, everything was in order. The density altitude chart calculations based on the given temperature and the pressure altitude were conducted and were determined to be 7407ft. According to the chart, the recommended maximum operating weight was 2400lbs for a safe operation at a given temperature of 36ºC. The helicopter initially took off with a total weight of 2233.8lbs. At the time of the of the accident, fuel burnt over a duration of approximately 0.83 hours was approximately 69lbs. According to the helicopter specification, the equipped engine model has a fuel consumption rate of approximately 14 gallons per hour. The helicopter weight was within acceptable limits of approximately 2164lbs at the time of the accident. Figure 5 shows the Weight and Balance calculations.

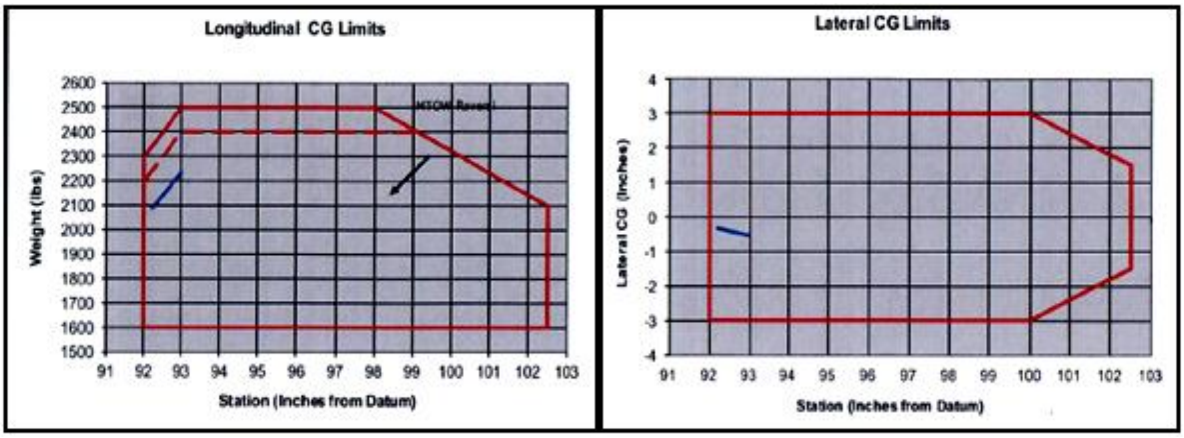

Figure 5: The Weight and Balance calculations of the helicopter.

1.7. Meteorological Information

1.7.1 The meteorological information was obtained from the mandatory occurrence report provided by the Air Traffic Navigation Services (ATNS) on 25 October 2019 at 1445Z.

Wind direction	270º	Wind speed	14kt	Visibility	CAVOK
Temperature	36ºC	Cloud cover	Nil	Cloud base	Nil
Dew point	14ºC	QNH	1018		

1.8. Aids to Navigation

1.8.1 The aircraft was equipped with standard navigational aids as approved by the Regulator (SACAA) for the helicopter type. There were no reported defects regarding the equipment prior to the flight.

1.9. Communication

1.9.1 The helicopter was fitted with standard communication aids as approved by the Regulator for the helicopter type. There were no reported defects relating to the equipment prior to the flight. There was no communication with the tower.

1.10. Aerodrome Information

1.10.1 The accident occurred 0.6nm south of Runway 06 threshold at GPS co-ordinates S 25º 40ˈ 18.67ˮ E 028º 12ˈ 54.12ˮ and at a field elevation of 4092ft AMSL.

Aerodrome location	Gauteng Province at FAWB	
Aerodrome co-ordinates	S 25º 39ˈ 11ˮ, E 028º 16.81ˮ	
Aerodrome elevation	4095 feet above mean sea level (AMSL)	
Runway designations	06/24	11/29
Runway dimensions	1280m x 22m	1828m x 30m
Runway used	06	
Runway surface	Asphalt	
Approach facilities	DME VOR, Runway lights	
Aerodrome status	Licensed	

1.11. Flight Recorders

1.11.1 The helicopter was not fitted with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it a requirement by regulation to be fitted on this helicopter type.

1.12. Wreckage and Impact Information

1.12.1 The helicopter accident occurred in a built-up area on Marjoram Avenue, which is approximately 0.6nm (1km) south of the threshold of Runway 06 with the following GPS co-ordinates: S 25º 40' 18.67” E 028º 12' 54.12” at a field elevation of 4092ft AMSL. The accident site was secured by both police as well as airport fire and rescue services with the street almost completely closed off to secure evidence. The helicopter was found lying on its left-hand side facing an easterly direction, approximately 20m from the initial point of impact with the ground. The helicopter’s tail boom, which was severed and damaged, was lying close to the main wreckage.

Figure 6: Aerial view of the accident site. (Source: Google Maps)

1.12.2 The helicopter approached from a north-eastern direction. During the forced descent as the helicopter began to flare, its main rotor clipped a treetop and cut off some branches before striking the streetlight pole. Upon striking the streetlight pole, the outer piece of the main rotor blade was severed. The streetlight pole was bent in two positions. Subsequently, the tail-boom was impacted by the main rotor disc as the helicopter impacted the ground hard, causing damage to the tail rotor skid as well as damage to the bottom vertical stabiliser, which bent towards the right.

Figure 7: Damage caused by the main rotor strike on both the tree and streetlight pole.

The helicopter then impacted the ground hard, causing both skid gears to bend sideways. Subsequently, the helicopter's belly impacted the ground hard and skidded along the road's surface, further sustaining scrapping marks. The marks on the helicopter's belly indicated that the helicopter was scrapping from its right-hand side along its belly.

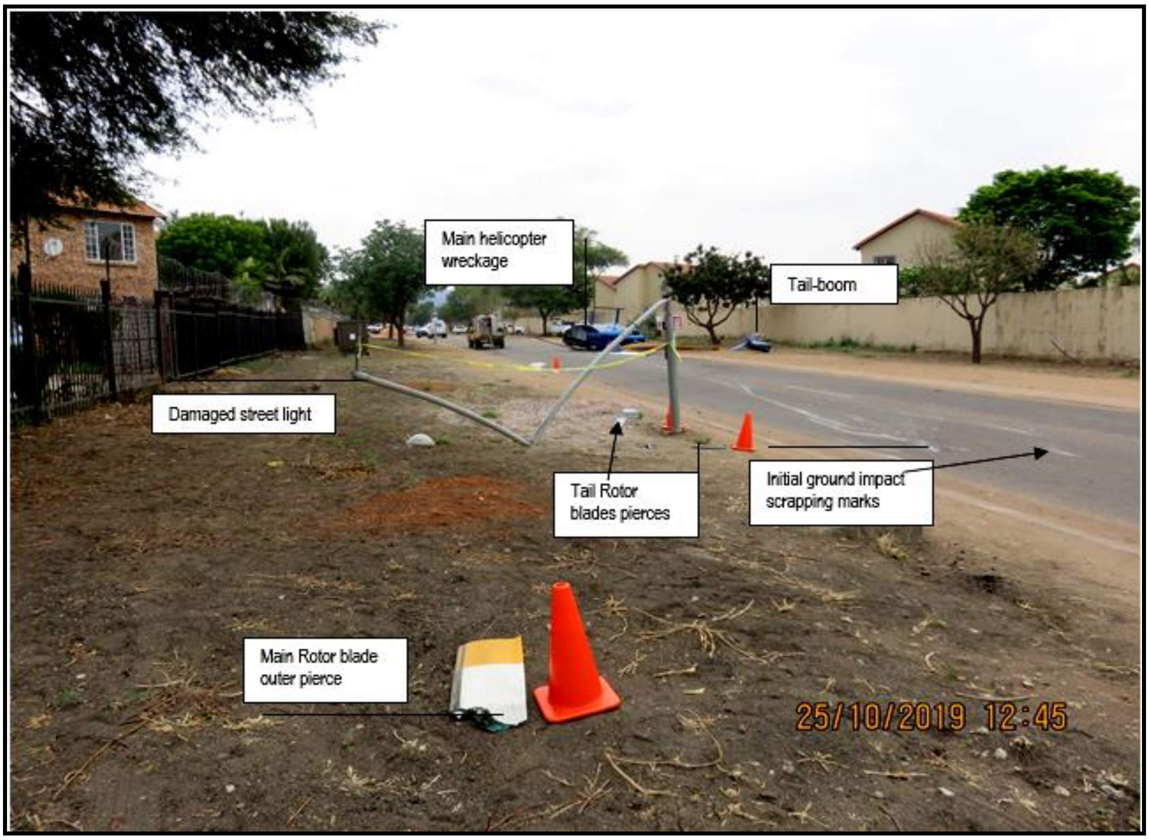

Figure 8: The wreckage distribution as it was observed at the accident site.

1.12.3 There were skid marks which were approximately 20m, starting from a position near the streetlight pole along the road to where the main wreckage was found lying on its left-hand side. The tail boom followed through as it was attached, however, it later broke off completely and was found lying behind the main helicopter wreckage. A large piece of the helicopter's windshield Perspex material was found approximately 10m from the initial point of ground contact.

Figure 9: Main wreckage (belly and thain boom).

1.12.4 The main wreckage bottom belly damage is consistent with hard impact and skidding along the street, leaving marks on the surface. The landing gear skids were bent sideways, leaving the belly to hit the ground hard. The right-hand side skid gear was fractured towards the front.

Figure 10: The main rotor blade outer piece and the tail rotor blade.

1.12.5 A piece of one of the main rotor blades' outer piece, one of the tail-rotor blades and the tail skid were found around the damaged streetlight pole. Damage on both rotor blades pieces is consistent with the damage caused when the helicopter engine was running at high-power settings.

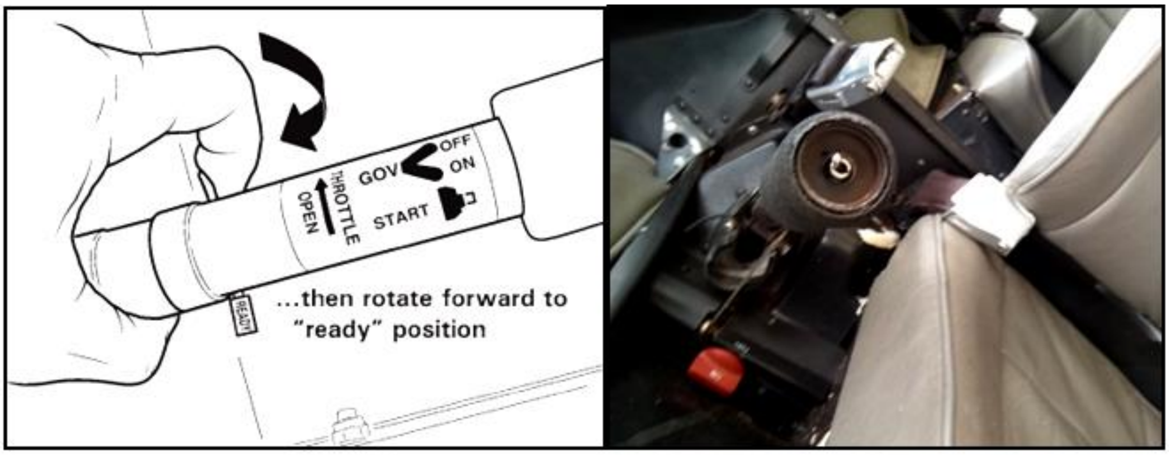

Figure 11: The governor switch in ON position.

1.12.6 Hydraulic fluid spillage was observed near the main helicopter wreckage. The main rotor connecting links were damaged. Both blades were severely damaged. Upon arrival of the airport fire and rescue services, a fire extinguishing foam was poured over the area where there was spillage to prevent any possibilities of fuel ignition. The fuel tanks, which are bladder type, did not rupture during the accident sequence. There was still enough fuel on-board in both fuel tanks. The RPM governor switch was on an "ON" position after the accident.

1.13. Medical and Pathological Information

1.13.1 None.

1.14. Fire

1.14.1 There was no evidence of a pre- or post-impact fire at the accident site.

1.15. Survival Aspects

1.15.1 The helicopter accident was considered survivable as there was no damage to the cockpit and cabin areas which could have caused serious injuries to the occupants. The attitude at which the helicopter impacted the ground did not severely impact the occupants during the accident.

1.16. Tests and Research

1.16.1 There were no reported defects on any of the helicopter components or operating systems. The pilot reported a sounding of a low rotor RPM warning horn which occurred twice after the instructor took over the flight controls.

1.16.2 RPM Governor

Information was extracted from Model R44 I, POH, Page 7-6

The governor is designed to assist in controlling RPM under normal conditions. It may not prevent over or under speed conditions generated by aggressive flight manoeuvres.

Caution: When operating at high density altitudes, governor response rate may be too slow to prevent overspeed during gusts, pull-ups, or when lowering collective.

1.16.3 The following information was extracted from R44 Raven II helicopter type POH, approved by the FAA: 12 October 2016

1.16.4 Main rotor speed limitation (Page 2-2)

Condition	**Tachometer Reading**	**Actual RPM**
Power ON		
Maximum	102%	408
Minimum	101%	408
Power OFF		
Maximum	108%	432
Minimum	90%	360

Note: Transient operation below 101% permitted for emergency procedures training

According to the Rotor Craft Flying Handbook FAA-H-8083-21

The danger of low RPM and blade stall is greatest in small helicopter with low blade inertia. It can occur in a number of ways, such as simply rolling the throttle the wrong way, pulling more collective pitch than power available, or when operating at a high-density altitude.

When the rotor RPM drops, the blades try to maintain the same amount of lift by increasing pitch. As the pitch increases, drag increases, which require more power to keep the blades turning at the proper RPM. When power is no longer available to maintain RPM, and therefore lift, the helicopter begins to descend. This changes the relative wind and further increases the angle of attack. At some point the blades will stall unless RPM is restored. If all blades stall, it is almost impossible to get smooth air flowing across the blades.

Low rotor RPM sounding during flight in a Robinson R44 (Page 3-10)

A horn and an illuminated caution light indicated that rotor RPM may be below safe limits. To restore RPM, immediately roll throttle on, lower collective and, in forward flight apply aft cyclic. The horn and caution light are disabled when collective is full down.

1.16.5 Power failure between 8ft and 500ft

The information was extracted from Model R44 I, POH, Page 2-3

- *Lower collective immediately to maintain rotor RPM*
- *Adjust collective to keep RPM between 97 and 108% or apply full down collective if light weight prevents attaining above 97%.*
- *Maintain airspeed until ground is approached, then begin cyclic flare to reduce rate of descent and forward speed.*
- *At about 8ft AGL, apply forward cyclic to level ship and raise collective just before touchdown to cushion landing. Touch down in level attitude and nose straight ahead.*

The information (below) regarding the low rotor RPM safety notice SN-24 was extracted from Robinson Model R44 II POH manual:
Safety Notice SN-24: Low RPM rotor stall can be fatal (Issued: Sep 86 Rev: Jun 94)

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 enough 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 fall out of the sky. Fortunately, rotor stall accidents most often occur close to the ground during take-off or landing and the helicopter falls only four or five feet. The helicopter is wrecked but 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 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 upward movement of air to the rotor provides the necessary increase in blade angle of attack. As with the airplane wing, the blade aerofoil will stall at a critical angle, resulting in a sudden loss of lift and a large increase in drag. The increase 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 the 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 tail-boom as the stalled helicopter falls. Due to the magnitude of the forces involved and the flexibility of the 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.*

1.17. Organisational and Management Information

1.17.1 The helicopter was operated as a hire and fly for instrument rating renewal on the day of the accident. The instructor was also undergoing a regulatory oversight review for his renewal on the same flight with an authorised officer (SACAA) on-board.

1.17.2 The helicopter was issued a certificate of airworthiness (CoA) on 3 November 2018 with an expiry date of 30 November 2019. The helicopter's annual mandatory periodic inspection maintenance was conducted on 19 September 2019 at 2041.4 airframe hours by a Regulator-approved aircraft maintenance organisation (AMO). The certificate of release to service was issued on 19 September 2019 with an expiry date of 19 September 2020 or at 2141.4 airframe hours.

1.17.3 The operator/owner of the helicopter had a valid training organisation certificate (ATO No: CAA/0280) issued on 1 March 2018 with an expiry date of 28 February 2023. The training operation specifications certificate (ATO No: SACAA/1104/ATO) was valid and the helicopter was endorsed on it under certification Part 127 issued by the Regulator on 19 July 2019.

1.18. Additional Information

1.18.1 According to the operator of the helicopter, the pilot who was intending to do his instrument rating revalidation had arranged in advance to hire and fly the helicopter on 25 October 2019. He brought along a designated flight examiner (DFE) of choice who is not part of the operator's employees. On the date of the flight, the operator was informed that an authorised officer from the Regulator was coming on-board to conduct oversight on the DFE for his designated examiner licence renewal.

1.18.2 Instrument Rating renewal

According to the instrument rating skills test and revalidation checklist form number CA 61-11.4, both theoretical and practical test are conducted. The tabled procedure does not involve emergency tests.

1.18.3 On the day of the accident, the SACAA authorised officer was conducting an oversight review on the DFE, which was arranged in advance. A debrief was conducted prior to flight and all terms of the exercise where discussed.

1.18.4 According to the SACAA's Technical Guidance Material for Authorised Officer (AO) Conducting Oversights.

- *The AO designated for the purpose of conducting an oversight should possess the single engine piston (SEP) and multiple engine piston (MEP) class rating and the applicable type rating as per subpart 9.*
- *The AO must have completed the following PEL course:*
  - *Government Safety Inspector Course PEL or Government Safety Inspector Course (OPS)*
  - *Human Factors*
  - *Safety Management Systems*
  - *Auditing Systems*
  - *Following the completion of the core courses the AO must conduct 3 oversight as an observer with a qualified AO. The three oversight must consist of general aviation, Part 121 operations and both 135 and 127 operations.*
- *After the completion of 3 observation oversight, the AO should then conduct 1 oversight under supervision of another AO that has been signed out for the purpose of conducting oversights, to observe 3 oversights consistent with general aviation, 121 operation and 135 or 127 operation.*

- *Following the completion of 3 oversights as an observer, the AO should then conduct DFE oversights.*
- *During an oversight, the AO is assuming an administrative duty and does not conduct a licensing action. He or she may therefore by no means interfere with the flow or the outcome of the test or check unless it is imperative in the interests of safety.*
- *An oversight may only be conducted during the administration of test or check (actual or mock) which requires a DFE.*

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. These shall not be read as apportioning blame or liability to any particular organisation or individual.

2.2 Analysis

2.2.1 The instructor (DFE) was issued an Airline Transport Pilot Licence (helicopters and aeroplanes) on 19 August 2019 with an expiry date of 30 September 2020. His medical certificate was issued on 23 July 2019 with an expiry date of 11 January 2020. On the date of the accident, he was also undergoing a review by an inspector from the Regulator.

2.2.2 The pilot, who was being tested for his instrument rating renewal, was issued a Commercial Pilot Licence (CPL) (helicopters and aeroplanes) on 28 October 2018 with an expiry date of 25 October 2019. His medical certificate was issued on 24 October 2019 with an expiry date of 30 April 2020. His instrument rating was still current, issued on 17 October 2018 with an expiry date of 31 October 2019. The pilot had more flying experience on the helicopter type than the DFE. The DFE had 134.1 hours on the helicopter type and the pilot had 558.1 hours on the helicopter type.

2.2.3 The AO was in possession of the Authorised Officer's Appointment letter as designated by the regulating authority. He met the requirements of the position and held the required helicopter type rating for the task as mandated by the Regulator.

2.2.4 The helicopter was issued a certificate of airworthiness (CoA) on 3 November 2018 with an expiry date of 30 November 2019. The helicopter's annual mandatory periodic inspection maintenance was conducted on 19 September 2019 at 2041.4 airframe hours by a Regulator-approved AMO. The certificate of release to service was issued on 19 September 2019 with an expiry date of 19 September 2020 or at 2141.4 airframe hours.

2.2.5 The pilot was in control of the helicopter as well as on approach for landing at the operator's landing pad following completion of the exercise. The instructor (DFE) indicated that he was not satisfied with the approach and he took over controls and initiated a go-around. The instructor (DFE), upon assuming controls, initiated a go-around and climbed. The helicopter experienced two indications of low rotor RPM. During the climb at approximately 200ft AGL, the helicopter's low rotor RPM warning horn went off. The instructor (DFE) was able to correct this accordingly by slightly lowering the collective and proceeded with a climb. At a height of approximately 300ft AGL whilst in a turn, the helicopter's low rotor RPM warning lighting came on and a horn went off again. This time, the instructor was unable to recover from the low rotor RPM situation. Due to insufficient height, which was below 500ft, the instructor (DFE) had no other option but to prioritise landing the helicopter safely. This is recommended by the R44 manual of operation about power failure below 500ft during operation. Although the helicopter did not experience power failure, however, it suffered a low rotor RPM deficiency which made it difficult to sustain lift at that height. The pilot had to adhere to the precautionary measure for the affected flight height conditions. What is emphasised in the manual is the height of operation at the time in which flight lift recovery was not possible.

2.2.6 It is likely that following the instructor's abrupt taking over controls of the helicopter, he may have rolled the throttle the wrong way or pulled more collective pitch than power available during a go-around. That resulted in the rotor RPM drop and the blades trying to maintain the same amount of lift by increasing pitch. As the pitch increased, the drag also increased, which required more power to keep the blades turning at the proper RPM. When power available was no longer sufficient to maintain RPM, and therefore lift, the helicopter began to descent, and a forced landing was eminent as the helicopter was at a low height.

2.2.7 As the helicopter was low during a forced landing, it first clipped the treetops, then cut off some branches and, later, struck a streetlight pole with its main rotor. The part of the main rotor that struck the streetlight pole broke off; the pole was bent in two places. The helicopter impacted the ground hard on its landing gear skids, causing them to collapse and spread outwards. Subsequently, the fuselage belly impacted the ground hard and got damaged. The helicopter skidded approximately 20m along the road's surface and came to a stop before rolling onto its left-hand side.

2.2.8 The RPM governor switch was found in "ON" position. The governor is designed to assist in controlling RPM under normal conditions. It may not prevent over or under speed conditions generated by aggressive flight manoeuvres (pull-ups and lowering of collective) during the climb and turn.

2.2.9 The weather did not play a significant role in the accident. The helicopter performance calculations indicated that the helicopter weight was within limits at the time of operation at the given temperature and the density altitude around the aerodrome operation.

2.2.10 The investigation revealed that it is likely that following the instructor's abrupt taking over controls of the helicopter, he may have rolled the throttle the wrong way or pulled more collective pitch than power available during a go-around. That resulted in the rotor RPM drop and the blades trying to maintain the same amount of lift by increasing pitch. As the pitch increased, the drag also increased, which required more power to keep the blades turning at the proper RPM. When power available was no longer sufficient to maintain RPM, and therefore lift, the helicopter began to descent, and the pilot elected to execute a forced landing, which was unsuccessful.

3 CONCLUSION

3.1 General

3.2 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 particular organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusions 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 or incident occurring, or mitigated the severity of the consequences of the accident or incident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

3.3 **Findings**

3.3.1 The instructor (DFE) was qualified for the flight. He held a valid Airline Transport Pilot Licence (helicopters and aeroplanes) issued by the Regulator in accordance with approved procedure on 19 August 2019 with an expiry date of 30 September 2020. His medical certificate revalidation was issued on 23 July 2019 with an expiry date of 11 January 2020.

3.3.2 The pilot, who was conducting his instrument rating renewal, had a valid Commercial Pilot Licence (helicopters and aeroplanes) issued by the Regulator on 28 October 2018 with an expiry date of 25 October 2019. His medical certificate was issued on 24 October 2019 with an expiry date of 30 May 2020. His instrument was still valid and was revalidated on 17 October 2018 with an expiry date of 31 October 2019.

3.3.3 The AO was in possession of the Authorised Officer's Appointment letter as designated by the regulating authority. He met the requirements of the position and held the required helicopter type rating for the task.

3.3.4 The helicopter had a valid certificate of airworthiness issued by the Regulator on 20 September 2018 with an expiry date of 30 November 2019. The helicopter's annual mandatory periodic inspection maintenance was conducted on 19 September 2019 at 2041.4 airframe hours.

3.3.5 On the date of the accident, the instructor (DFE) who was conducting the instrument renewal was also evaluated by the Regulator's authorise officer who was on-board for his DFE renewals.

3.3.6 After the accident, the AO personnel sustained serious back injuries which caused him to be booked off duty for approximately six weeks. Both the instructor (DFE) and the pilot were never admitted to hospital following the accident.

3.3.7 It is likely that following the instructor's abrupt taking over controls of the helicopter, he may have rolled the throttle the wrong way or pulled more collective pitch than power available during a go-around. That resulted in the rotor RPM drop and the blades trying to maintain the same amount of lift by increasing pitch. As the pitch increased, the drag also increased, which required more power to keep the blades turning at the proper RPM. When power available was no longer sufficient to maintain RPM, and therefore lift, the helicopter began to descent, and a forced landing was eminent as the helicopter was at a low height.

3.3.8 The weight calculations were within acceptable limits and could not be associated with the contributory factors of the accident.

3.3.9 Fine weather conditions with 36ºC air temperature prevailed on the day of the accident. According to the density altitude based on the weight and the weather conditions, safe operating parameters prevailed during operation of the helicopter on the day and time of the accident.

3.3.10 The investigation revealed that it is likely that following the instructor's abrupt taking over controls of the helicopter, he may have rolled the throttle the wrong way or pulled more collective pitch than power available during a go-around. That resulted in the rotor RPM drop and the blades trying to maintain the same amount of lift by increasing pitch. As the pitch increased, the drag also increased, which required more power to keep the blades turning at the proper RPM. When power available was no longer sufficient to maintain RPM, and therefore lift, the helicopter began to descent, and the pilot elected to execute a forced landing, which was unsuccessful.

3.4 Probable Cause/s

3.4.1 It is likely that following the instructor's abrupt taking over controls of the helicopter, he may have rolled the throttle the wrong way or pulled more collective pitch than power available during a go-around. That resulted in the rotor RPM drop and the blades trying to maintain the same amount of lift by increasing pitch. As the pitch increased, the drag also increased, which required more power to keep the blades turning at the proper RPM. When power available was no longer sufficient to maintain RPM, and therefore lift, the helicopter began to descent, and the pilot elected to execute a forced landing, which was unsuccessful.

3.5 Contributory Factors:

3.5.1 None.

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