

AA2017-8

**AIRCRAFT ACCIDENT
INVESTIGATION REPORT**

AERO ASAHI CORPORATION

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November 30, 2017

The objective of the investigation conducted by the Japan Transport Safety Board in accordance with the Act for Establishment of the Japan Transport Safety Board and with Annex 13 to the Convention on International Civil Aviation is to determine the causes of an accident and damage incidental to such an accident, thereby preventing future accidents and reducing damage. It is not the purpose of the investigation to apportion blame or liability.

Kazuhiro Nakahashi
Chairman
Japan Transport Safety Board

Note:

This report is a translation of the Japanese original investigation report. The text in Japanese shall prevail in the interpretation of the report.

AIRCRAFT ACCIDENT INVESTIGATION REPORT

**AERO ASAHI CORPORATION
KAWASAKI BK117C-2 (ROTORCRAFT)
JA6917
DAMAGE TO THE AIRCRAFT DUE TO HARD LANDING
TEMPORARY HELIPAD
HADANO CITY, KANAGAWA PREFECTURE, JAPAN
AT AROUND 14:04 JST, AUGUST 8, 2016**

November 10, 2017

Adopted by the Japan Transport Safety Board

Chairman	Kazuhiro Nakahashi
Member	Toru Miyashita
Member	Toshiyuki Ishikawa
Member	Yuichi Marui
Member	Keiji Tanaka
Member	Miwa Nakanishi

1. PROCESS AND PROGRESS OF THE INVESTIGATION

1.1 Summary of the Accident	<p>On Monday, August 8, 2016, a Kawasaki BK-117C-2, registered JA6917, operated by AERO ASAHI Corporation, was damaged because of a hard landing in an attempt to land at the Temporary Helipad in Hadano City, Kanagawa Prefecture, in order to transport a sick and wounded person for an emergency medical care.</p>
1.2 Outline of the Accident Investigation	<p>On August 8, 2016, the Japan Transport Safety Board designated an investigator-in-charge and an investigator to investigate this accident. JTSC designated one more investigator on August 12, 2016.</p> <p>An accredited representative and an adviser of French Republic, as the state of Design and Manufacture of the engines involved in the accident, participated in this investigation.</p> <p>Comments were invited from parties relevant to the cause of the accident and the relevant states.</p>

2. FACTUAL INFORMATION

2.1 History of the Flight	<p>The history of the flight is summarized below, based on the statements of the pilot, the maintenance engineer, the dispatcher and witness, and the records of Global Positioning System receiver (hereinafter referred to as "GPS") of the rotorcraft and Cockpit Voice Recorder (CVR).</p> <p>A Kawasaki BK117C-2 registered JA6917, operated by AERO ASAHI CORPORATION, took off from the Temporary Helipad in the Isehara City,</p>
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Kanagawa Prefecture at around 13:56 on August 8, 2016, as a helicopter for Emergency Medical Care, with 5 people onboard in total, consisting of a pilot, a maintenance engineer and three medical staff. During the flight, the rotorcraft did not show any abnormalities. The rotorcraft approached from the south side as planned, at the time of landing at the helipad in the Hadano City of Kanagawa Prefecture (hereinafter referred to as “the helipad”), but because the rotorcraft passed the approach point from the south by the time that a fireman on standby reported “the helipad is clear” for landing, the rotorcraft continued to turn to the right and commenced the approach from the west side as passing over the about 27 m high steel tower.

The pilot made an approach as expecting the east wind at the helipad since there was east wind at the takeoff point where was not so far away, but he did not feel an effect by the wind. According to the witness, a weak northerly wind was blowing on the surface.

Since the rotorcraft was approaching as flying over the steel tower, it had enough margin to its weight limit, and the pilot confirmed that the engine had sufficient power by engine instruments during take-off, he thought that if the rotorcraft approached with a rather large approach angle and descent rate for losing altitude and once the ground was close, then maneuvered to pull up collective pitch lever (hereinafter referred to as “CP”) to gain enough lift in order that it could transit to hovering. During the approach, the pilot was piloting as watching the landing target point and not a vertical speed meter.

The pilot pulled CP up to descend vertically with an intention to transit to hovering at about 5 m above ground, but the rotorcraft failed to transit to hovering, then it started to spin to the right as and continued to descend. Since the warning for overtorque¹ was sounded at the moment, the pilot thought that his pulling CP further up caused the spin to the right stronger and pulling CP down increased the descent rate, so he kept CP at the last used position. Applying left rudder did not stop the spin to the right and the rotorcraft touched down with a strong impact, then after bending the tail boom and leaning forward, it bounced and stopped as the nose facing southwest.

The accident occurred at the Temporary Helipad in Hirasawa of Hadano City, Kanagawa Prefecture (Latitude 35 °22' 44" N, Longitude 139 ° 11' 47" E) and at around 14:04 on August 8, 2016.

¹ “Overtorque” means that a rotational moment being generated for an engine to drive rotor and others is exceeding the operational limits.

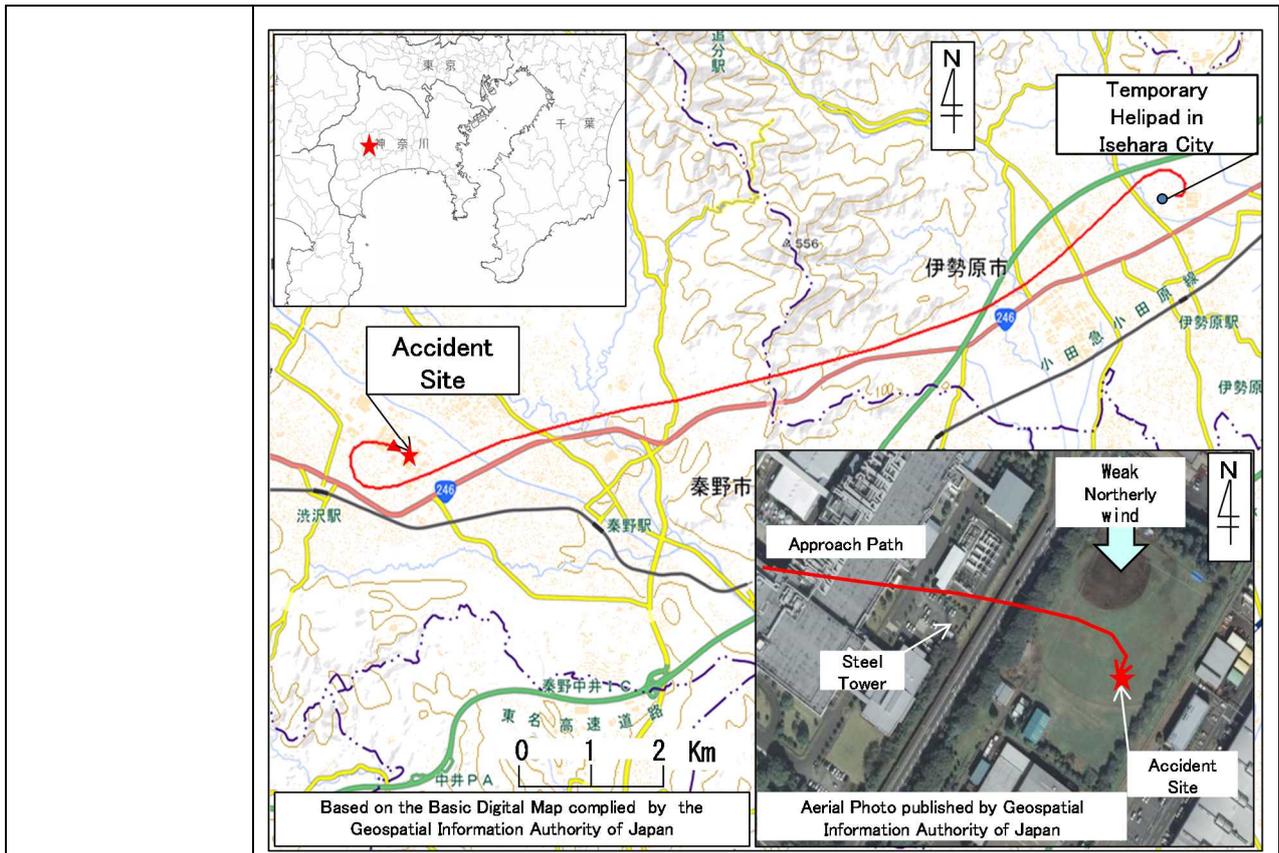


Figure 1 Estimated flight route

2.2 Injuries to Persons

None

2.3 Damage to Aircraft

Extent of damage; Destroyed

- (1) Tail Boom; Broken off at the joint with fuselage
- (2) Tail Fin; Broken
- (3) Main Rotor; Damaged
- (4) Tail Rotor; Broken
- (5) Skid; Buckling



Photo 1 the Accident Rotorcraft

2.4 Personnel information

Captain: Male, Age 51
 Commercial pilot certificate (Rotorcraft)
 Pilot Competence assessment

February 7, 1992

	<p>Expiration date of piloting capable period: March 17, 2018 Type rating: Kawasaki BK117C-2 March 12, 2010 Class 1 aviation medical certificate Validity: February 5, 2017 Total flight time 7,111 hours 56 minutes Total flight time on the type of rotorcraft 264 hours 8 minutes Landing experiences to the temporary helipad: Seven times since 2012 (The latest one was on April, 2016.)</p>
2.5 Aircraft information	<p>Aircraft Type: Kawasaki BK117C-2 Serial number :4006 , Date of manufacture :February 19, 2003 Certificate of Airworthiness : No.Dai-2015-490 Validity : December 4, 2016 Category of airworthiness :Rotorcraft Transport TA, TB or Special Aircraft X Total flight time 2,797 hours 55 minutes When the accident occurred, the rotorcraft's weight was estimated to have been 3,110 kg and the position of the center of gravity was estimated to have been 4,418 mm and 11 mm to right, both of which were estimated to have been within the allowable range.</p>
2.6 Meteorological information	<p>According to the witness who was near the accident site, there was a weak northerly wind. And the observation value at Hadano Fire Station located about 1.3 km east from the accident site around the time of the accident were as follows; 13:00; Wind Direction; North, Wind Velocity; average 7.2 m/s (Maximum instantaneous wind; 17.1 m/s) Temperature; 32.1°C 14:00; Wind Direction; North, Wind Velocity; average 4.9 m/s (Maximum instantaneous wind; 14.8 m/s) Temperature; 32.1°C</p>
2.7 Additional information	<p>(1) Relationship between temperature and engine output According to the Flight manual of the rotorcraft, calculating at an altitude as about 514 ft which is the elevation of the temporary helipad, the outside temperature as 32 °C and the output as takeoff output, it was possible to hover out of ground effect at a gross load 3,585 lb or less. (2) Situation at the time of touch-down The situation of the rotorcraft touchdown was saved in the drive recorder of the fire engine (hereinafter referred to as "the video records") of Hadano Fire Station on standby at the site during the accident. (Photo 2)</p>



Photo 2 Situation at the time of Hard Landing

(3) Damages to the rotorcraft

i) Engine

As the result of engine teardown inspection by the engine manufacturer, there were traces of foreign objects sucked in, but no occurrence of abnormality during the flight was found.

ii) Flight control system

Regarding the main rotor system of the flight control systems, no abnormality was found by a visual check and the linkage moved without any restrictions. Tail rotor control was broken at flex ball (a linkage to transmit the input to control).

iii) Hydraulic system

Regarding the Hydraulic system, No.1 system had piping of AVR (anti-vibration) system separated and No.2 system had piping of tail rotor system broke off.

(4) Approach angle and the descent rate

Based on the video records and data of GPS mounted on the rotorcraft, dividing the approach angle of the rotorcraft from the time to start the approach till the landing into four phases named ① to ④, the table 1 shows Average Ground Speed, Average Descent Rate, Ground Altitude and Approach Angle for each phase and Figure 2 shows the change in altitude as a graph. Also, phases from ① to ③ are based on GPS data, and phase ④ is based on the video records.

Table 1 Average Ground Speed, Average Descent Rate, Ground Altitude and Approach Angle for each phase

Phase	Average Ground Speed (kt)	Average Descent Rate (ft/min)	Ground Altitude (ft)	Approach Angle (°)
①	32	1080	360→180	18
②	19	1200	180→100	32
③	7	1500	100→10	63
④	7	1200	10→0	61

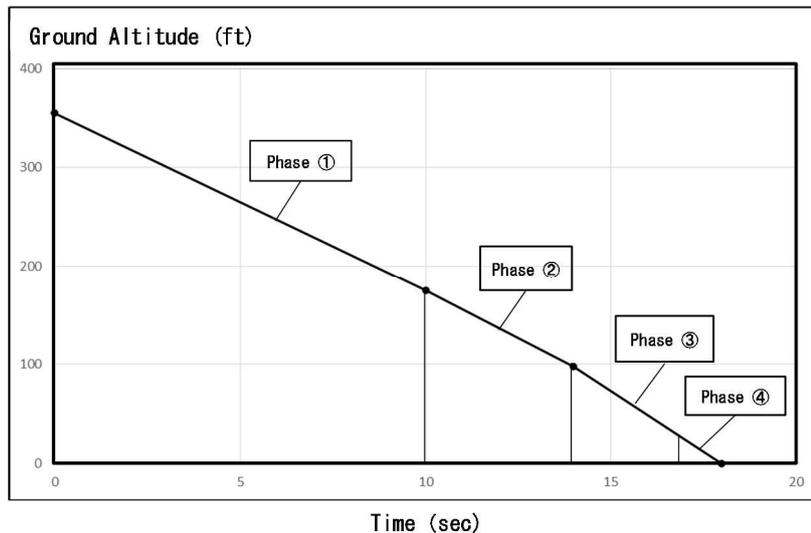


Figure 2 Changes in altitude after commencing the approach

(5) Vortex Ring State

As a rotorcraft is increasing its descent rate while flying at low speed, at the time for a downwash flow from main rotor to equal the descent rate of the rotorcraft, the downwash flow from the main rotor goes around an outer circumference of the main rotor from bottom to top and becomes the state called Vortex Ring State (hereinafter referred to as "VRS").

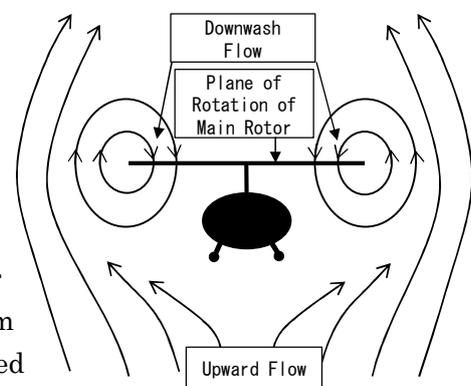


Figure 3 VRS Diagram

Because even though pulling CP up at this situation, most of engine output is used not to generate lift, but used only to accelerate donut shaped vortex generated at the tip of rotor, the lift is not increased, on the contrary, only descent rate increases by descending through own down washed flow. (Figure 3)

Occurrence conditions of VRS relates to the ratio (V_x/V_h) of forward airspeed (V_x) onto the induced velocity (V_h) and the ratio (V_z/V_h) of vertical descent velocity (V_z) which is the descent rate of the rotorcraft onto the induced velocity (V_h).

$$\text{Induced velocity (Vx) can be calculated using } V_h = \sqrt{T / 2 \rho \pi R^2}$$

when hovering. As ρ is Air Density, R is Radius of main rotor and T denotes Thrust, Thrust T can be approximated by Gross Weight.

Figure 4 is the figure of Vortex Ring State boundaries included in STI (Scientific Technical Information) Report by National Aeronautics and Space Administration (NASA) and expresses an occurrence condition in diagram. Looking at the numerical values which are almost common to each model illustrated in this figure, from the position ($V_z/V_h = -0.4$), VRS starts to develop at where V_x/V_h is 1.0 or less and vertical descent velocity (V_z) is near

40 % of induced velocity (V_h), around 60 % to 100 % ($V_z/V_h = 0.6 \sim 1.0$), VRS develops in full, and it is indicating to be out of boundaries at 160 % ($V_z/V_h = 1.6$) or more.

(6) Descent rate of BK117-2

Flight Manual of BK117-2 has the following description regarding descent rate;

At the time of hovering, or at low speed flight (up to 20 kt), the descent shall be carried out at descent rate of 600 ft/min or less.

(7) Requirements of the Temporary Helipad and others

Appended Operating work guideline for Helicopter of Operation Manual of the company (hereinafter referred to as “the Operating Guideline”) has the following stipulations;

Chapter 2 How to implement the Operation management (excerpts)

2-4 Operation Management standard

2-4-1 Creation of flight plan and decision of departure

(3) Characteristic of an airport in use and others

Flight plan shall be comply with the following standards, taking into consideration on altitude, physical specifications, states of obstacles and others of airport to be used.(including a case to land or take off at places other than airport, the rest is the same.)

A. General Standard (including the structures other than buildings)

c. (Omitted) gradient of an approach surface shall be one eighth or less to the direction to takeoff and one forth or less to the direction to land, and no obstacle shall project above an approach surface.

I. Safety Actions on the flight for an Emergency medical care

A. Requirements and others about taking off and landing strip comply with the standards of A. to H. of this chapter (3) as a basic, therefore the checking shall be done on the surface.

(8) Situation at/around the Temporary Helipad

① Approach Area and Approach Surface

The temporary helipad is previously set place as a most appropriate temporary helipad for an emergency medical care by the company, and was confirmed that the helipad complied with the standards based on the Operation manual guidelines of the company, however, there was no approach area or approach surface set at the west side of the temporary

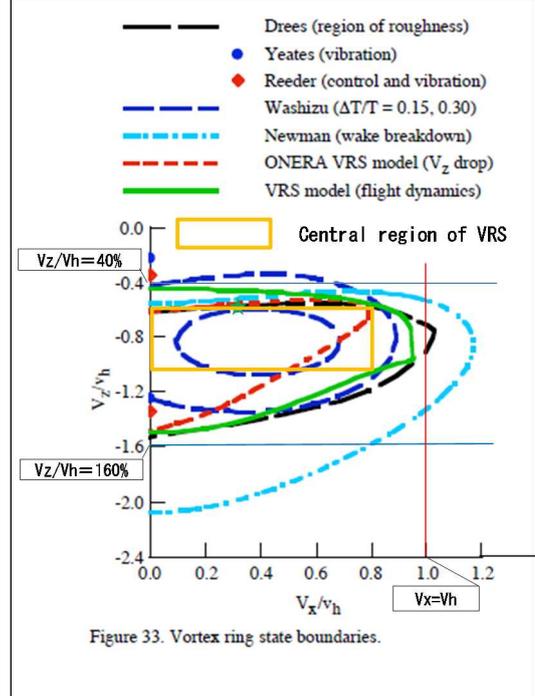


Figure 4 VRS boundaries

helipad for the landing direction where the rotorcraft approached at the time of accident. (Figure 5)

② Obstacles

There was a 27 m high steel tower located at about 100 m from the temporary helipad below the approaching path of the rotorcraft. (Figure 5)

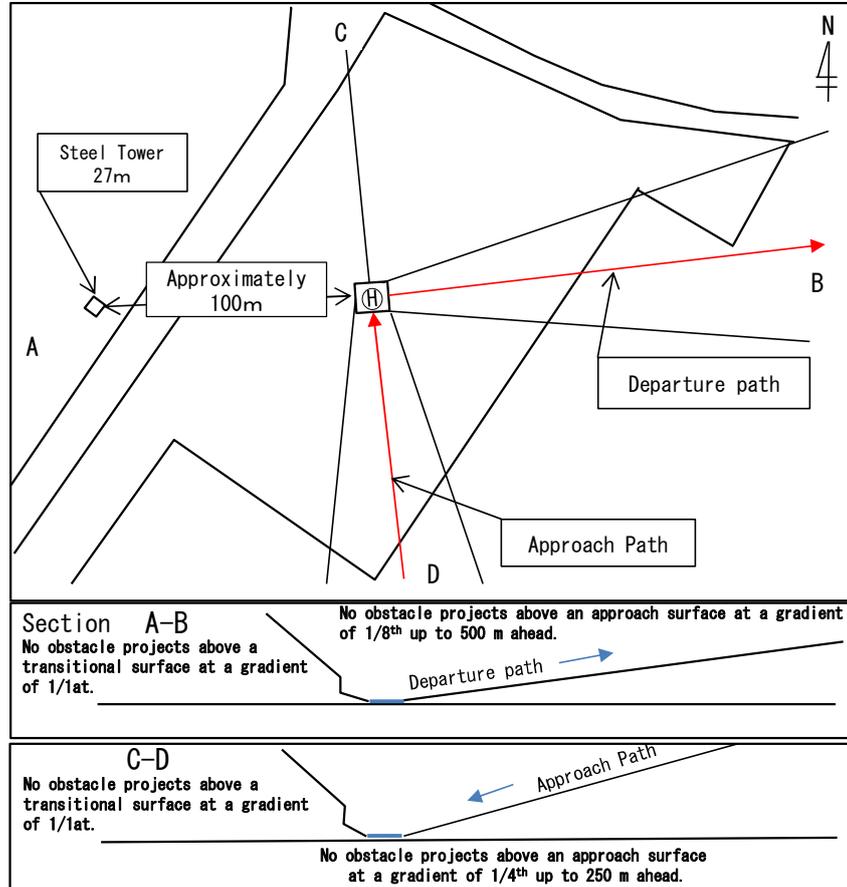


Figure 5 Approach/Departure path at the Temporary Helipad

3. ANALYSIS

3.1 Involvement of weather	None
3.2 Involvement of pilot	Yes
3.3 Involvement of equipment	None
3.4 Analysis of known items	<p>(1) Damage to the rotorcraft</p> <p>It is highly probable that the rotorcraft did not have any abnormality till the occurrence of the accident and all of the damages to the rotorcraft were caused at the time of the hard landing.</p> <p>(2) Causes leading to the hard landing</p> <p>The pilot said that he was intended to decrease the descent rate by pulling CP up in order to transit to hover as commencing the approach with a rather large approach angle and descent rate, but because the rotorcraft could not be transited to hover, and continued to descend along with the</p>

commence of the slow spin to the right, he applied the left rudder but the spin to the right did not stop and the rotorcraft made a touchdown with strong impact.

Normally, a ground effect due to approaching the ground prior to touchdown, a flare effect due to deceleration and increases in lift by pulling CP up could decrease descent rate to enable the transition to hovering, but because this case lead up to the hard landing without transiting to hover, it is somewhat likely that the rotorcraft fell into VRS where even though increasing the lift in the main rotor, the descent rate still increased.

To analyze the situation whether the rotorcraft fell in VRS or not, setting the estimated gross weight of the rotorcraft at the time of accident as 3,110 kg, the radius R 5.5 m of the main rotor, the outside temperature near the accident site at the time as approximately 32°C, and the altitude of the temporary helipad as 514 ft, based on the data in Table 1, V_h , V_z and V_x for phase ① to phase ④ and V_z/V_h and V_x/V_h were calculated in Table 2. (According to the information of the witness, because the surface wind was light northerly wind at the time of the accident (the left side wind for the rotorcraft), use average ground speed in Table 1 as a forward airspeed (V_x) to calculate.)

Table 2; V_z , V_x , V_z/V_h and V_x/V_h for each phase

Phase	Altitude (ft)	Density ρ (slug/f ³)	V_h (ft/s)	V_h (m/s)	V_z (m/s)	V_x (m/s)	V_z/V_h	V_x/V_h
①	874 (groundspeed 360)	0.00217984	39.2	11.9	5.5	16.5	0.46	1.39
②	694 (groundspeed 180)	0.00219428	29.1	11.8	6.1	9.8	0.52	0.83
③	614 (groundspeed 100)	0.00220072	39.0	11.8	7.6	3.6	0.64	0.30
④	524 (groundspeed 10)	0.00220799	39.0	11.8	6.1	3.6	0.52	0.31

At the phase ① when the rotorcraft started the approach, the rotorcraft was at the outside of a border of VRS, because the forward airspeed (V_x) was larger ($V_x/V_h = 1.39$) than the induced velocity (V_h). It is highly probable that after the phase ②, the forward airspeed (V_x) entered the inside of a border of VRS and since the vertical descent speed (V_z) was 52% ($V_z/V_h = 0.52$) of induced velocity at the phase ② to generate a light VRS, at the phase ③ where the pilot pulled CP up to transit to hover, enter VRS at 64 % ($V_z/V_h = 0.64$) of the induced velocity (V_h), at phase ④, and returned to the light VRS at 52% ($V_z/V_h = 0.52$).

It is probable that regarding why the rotorcraft resulted in the hard landing, based on these, because the rotorcraft did not use the approach path which is set at the temporary helipad, flew over the steel tower near the temporary helipad of the destination, commenced the approach with a rather large approach angle and decreased the forward airspeed in order to transit to hover, the main rotor of the rotorcraft fell into VRS and even though the pilot pulled up CP, it could not gain the corresponding lift.

(3) Descent rate of the rotorcraft

Regarding the increase of descent rate of the rotorcraft from phase ① to phase ③, because the pilot was piloting as watching the landing target point

and he did not see a vertical speed indicator, it is somewhat likely that he did not notice an increase in the descent rate.

From phase ② to phase ④, as the average velocity of the rotorcraft was as Table 1, calculating the average descent rate for the case of $V_z/V_h=0.35$ or less without developing VRS is resulted in about 800 ft/min. Even if the rotorcraft approached with same forward airspeed and descent rate at phase ① of Table 1, it is probable that there is a possibility not to develop VRS, if the descent rate became about 800 ft/min till phase ② due to the operation of pulling CP up by the pilot. If the descent rate was 600 ft/min as shown in Flight Manual, V_x/V_h was 0.26 even at phase ③ and it is highly probable that it was possible to transit to hover without developing VRS.

(4) Slow spin to the right of the rotorcraft

Regarding the slow spin to the right of the rotorcraft, it is somewhat likely that because tail rotor thrust due to controls of the left rudder could not follow the rapid use of CP in full by the pilot in order that he intended to decrease the excess of descent rate.

(5) Approach path to the temporary helipad

It is probable that at first the rotorcraft intended to approach from the south side to land at the temporary helipad, but because when the fireman on standby at the temporary helipad reported for the helipad to be cleared to landing, it was already passing the approach point from the south, the pilot commenced the approach at a rather large approach angle and descent rate as flying over the steel tower 27 m high from the west side where no approach area or approach surface was set, with his expectation of the east wind blowing at the helipad and judging the ability of the rotorcraft performance to land in a view of an emergency of the rotorcraft's roll. It is very important to operate a flight of helicopter for an emergency medical care require high urgency, but because at the same time it requires high safety, along with collecting surface wind information as much as possible, if there is an approach path to the temporary helipad along an approach surface which is confirmed to comply with the standard should be used, or when approaching have to be made with large approach angle for the use of temporary helipad, the descent rate set forth in the flight manual shall be complied with giving the most priority to safety in order to avoid VRS.

4. PROBABLE CAUSES

It is highly probable that in this accident, the rotorcraft was damaged because the landing was resulted in the hard landing. With regard to the hard landing of the rotorcraft, it is probable that because it did not used an approach path to the temporary helipad along an approach surface which is confirmed to comply with the standard, flew over the high steel tower near the temporary helipad of the planned destination, commenced the approach at a rather large approach angle and descent rate, and decreased the forward airspeed in order to transit to hover, the main rotor developed VRS and in spite that the pilot pulled CP up, the corresponding lift could not be gained.

5. SAFETY ACTIONS

The company carried out the following safety actions;

1. Piloting

- (1) Restrictions for descent rate in order to avoid VRS during the flight shall be set and shall be stipulated in Regulations for the Implementation of Flight Operations and By-work Operating Manual “Transport for an emergency medical care”.
- (2) Education for VRS to all helicopter pilots of the company were carried out and included in the periodic training for the helicopter pilots in the fiscal year of 2017.

2. Environment related

- (1) At the time of operating Medical Helicopter, a wind situation of the temporary helipad shall be obtained from the fire stations prior to the landing and it shall be provided for this By-work Operating Manual “Transport for an emergency medical care”.

Furthermore, after this incident, the company requested Kanagawa prefecture to provide wind information via fire agencies of the prefecture and to install windsocks, and the effects shall be described in Medical Helicopter Flight handbook. The company requested similar cooperation from other prefectures too.

- (2) The company reported this event and the corresponding safety action to the subcommittee of Helicopter of All Japan Air Transport and Service Association to share this information with the same business group.