AA2010-8

AIRCRAFT ACCIDENT INVESTIGATION REPORT

OSAKA AVIATION INC.

J A 7 9 8 7

November 26, 2010

Japan Transport Safety Board

The investigation for this report was conducted by Japan Transport Safety Board, JTSB, about the aircraft accident of Osaka Aviation Inc., Robinson R22 Beta (Rotorcraft) registration JA7987 in accordance with the Act for the Establishment of the Japan Transport Safety Board and Annex 13 to the Convention on International Civil Aviation for the purpose of determining causes of the aircraft accident and contributing to the prevention of accidents/incidents and not for the purpose of blaming responsibility of the accident.

This English version of this report has been published and translated by JTSB to make its reading easier for English speaking people who are not familiar with Japanese. Although efforts are made to translate as accurately as possible, only the Japanese version is authentic. If there is any difference in the meaning of the texts between the Japanese and English versions, the text in the Japanese version prevails.

Norihiro Goto
Chairman,
Japan Transport Safety Board

AIRCRAFT ACCIDENT INVESTIGATION REPORT

OSAKA AVIATION INC.
ROBINSON R22 BETA (ROTORCRAFT), JA7987
NEAR RUNWAY 27 OF YAO AIRPORT, JAPAN
AT ABOUT 15:32 JST, APRIL 27, 2009

October 22, 2010
Adopted by the Japan Transport Safety Board (Aircraft Sub-committee)

1. PROCESS AND PROGRESS OF AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident

On April 27 (Monday), 2009, the Robinson R22 Beta, registered JA7987, operated by Osaka Aviation Inc., took off from Yao Airport for flight training. While the aircraft was performing takeoff and landing training with autorotation power recovery at the airport following air work training, the captain as the instructor judged that the engine had stopped. Then, the aircraft made an emergency landing on a grass field at the airport at about 15:32 Japan Standard Time (JST: UTC+9hr, unless otherwise stated all times are indicated in JST on a 24-hour clock), and the aircraft was damaged.

The captain and a trainee were on board the aircraft and they were not injured.

The aircraft sustained substantial damage, but there was no outbreak of fire.

1.2 Outline of the Accident Investigation

1.2.1 Investigation Organization

On April 27, 2009, the Japan Transport Safety Board designated an investigator-in-charge and two other investigators to investigate this accident.

1.2.2 Representatives from Foreign Authorities

An accredited representative and an advisor of the United States of America, as the State of Design and Manufacture of the aircraft involved in this accident, participated in the investigation.

1.2.3 Implementation of the Investigation

April 28, 2009	Interviews, on-site investigation, aircraft examination
April 29, 2009	Examinations of aircraft and engine

1.2.4 Comments from Parties Relevant to the Cause of the Accident

Comments were invited from parties relevant to the cause of the accident.

1.2.5 Comments from the Participating State

Comments were invited from the participating State.

2. FACTUAL INFORMATION

2.1 History of the Flight

On April 27, 2009 at about 14:40, the Robinson R22 Beta, registered JA7987 (hereinafter referred to as "the Aircraft"), operated by Osaka Aviation Inc. (hereinafter referred to as "the Company"), took off from Yao Airport for flight training with the captain and one trainee on board.

The outline of the flight plan was as follows:

Flight rules:	Visual Flight Rules (VFR)
Departure aerodrome:	Yao Airport
Estimated off-block time:	14:30
Cruising speed:	80 knots
Cruising altitude:	VFR
Route:	Chubu-Kinki 11-1 (Civil training/testing area) — Traffic pattern
Destination aerodrome:	Yao Airport
Total estimated elapsed time:	1 h and 30 min
Fuel load expressed in endurance:	2 h and 40 min
Persons on board:	2

The history of the flight up to the time of the accident is summarized as below, based on ATC communication records and the statements of persons related to the accident.

2.1.1 Statements of Persons Related to the Accident

(1) Captain

Early in the morning of the day of the accident, I received a report from a mechanic that there was no abnormality in the engine run up. I flew twice with other trainees in the morning, and I performed trainings in air work, takeoff and landing and hovering with no abnormalities, such as malfunctioning of the engine. I performed the third flight for the day in a training area called Chubu-Kinki 11-1. After training for instrument flight, steep turn, quick stop and other items, the trainee and I returned to Yao Airport and performed takeoff and landing training.

We used runway 27 and we had a tail wind at that time. First of all, we performed a normal landing while targeting the runway middle line marker. After that, we performed straight autorotation power recovery*[1] twice. Then, in order to perform 180° turn autorotation power recovery, we flew on a downwind with a narrower distance with the runway at an altitude of 1,000 feet and a speed of 80 knots. I usually start descent and approach procedures for autorotation with the landing target point right at my side. But because a tail wind was blowing, I instructed the trainee to slightly delay the timing to start the procedures. But the timing to take a turn was too early, so I got the tilted cyclic back to the previous position. When I was watching the outside to ascertain the runway and confirm the attitude of the Aircraft, I felt unusual impacts. I felt this was an unusual situation, so I looked at the instruments. Because the oil pressure warning light was on, I judged that the engine has stopped. We were on a turning flight, and I think the altitude was about 350 feet. I took over flying from the trainee. Because I considered that we would have a severe impact on landing on the runway, I decided to descent on a grass field, I flared while reporting to the Tower that we would land on a grass field. At that time, the rotor low rotation warning sound was ringing. I think I used the collective pitch, but the

*[1] Autorotation power recovery is training for helicopters aimed at experiencing a series of judgments and operations in a simulation that the engine and others developed trouble. The training calls for using no power by reducing the rotor pitch and gliding on the rotations of wings to land safely on a target point. There are two training methods—full landing which includes a process up to landing and power recovery in which an approach is followed by hovering, not actual landing.

rate of descent was high.

I did not touch the mixture during the flight. I do not think that there would be carburetor icing*[2] under the air temperature for that day. The trainee was maneuvering the aircraft while preparing himself to pull the carburetor heat*[3] knob before starting autorotation and to return the knob when an approach is stabilized, and I did not feel any problem with his operation. When I start autorotation, I lower the collective, and I close the grip for the throttle operation at a stroke to full idle. In the past 11 years or so, I have flown for 3,500 hours on Robinson models alone. I have no experience of an engine stall, though I may forget operations for carburetor heat. I have heard no case of a stopped engine, either, around me. When I found the engine has stopped, the altitude was low, so I had no other choice but landing on a grass field. Eventually, it became a hard landing, but the Aircraft did not turnover. After landing, I checked the fuel indicator, and the mixture knob, ignition switch and fuel shut-off valve, but they were at normal positions. I had no idea about why the engine stopped;

(2) Trainee

As we planned to perform air work training and takeoff and landing training in the afternoon, the Company took the Aircraft out of the hangar. As for the fuel of the Aircraft, its main tank was filled up with 19.2 gallons of fuel. Its sub-tank has a capacity of 10.5 gallons, and I checked with the fuel indicator that there was a load equivalent to two-thirds of the capacity. The Aircraft's fuel consumption is about 9 gallons per hour. So, there was a fuel load for two and a half hours. After pre-flight checks, we started the engine by the checklist and took off with no trouble.

After air work training in a training area, we started takeoff and landing training at Yao Airport. We performed normal landing once and straight autorotation power recovery twice. Then, we started 180° turn autorotation power recovery. The autorotation process calls for pulling the carburetor heat knob before the start and pushing back the carburetor heat knob before increasing the rotation of the engine. In our training, too, we confirmed the target point, and we pulled the carburetor heat knob, gradually lowered the collective, closed the throttle and entered autorotation while confirming the engine was idle. The rotation of blades was within the green arc on the indicator.

We started taking a turn after decelerating to 60 knots. When I tried to open the throttle to recover at an altitude of 300 feet, the instructor told me that the engine has stopped with the oil warning light on. He said we were going to land on a grass field and he took over flying from me. I was looking only at the outside all the time and I did not know that the engine stopped, because I was hearing the sounds of blades.

I took my right hand off the cyclic and took a posture with my right elbow stuck to the doorframe. I had kept my left hand on the collective, but I do not remember a feeling that the collective moved. My body got tight, I think, because I was putting all of my effort into looking ahead.

I think the temperature was around 12 °C when we started the flight. I always try to see the carburetor temperature indicator. When the indicator came to the yellow arc during air work training at an altitude of 2,000 feet, I pulled the carburetor heat knob by about half. During takeoff and landing training, the indicator came to the yellow arc again when we were in a traffic pattern before the second round of straight autorotation power recovery. So I had slightly pulled the carburetor heat knob and before entering autorotation, I pulled the knob to full.

*[2] The carburetor infuses fuel into inlet air to produce mixed gas for combustion in the engine. Carburetor icing occurs when the temperature of inlet air is low or when the humidity is high. Ice can form in an air intake channel due to a drop in the temperature because of fast airflows in the venture within the carburetor and latent heat from the vaporization of fuel. If the air intake channel for the fuel-air mixture is trimmed, the intake of the fuel-air mixture becomes insufficient, causing the engine to stall in some cases.

*[3] Carburetor heat is a step to warm the inlet air in the carburetor to prevent carburetor icing. The Aircraft has a system in which the air warmed around the exhaust pipe is mixed into the fuel and the fuel-air ratio can be adjusted by controlling the knob.

(3) Air Traffic Control

The Aircraft took off from runway 27 and left out of the air traffic control area to the north as usual. After a lapse of about 30 minutes, it returned to Yao Airport and performed takeoff and landing training in various manners. Just before touchdown in the fourth round of 180° turn autorotation power recovery, the Aircraft reported to us “the engine has stopped.” The location where the Aircraft starts 180° turn autorotation power recovery cannot be seen beyond windows from the control tower. I have no idea about the condition of its approach to final leg. The Aircraft eventually landed on a grass field, but there was no indication that the Aircraft has pushed onto the ground in a forceful manner, and its speed appeared to be slow. When it touched the ground, it bounded. The bound was not so high, but I could see it bound. The rotors stopped after a while, so I thought they were not being driven.

2.1.2 Outline of ATC Communications Records

15:11:35 The Aircraft requested the Yao Airport Traffic Control Tower (hereinafter referred to as “the Tower”) at a point in Higashi-Osaka about nine kilometers north of Yao Airport to issue a clearance for its takeoff and landing training.

15:15:15 to 15:26:27 The Tower issued a clearance for three rounds of landing and takeoff to the Aircraft.

15:30:28 The Tower issued a clearance for using runway 27 for landing and takeoff for the Aircraft and informed it of a wind direction of 040° and a wind velocity of six knots.

15:31:50 The Aircraft reported to the Tower that the engine has stopped.

15:32:17 The Aircraft reported to the Tower that its crewmen are safe and that the Aircraft needs to be towed.

The accident occurred on a grass field in a landing area of runway 27 at Yao Airport (Latitude 34˚36’ N, Longitude 135˚36’ E) and the time of the accident was about 15:32.
(See Figure 1 Estimated Flight Route and Layout of Traces of Touch on the Ground, Photo 3 Instruments of the Aircraft)

2.2 Injuries to Persons

No one was injured.

2.3 Damage to the Aircraft

2.3.1 Extent of Damage

Substantial

2.3.2 Damage to the Aircraft Components

(1) In the landing gear assembly, the cross tube was bent and the skids were deformed with their interval widened by about 20 centimeters laterally.

(2) The lower part of the mast fairing and the cowling in the right aft section of the fuselage were deformed.

(3) The frames of the right side and left side doors, the outer skins on both sides of the fuselage and the base of the tail cone buckled.

(4) The bottom side of one main rotor blade was wrinkled.

(See Photo 1 Accident Aircraft and Damaged Portions, Photo 2 Damaged Portions)

2.4 Personnel Information

(1) Captain	Male, Age 71
Airline transport pilot certificate (Rotorcraft)	July 3, 1996
Type rating for single-turbine engine (land)	April 18, 1970
Type rating for multiple-turbine engine (land)	September 16, 1980
Type rating for single-piston engine (land)	August 19, 1997
Flight instructor certificate (Rotorcraft)	May 8, 1979
Flight time for flight instruction in the last one year	393 h 14 min
Class 1 aviation medical certificate	
Validity	May 31, 2009
Total flight time	15,108 h 52 min
Flight time in the last 30 days	35 h 12 min
Total flight time on the type of aircraft	4,811h 25 min
Flight time on the type of aircraft in the last 30 days	35 h 12 min
(2) Trainee	Male 67
Private pilot certificate (Aircraft)	April 11, 1985
Type rating for single engine (land)	April 11, 1985
Instrument flight certificate (Aircraft)	April 24, 2003
Class 2 aviation medical certificate	
Validit	May 19, 2009
Total flight time	About 2,300 h
Flight time in the last 30 days	7 h 40 min
Total flight time on the type of aircraft	105 h 35 min
Flight time on the type of aircraft in the last 30 days	5 h 05 min

2.5 Aircraft Information

2.5.1 Aircraft

Type	Robinson R22 Beta
Serial number	3445
Date of manufacture	May 12, 2003
Certificate of airworthiness	DAI-20-414
Validity	October 14, 2009
Category of airworthiness	Rotorcraft, Normal N
Total flight time	335 h 35 min
Flight time since last periodical check (50h check on March 4, 2009)	16 h 53 min

(See Figure 2 Three Angle View of Robinson R22 Beta)

2.5.2 Engine

Type	Lycoming O-360-J2A
Serial number	L-39099-36A
Date of manufacture	March 6, 2003
Total time of use	335 h 35 min

2.5.3 Fuel and Lubricating Oil

The fuel used was AVGAS100 for aircraft and the lubricating oil was MIL-L-22851 (Philips 20W-50). No foreign substance was found in the fuel left in the Aircraft, while the remaining fuel load was about 50 liters (13.2 gallons). The residual lubricating oil totaled about 5.1 liters (5.3 quarts).

2.5.4 Weight and Balance

At the time of the accident, the weight of the Aircraft is estimated to have been 1,301.45 pounds and the position of the center of gravity is estimated to have been longitudinally at 97.73 inches aft of the datum and laterally 0.46 inch to the left of the airframe symmetry plane, both of which are estimated to have been within the allowable limits (i.e., maximum gross weight of 1,370 pounds, minimum gross weight of 920 pounds, center-of-gravity range for the weight at the time of the accident: longitudinally 95.8 to 100.6 inches aft of the datum and laterally within 2.2 inches to the left and 2.4 inches to the right of the airframe symmetry plane).

2.6 Meteorological Information

(1) Following are aeronautical weather observation data around the time of the accident at Yao Airport:

15:00 Wind direction 270° ; Wind velocity 10 knots; Wind direction fluctuation 230° to 290°
Visibility 20 kilometers; Current weather light showers
Cloud: Amount 1/8, Type Cumulus, Cloud base 2,500 feet
Amount 3/8, Type Cumulus, Cloud base 3,500 feet
Amount 5/8, Type Altocumulus, Cloud base 10,000 feet
Temperature 15 °C; Dew Point 2 °C
Altimeter setting (QNH) 29.77 inHg

16:00 Wind direction 040° ; Wind velocity 5 knots; Wind direction fluctuation 320° to 100°
Visibility 20 kilometers
Cloud: Amount 1/8, Type Cumulus, Cloud base 2,500 feet
Amount 6/8, Type Altocumulus, Cloud base 10,000 feet
Temperature 15 °C; Dew Point 1 °C
Altimeter setting (QNH) 29.78 inHg

(2) Two-minute averages of wind direction and wind velocity (An excerpt of data taken every three seconds)

hour: min: sec	Wind direction (degree) (magnetic bearing)	Velocity (knot)	hour: min: sec	Wind direction (degree) (magnetic bearing)	Velocity (knot)	hour: min: sec	Wind direction (degree) (magnetic bearing)	Velocity (knot)
15:10:00	351	11	15:20:00	061	5	15:30:00	041	6
11:00	002	10	21:00	060	5	31:00	036	7
12:00	008	8	22:00	057	7	32:00	056	8
13:00	010	7	23:00	055	7	33:00	070	8
14:00	020	6	24:00	050	7	34:00	073	6
15:00	033	7	25:00	052	6	35:00	064	5
16:00	036	8	26:00	061	6	36:00	043	4
17:00	038	7	27:00	066	6	37:00	043	6
18:00	047	6	28:00	068	4	38:00	051	6
19:00	057	5	29:00	059	4	39:00	051	5

2.7 Accident Site Information

Traces of touchdown which are almost identical to the shape of the Aircraft's skids were found at three different places about 20 meters apart on a grass field between taxi ways A-1 and A-2 on the northern side of runway 27 at Yao Airport.

There is a runway edge light at a point about 128 meters eastward along the northern side of the runway side stripe marking (hereinafter referred to as "the Side Marking") from the eastern end of the runway middle line marker on runway 27. The runway edge light is the third one to the east from the runway middle line marker. The traces, which are believed to be those of the left skid of the Aircraft, were found from a place about 10.6 meters east of the runway edge light and 10.8 meters from the outer edge of the Side Marking to a place about 9.4 meters west of the runway edge light and about 5 meters from the outer edge of the Side Marking.
（See Figure 1 Estimated Flight Route and Layout of Traces of Touchdown）

2.8 Examination and Confirmation of Engine

An examination was made on April 29, 2009 for each of the four systems--infusion of fuel-air mixture, fuel, lubrication and ignition--based on items and points on 100-hour and annual checklists for the Aircraft. An engine run up test was also performed for the engine, and no abnormalities were found.

2.9 Remarks on Flight Manual

The flight manual for the Aircraft contained the following remarks in Chapter 3 Emergency Operations, Chapter 4 Normal Operations and Chapter 10 Recommendations for Safe Flights (Excerpt):

(1) Chapter 3 Emergency Operations

3-5 Power system failure in 8 to 500 feet AGL

(2) If trouble occurred in the power system, the collective shall be immediately lowered to maintain the rotor revolution.

(3) The collective shall be adjusted so as to keep the rotor revolution within the green arc. When the revolution cannot be raised to 97 % due to a light flight weight, the collective shall be full down.

(4) The speed shall be kept until the aircraft comes close to the ground and then, the cyclic flare shall be started to reduce the rate of descent and the forward speed.

(5) The aircraft shall be kept level by moving the cyclic forward at about 8 feet AGL, and just before touchdown, the collective shall be raised to cushion the impact. Touchdown shall be performed with the nose of the aircraft kept ahead and the skids at the level position.

3-8 Air restart procedures

(1) Mixture ------------------------- Full rich

(2) Primer (if equipped) ----------- Down and locked

(3) Throttle -------------------------- Off and then slightly opened

(4) Starter ---------------------------- Operated with left hand

"Caution"

When an engine failure is suspected or until a safe autorotation descent is established, a restart shall not be attempted.

3-18 Warning light/caution light

(1) Oil

These lights indicate the loss of the engine power or the lubricating oil pressure. The engine tachometer shall be checked to examine if the engine power is not lost. If and when a loss of the lubricating oil pressure is confirmed, the aircraft shall immediately land on the ground. If the flight is continued with no lubricating oil pressure, serious damage will be inflicted on the engine, leading to an engine failure.

(Omitted)

3-19 Low rotor rotation warning sound and caution light

When the warning sound rings and the caution light turns on, it means that the rotor revolution *has fallen below an optimum level. In order to restore the revolution, the throttle shall be opened immediately and the collective shall be lowered. During forward flight, the cyclic shall also be operated backward. When the collective control is full down, the warning sound and the caution light do not work.*

(2) Chapter 4 Normal operations

4-9 Autorotation training (power recovery)

(1) The collective shall be lowered to down stop and as the need arises, the throttle shall be adjusted to maintain a slight needle split on the tachometer.

(Note: A needle split means a situation in which the two separate needles that indicate the rotation of the engine and rotor, usually synchronized, point to different values and do not overlap with each other.)

"Caution"

In order to prevent an unintended stall of the engine, the throttle shall not be closed too fast while simulating a failure of the power system. The throttle shall be always slowly closed to keep a slight needles split.

(Omitted)

(2) When the rotor revolution is about to exceed the green arc, the collective shall be raised, if need be, to keep the rotor revolution within the green arc and a slight needle spit shall be maintained by controlling the throttle.

(3) The revolution shall be kept within the green arc and the speed shall be maintained the speed at 60 to 70 KIAS.

(4) At about 40 feet AGL, a cyclic flare shall be started to reduce the rate of descent and the forward speed.

(5) At about eight feet AGL, the cyclic shall be operated forward to have the aircraft in a level attitude and the collective shall be raised to stop the descent. The throttle shall be used, if need be, to keep the revolution within the green arc.

4-10 Autorotation training accompanied with touchdown

(Omitted)

Whenever the aircraft touches down, the skids shall be in a level position and the nose of the aircraft shall be kept straight ahead.

(Omitted)

4-11 The manner to use carburetor heat

When the aircraft flies in conditions in which carburetor icing occurs or is expected to occur, such as in fogs, rain, high humidity and just above the water, carburetor heat shall be used under the following steps:

In a power setting of over MAP 18 in.Hg, carburetor heat shall be used, if need be, to keep the needle of the carburetor temperature indicator out of the range of the yellow arc.

When the power is reduced to less than MAP 18 in.Hg, regardless of the pointing of the carburetor temperature indicator, carburetor heat shall be set at full heat.

(At levels below MAP 18 in.Hg, the carburetor temperature indicator does not properly show the carburetor temperature.)

(Omitted)

(Note: MAP stands for Manifold Pressure, and it means the inlet air pressure.)

(3) Chapter 10 Recommendations for Safe Flights

10-1 Outline

Chapter 10 states various proposals for the pilot to maneuver the helicopter in a safer operation.

10-2 Recommendations for Safe Flights

(10) Takeoff and landing shall not be performed on a tail wind. This is important especially at very high altitudes.

(Omitted)

Safety Notices

The safety notices have been issued by Robinson Helicopter Co. based on various accidents and incidents which have occurred in the past. The material can be used to help prevent a recurrence of the same errors by learning from the failures of other pilots.

SN-25 "Carburetor Icing"

(Issued in December 1986, revised in November 1999)

Carburetor icing becomes a cause for stalling the engine. The phenomenon is most likely to occur when humidity is high or steam exists visibly, at temperatures of less than 70 °F (21 °C). In such conditions, the following preventive steps must be taken:

In case of takeoff

Unlikely the takeoff of airplanes in which the throttle will be fully opened, helicopters use only a necessary amount of power for takeoff and as a result, they are prone to carburetor icing particularly when the temperatures of the engine and the inlet system are low. Carburetor heat (which comes through the filter) shall be fully used to preheat the inlet system while the engine is warmed up. In cases of hovering and takeoff, carburetor heat shall be used, if need be, to keep the needle of the carburetor temperature indicator out of the yellow arc.

In case of ascent and cruising

Carburetor heat shall be used, if need be, to keep the needle of the carburetor temperature indicator out of the yellow arc.

In case of descent and during autorotation

For R22 models, carburetor heat shall be fully used at less than MAP 18 in.Hg, regardless of the readings of the carburetor temperature indicator.

(Omitted)

SN-38 "Many Accidents during Training Caused by Autorotation Training"

(Issued in July 2003, Revised in October 2004)

Many helicopters are destroyed every year training for engine failures which seldom occur.

(Omitted)

There are cases in which the engine has stopped during autorotation training. In order to prevent an unintended stall of the engine, the throttle shall not be closed to full idle. The throttle shall be slowly closed so the two needles appear to be slightly split. A firm grip shall be kept on the throttle to override the governor.

If the engine goes rough or the engine RPM continues to decline, steps shall be quickly taken for recovery.

3. ANALYSIS

3.1 Airman Competence Certificate and Aviation Medical Certificate

The captain and the trainee held both valid airman competence certificates and valid aviation medical certificates.

3.2 Airworthiness Certificate

The Aircraft had a valid airworthiness certificate and had been maintained and inspected as prescribed.

3.3 Meteorological Conditions

As described in the statements in 2.1.1 and according to the meteorological observations at Yao Airport as described in 2.6, the wind direction was 270° as of 15:00, but as the wind was shifting to the north, the direction later changed to northeast. It is considered highly probable that when the Aircraft was making takeoff and landing training, there was a tail wind component of 3 to 6 knots against its final approach direction (280° in magnetic compass) toward runway 27.

3.4 Situation at the Time of Touchdown

(1) As described in the statements of related persons and ATC communication records in 2.1 and according to the traces of touchdown as stated in 2.7, it is considered highly probable that the Aircraft was in the following situation:

The Aircraft performed normal landing once and straight autorotation power recovery twice and after that, it started 180° turn autorotation power recovery. With the trainee in control, the Aircraft started a left turn by decelerating to 60 knots with the collective lever lowered and the throttle closed on a down wind (an altitude of about 1,000 feet and the course at around 090°). While approaching with the turn, the captain felt an unusual condition and found the oil warning light was illuminating. The captain recognized that the engine has stopped and took over the control from the trainee and decided to land on a grass field. According to the captain's memory, the Aircraft was at an altitude of about 350 feet. There was not enough time for the captain to take steps shown in "3-5 Power system failure in 8 to 500 feet AGL" and "4-9 Autorotation training (power recovery)" which contains adjustment of operation parameters for approach, and in "3-8 Air restart procedures" as described in 2.9 (1) and (2). At about 15:32 on the day, the Aircraft made a hard landing with about two bounds on a grass field north of runway 27.

(2) The captain flared to reduce the ground speed and the rate of descent up to the touchdown on the ground, but due to the existence of a tail wind component as described in 3.3, it is considered possible that the effect of the flare was not enough due to low air speed. When the captain flared, he heard the low rotation warning sound. Therefore, it is considered probable that the collective was raised and the rotor rotation decelerated. The captain and the trainee lack clear memories about the maneuvering of the collective, but the trainee stated that he was taking a posture to prepare for an impact of touchdown and holding the collective with his body tightened. Therefore, it is considered possible that the captain failed to operate the collective in the best possible manner to reduce the rate of descent of the Aircraft.

(See Photo 3 Instruments of the Aircraft)

3.5 Damage to the Airframe

As described in the statements of persons related and ATC communication records in 2.1, it is considered highly probable that the Aircraft had no abnormality until the time when it started 180° turn autorotation power recovery.

It is considered highly probable that the damaged portions of the Aircraft as described in 2.3 were generated with the impact of its hard landing due to the following reasons:

(1) The impact that the landing gear assembly received on landing exceeded the limit load which can be absorbed with bending because the load with descent was added to the gross weight of the Aircraft. As a result, the cross tube was bent and the skids were widened laterally.

(2) The lower part of the mast fairing and the cowling in the right aft section of the Aircraft were distorted by upward force created on landing and relayed from the landing gear to the sections affected through the frames and by a load applied forward and backward by a sudden deceleration.

(3) The frames of the right side and left side doors, the outer skins on both sides of the Aircraft and the base of the tail cone buckled due to an upward impact which came from the landing gear on landing through the frames.

(4) The bottom side of one main rotor blade was wrinkled due to upward force created on landing and relayed to the mast from the landing gear through the frames and a load applied forward and backward by a sudden deceleration.

(See Photo 1 Accident Aircraft and Damaged Portions, Photo 2 Damaged Portions)

3.6 Stop of the Engine

As described in the statements in 2.1.1 (1), the captain recognized that the oil warning light illuminated. After landing, the captain confirmed that the fuel indicator and the switches such as mixture knob, ignition switch and fuel shut-off valve were at the positions where the engine can continue to run. Therefore, it is considered probable that the engine of the Aircraft stopped on approach.

3.6.1 Condition of the Engine

As described in 2.8, it is considered highly probable that there was no abnormality with the Aircraft's engine.

3.6.2 Factors Related to the Engine Stop

As described in 2.9 (2), the flight manual of the Aircraft provides operation procedures and points to be observed in autorotation training and the way for using carburetor heat in "Chapter 4 Normal Operations." As described in 2.9 (3), "Chapter 10 Recommendations for Safe Flights" contains as proposals for pilots safety notices issued by the company responsible for the design and manufacture of the Aircraft based on various accidents and incidents which have occurred in the past and articles related to cases involving stopped engines.

(1) Carburetor Icing

Safety notice SN-25 explains that carburetor icing becomes a cause for stalling the engine and that the phenomenon is most likely to occur when humidity is high or steam exists visibly, at temperatures of less than 21 °C. The notice also cites preventive measures. According to the meteorological information described in 2.6, the temperature at Yao Airport was 15 °C and the dew point was 1 °C to 2 °C when the Aircraft was performing takeoff and landing training. This means that humidity was around 40 %, a reading which cannot be said high. The trainee stated that he had used carburetor heat in a situation where the needle of the carburetor temperature indicator is on the yellow line, before entering autorotation and in a traffic pattern for the second round of straight autorotation power recovery, while following the steps described in "The manner to use carburetor heat" in 2.9 (2). Therefore, it is considered probable that there was no carburetor icing.

(2) Operation of Throttle

Chapter 4 of the flight manual regarding autorotation training describes procedures that the throttle shall be adjusted as the need arises and the caution that the throttle shall not be closed too fast. Safety notice SN-38 equally explains cases in which the engine stopped during autorotation training. As a specific preventive measure, it proposes that the throttle shall be slowly closed and it shall not be closed to full idle.

The engine of the Aircraft has four cycles of action in the piston—intake, compression, explosion (ignition, combustion and expansion) and exhaust, in a repeated rotational movement to produce power. Fuel-air mixture is made in the carburetor and its flow into the cylinder can be adjusted by operating the throttle to open or close the carburetor valve.

When the engine is running with the throttle opened, and if the throttle is suddenly closed, a combustion failure occurs because the intake of fuel-air mixture into the cylinder is limited. This can disrupt the cycle of the piston. It is considered probable that if the disorder continues, the engine will stall in some cases. As described in 2.1.1 (1), the captain stated that he had closed the throttle at a stroke to full idle in the autorotation training. It is considered probable that the trainee took a similar operation under the captain's guidance. It is considered possible that this operation was related to the stall of the engine. In order to reduce the revolution of the engine while maintaining the piston cycle and at the same time, by weakening the explosive power, the amount of the fuel-air mixture must be reduced gradually. As described in the flight manual, the throttle shall not be closed too fast.

4. PROBABLE CAUSE

In this accident, the engine stopped in the approach with autorotation power recovery training. The captain took over flying from the trainee and tried to touch down on the ground, but it is considered highly probable that the rate of descent was high, causing the Aircraft to make a hard landing and damage itself.

It is considered possible that the throttle operation in which the throttle was closed too fast during the training contributed the stop of the engine.

With regard to the hard landing, it is considered possible that the captain failed to operate the collective in the best possible manner because the effect of the flare was not enough due to the existence of a tail wind component and because the trainee was holding the collective.

Figure 1 Estimated Flight Route and Layout of Traces of Touchdown

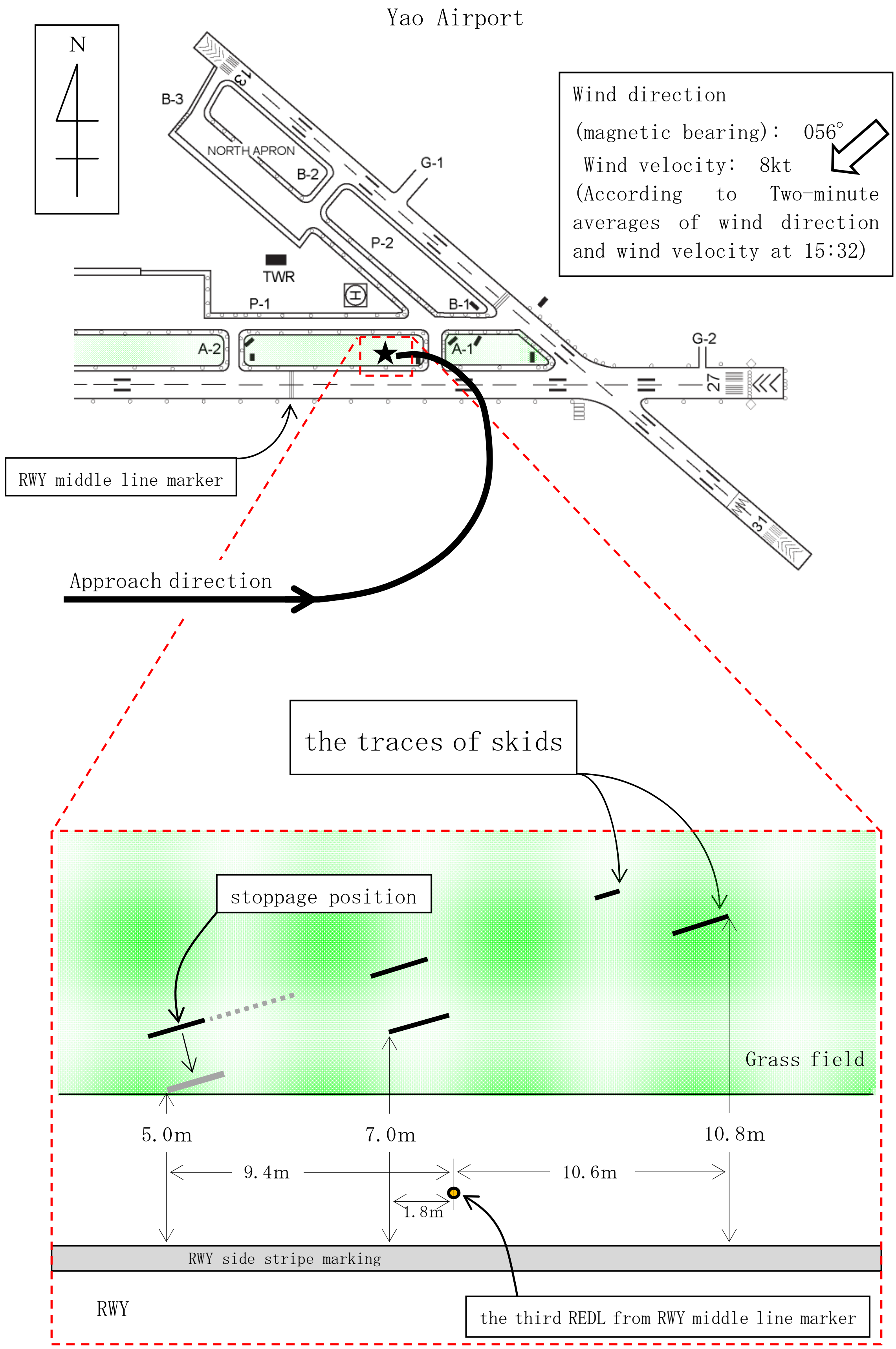


Figure 2 Three-angle-view of Robinson R22 Beta

Unit: m

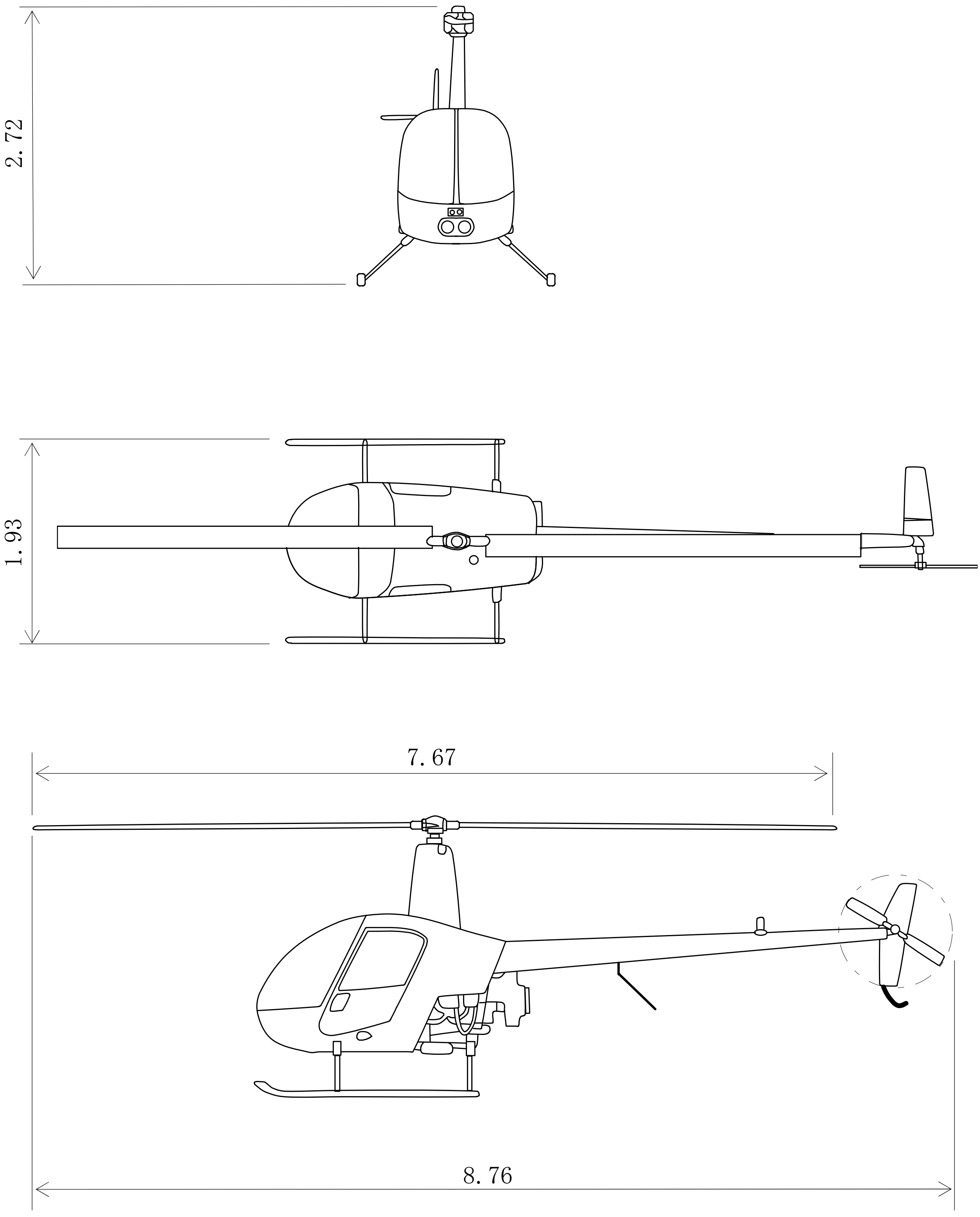
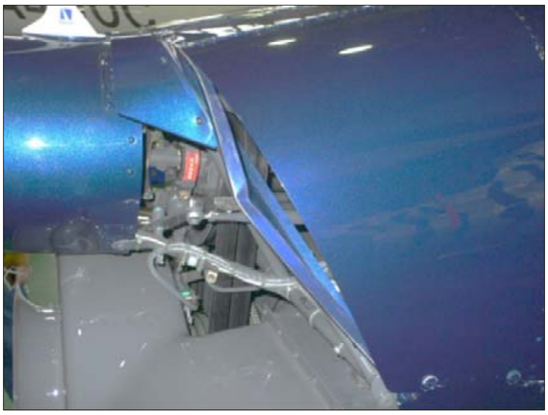


Photo 1 Accident Aircraft and Damaged Portions

Photo 2 Damaged Portions

Deformity of the left lower part of the mast fairing



Deformity of the cowling in the right aft section

Corn buckle of the frame of the right side door

Corn buckle of the outer skin on left side of the fuselage

The tail corn buckled in the direction at five o'clock

Wrinkle of the bottom side of one main rotor blade

Photo 3 Instruments of the Aircraft