

AIRCRAFT ACCIDENT INVESTIGATION REPORT

INJURY TO GROUND WORKER DURING

CARGO TRANSPORT OPERATION

SHIN NIHON HELICOPTER CO., LTD.

AEROSPATIALE AS332L1(ROTOR CRAFT), JA6686

AOI-WARD SHIZUOKA-CITY SHIZUOKA PREFECTURE, JAPAN

AT ABOUT 10:01 JST, APRIL 12, 2024

August 8, 2025

Adopted by the Japan Transport Safety Board

Chairperson	RINOIE Kenichi
Member	TAKANO Shigeru
Member	MARUI Yuichi
Member	SODA Hisako
Member	TSUDA Hiroka
Member	MATSUI Yuko

1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident	On Friday, April 12, 2024, an Aerospatiale AS332L1 helicopter, JA6686, operated by Shin Nihon Helicopter Co., Ltd., was transporting ready-mixed concrete from the Nakagochi operation site in Aoi Ward, Shizuoka City, Shizuoka Prefecture, to a loading/unloading site at a transmission tower construction site. As the helicopter approached the site at an altitude of approximately 50 ft (about 15 m) above the stage ^{*1} , the downwash caused a formwork panel placed on the stage to lift off. The panel struck the leg of a ground worker who had taken cover next to the panels, resulting in a serious injury. No other personnel were injured, and the aircraft sustained no damage.
1.2 Outline of the Accident Investigation	On April 18, 2024, upon receiving notification of the accident, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and two other investigators to investigate this accident. An accredited representative and an adviser of the French Republic, as the State of Design and Manufacturer of the aircraft and the engines, involved in this accident, participated in the investigation. Comments on the draft Final Report were invited from parties relevant

^{* 1} “Stage” refers to a work platform installed for loading and unloading site during construction.

to the cause of the accident and the Relevant State.

2. FACTUAL INFORMATION

2.1 History of the Flight

According to the helicopter's operational records and statements from the pilot, an onboard mechanic, and ground workers, the history of the flight is summarized as follows:
(1) Flight Summary

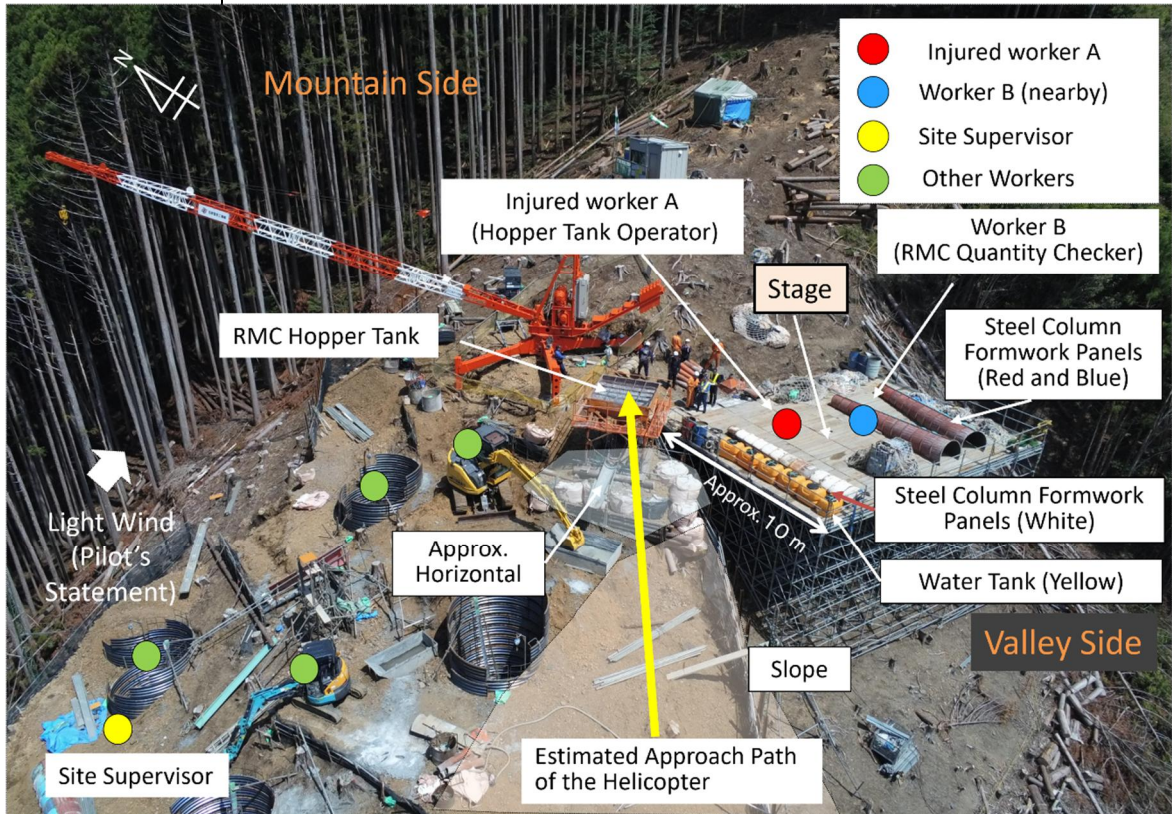


Figure 1: Positions at the Time of the Accident and Estimated Flight Path of the Helicopter

The helicopter, with a total of two persons onboard—the pilot and an onboard mechanic—took off from the Nakagochi operation site at approximately 08:50 Japan Standard Time (JST: UTC + 9hrs, unless otherwise stated all times are indicated in JST on a 24-hour clock), and conducted 13 transport runs for ready-mixed concrete (hereinafter referred to as “RMC”) between the operation site and the cargo loading/unloading site at the transmission tower construction site. After completing these transport runs, the helicopter was refueled with 1,000 lb (454 kg) of fuel. At approximately 10:01, following refueling, the helicopter approached the site above the RMC hopper tank*2 used for RMC (hereinafter referred to as the "hopper tank"), from the west-southwest direction of the accident site, flying at an altitude of approximately 50 ft (about 15 m) above the top of the stage. At that time, the rotor downwash*3 caused formwork panels placed on the

*2 "RMC hopper tank" refers to a device into which RMC is temporarily poured from a RMC bucket suspended by a helicopter.
*3 "Downwash" refers to the descending airflow generated behind (below) the main rotor of a helicopter as a result of the induced flow produced when the rotor generates lift.

stage to lift off, and the panel struck the leg of a ground worker who had taken cover next to them, resulting in a serious injury. No abnormalities were found in other personnel or the helicopter. According to the pilot's statement, whenever the helicopter approached the site above the hopper tank—including at the time of the accident—the same approach path was used by aligning the helicopter directly with the hopper tank as the target and reducing its ground speed to below 15 kt from a point approximately 20 m ahead. Under the guidance of the onboard mechanic, the helicopter gradually decelerated during the approach, hovered above the hopper tank, and then lowered the RMC bucket^{*4} onto the hopper tank to release the RMC. After the accident occurred, the helicopter crew was not aware that a ground worker had been injured and continued to conduct a total of fifty-one transportation flights of RMC or other materials until 12:58.

(2) Statements from Injured Worker A and Nearby Worker B

When the helicopter resumed operations after refueling and began its approach over the hopper tank with the RMC bucket suspended, both workers felt a stronger downwash than during the previous transport. The four stacked white formwork panels (see 2.7(1)) began to vibrate with a rattling sound. Immediately thereafter, the topmost panel lifted off toward Worker A, who was operating the hopper tank handle and had taken cover next to the panels. The formwork panel flipped over its wider southern edge as a pivot point, causing the northern tip to move. Worker A attempted to hold back the approaching formwork panel by hand but was unable to do so. The panel flipped over and came into contact with the upper right knee and lower left knee, resulting in injury. Worker B, who was nearby, heard a sound as if something had been struck when the formwork panel lifted off and flipped over. After the helicopter began to ascend, Worker B asked Worker A if everything was all right. Although there was pain in the knees, Worker A believed there was no bleeding and responded, "I'm okay."

Subsequently, to prevent the flipped-over formwork panel from being displaced by the downwash, Worker B placed weights, such as wires, on it. The remaining three white panels were secured by threading iron wires through bolt holes. In addition, the site supervisor was at the site the foundation work area where RMC was being continuously delivered and therefore did not notice the formwork panel lifted off.

Around 12:00, while the helicopter was conducting material transport runs for another construction site, Worker A noticed slight bleeding near the knee and reported the injury to the site supervisor. Since independent walking was possible, the Worker A descended the mountain using the transport monorail. Around 12:03, the site supervisor contacted the site manager, who was at a remote location, by phone to report that Worker A has been injured and had descended the mountain.

The two workers had received repeated instruction on the dangers of downwash

^{*4} "Concrete bucket" refers to equipment suspended from a helicopter hook that can discharge concrete by remote control. It has a bucket-shaped structure with a bottom plate that can be opened and closed.

during the group safety training conducted prior to the start of the construction project. They believed they were aware of the risks, but had not anticipated that a heavy object like a formwork panel could lift off.

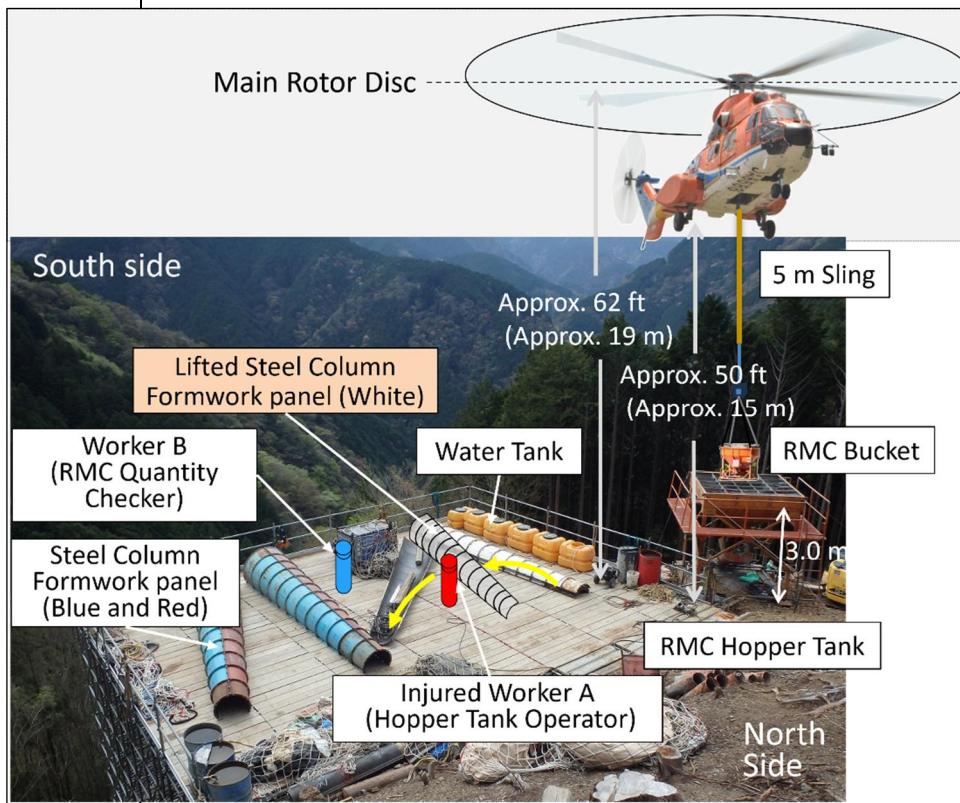


Figure 2: Stage Area Conditions During the Helicopter Approach (Composite Image)

The accident occurred at approximately 10:01 on April 12, 2024, at the site (35° 10' 28" N and 138° 19' 15" E).

2.2 Injuries to Persons

One ground worker was seriously injured (contusion and laceration of the left lower leg: injury requiring hospitalization and treatment for more than 48 hours).

2.3 Damage to the Aircraft

Damage to aircraft and ground equipment: No damage

2.4 Personnel Information

(1) Pilot: Age 47
Commercial Pilot Certificate (Rotorcraft): April 3, 2000
Pilot Competency Assessment
Expiration Date of Piloting Capable Period: March 29, 2026
Ratings and Limitations:
Type Ratings for Multi-engine turbine(land): March 16, 2012
Type Rating for Aerospatiale SA330: May 9, 2016
Class 1 Aviation Medical Certificate: December 24, 2024
Total flight time: 6,439 hours 42 minutes
Total Flight time in the past 30 days: 41 hours 08 minutes

	Flight time on the type of aircraft: 776 hours 08 minutes Flight time on the type of aircraft in the past 30 days: 30 hours 02 minutes (2) Worker A: Age: 50 Years of experience in the construction industry: 30 years Experience in transmission line foundation construction using helicopter cargo transport: 9 years
2.5 Aircraft Information	Aircraft Type: Aerospatiale AS332L1 Serial Number: 2350 Date of Manufacture: October 4, 1991 Airworthiness certificate: No. DAI-2023-645, Validity: February 27, 2025 Total Flight Time: 7,144 hours 26 minutes At the time of the accident, the weight of the helicopter is estimated to have been 8,707 kg and the position of the center of gravity is estimated to have been 463 cm, both of which are estimated to have been within the allowable range (the maximum takeoff weight 9,350 kg, and the center of gravity was within the range of 440 to 480 cm in corresponding to the weight at the time of the accident).
2.6 Meteorological Information	(1) Meteorological Observations According to the Shizuoka Local Meteorological Observatory, located approximately 5.4 km south-southwest of the accident site, the observed weather conditions around the time of the accident were as follows: 10:00 Wind direction: East-northeast Wind speed: 3.4 m/s, Visibility: 20 km Weather: Cloudy Temperature: 17.4°C, Dew point: 8.0°C Atmospheric pressure: 1020.8 hPa (2) Statement by the Pilot According to the pilot's statement, the weather conditions in the vicinity of the accident site were as follows: • Wind: Light wind from the west-northwest • Visibility: 10 km or more • Weather: Cloudy
2.7 Additional Information	(1) Overview of Steel Column Formwork Panels The steel formwork panels used to construct the foundations of transmission towers consist of cylindrical column segments divided into three 120° arc sections and color-coded white, red, and blue. Panels of each color, each 0.5 meters in length, are bolted together to form the required total length, and the three colors are then combined for use. The white formwork panel that lifted off at the time of the accident was 6.50 meters long (comprising 13 connected panels), had a tapered shape—1.08 meters wide at the bottom and 0.52 meters at the top—and weighed 139.77 kg per panel. (See Figure 3.) As shown in Figure 2, at the time of the accident, the red and blue formwork panels had been assembled and placed with their arc sections

facing upward. The white formwork panels were stacked in four layers. These panels were intended to be assembled at the foundation of the transmission tower at the appropriate time as molds for pouring the transported RMC.

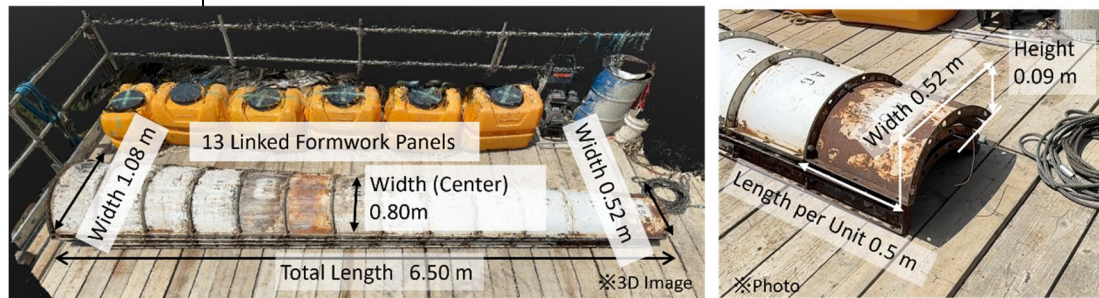


Figure 3: Steel Column Formwork Panels

(2) Flight Recorder Data

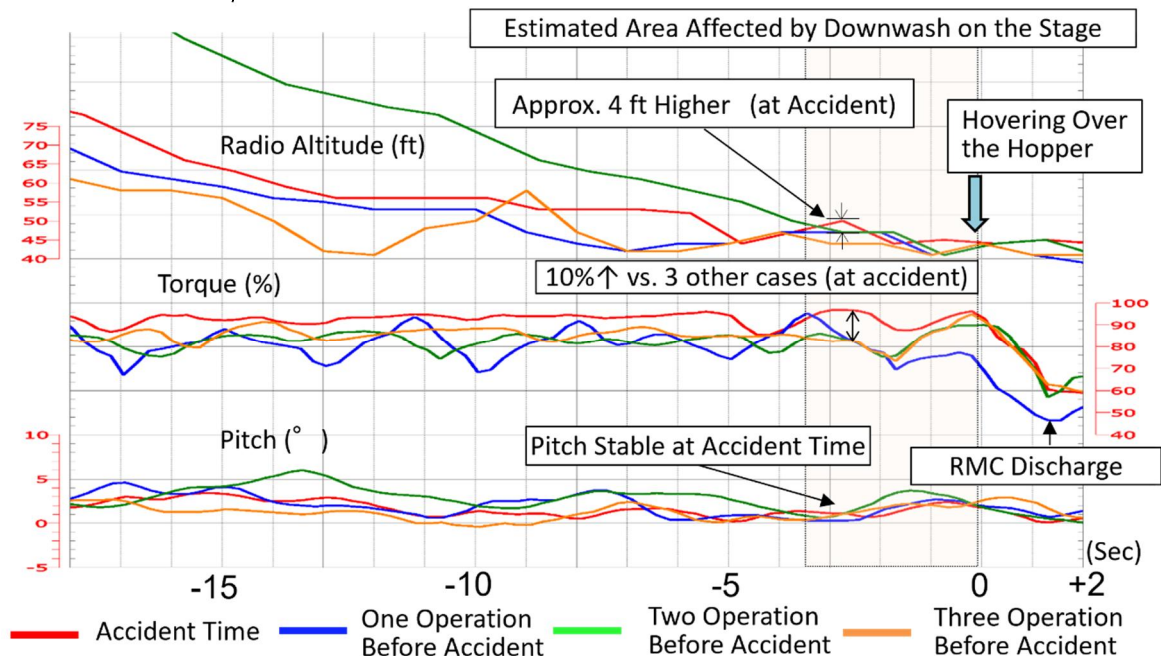


Figure 4: Comparison of Engine Torque, Pitch Attitude, and Radio Altitude During Approach

The helicopter was equipped with an integrated recorder (combining a flight data recorder and a cockpit voice recorder). However, due to the low-altitude flight near the accident site, GPS data was not properly recorded, and therefore, accurate information regarding GPS speed and position at the time of the accident could not be obtained. Figure 4 shows a comparison of the changes in radio altitude, engine torque^{*5}, and pitch attitude as the helicopter approached the site above the RMC hopper tank during the accident flight and during the three preceding flights.

^{*5} “Engine torque” refers to the measured twisting force of the engine output shafts that drive the main rotor. It is usually expressed as a percentage (%) rather than in absolute units, such as newton-meters (Nm), making it easier to evaluate operational limits and compare engine output regardless of altitude or temperature.

(3) Effect of Downwash at Ground Level

(Excerpt from Airbus Helicopters, Inc., SAFETY PROMOTION NOTICE*6)

a. Estimated Average Theoretical Downwash Wind Speed During Hovering Out of Ground Effect*7.

The theoretical induced velocity (hereinafter referred to as “induced velocity”) from the rotor disk when a helicopter is hovering out of ground effect can be calculated, as shown in Figure 5, using two primary parameters—aircraft weight and rotor disk area—as well as air density, which depends on temperature, altitude, and pressure.

As shown in Figure 5, when a helicopter is hovering in a condition unaffected by ground effect, the average induced velocity (V_i) discharged from the rotor disk forms a downwash that flows downward. Within a range of approximately 1 to 3 times the rotor diameter below the rotor disk, the flow velocity is accelerated to nearly twice the induced velocity. The flow is fastest at the blade tips, where tip vortices are generated and flow downward in a spiraling pattern around the blade ends. Beyond this region, the airflow gradually dissipates due to turbulence, the flow speed slowly approaches zero, and the air becomes nearly stationary at a distance of approximately 10 times the rotor diameter.

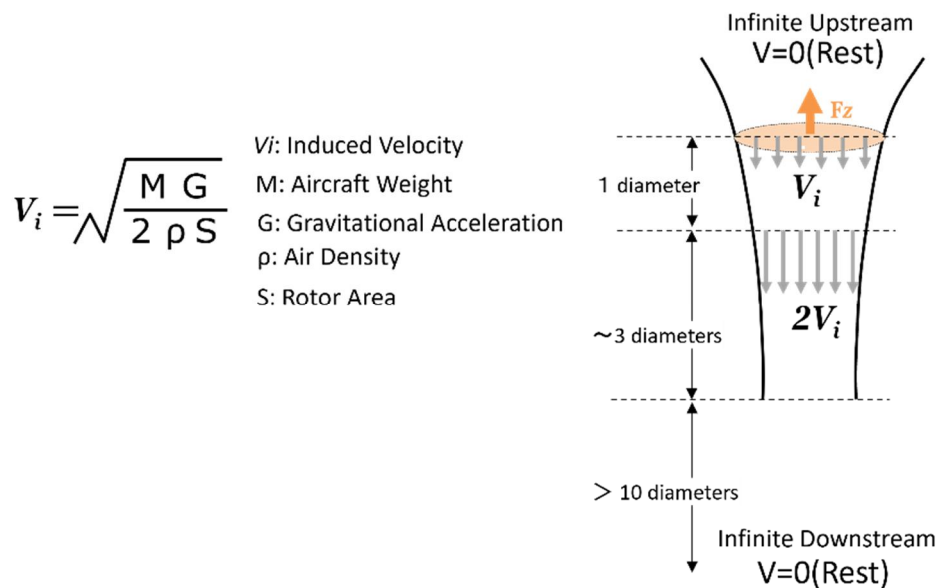


Figure 5: Changes in Induced Velocity During Hovering

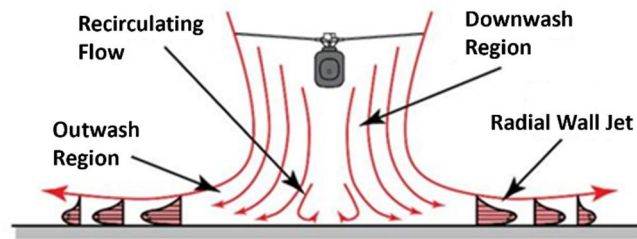
b. Variation in Downwash Caused by Ground Surface

When downwash flows near the ground, it is affected by the ground surface, as shown in Figure 6. The airflow changes direction due to the presence of the ground and becomes outwash, spreading outward. This

*6 Airbus Helicopters of SAFETY PROMOTION NOTICE “GENERAL, Noise & downwash considerations for ground operations” No. 3684-P-00, Revision 0 2021-11-22

*7 “ground effect” refers to the phenomenon that occurs when the induced airflow interacts with the ground. When a helicopter is within the ground effect zone, the airflow circulates between the rotor and the ground, reducing the engine power required to maintain rotor lift.

outward-flowing air forms a radial wall jet, where the flow speed temporarily increases, but gradually decreases as the horizontal distance from the rotor increases.



Ref: Experimental Investigation of Rotorcraft Outwash in Ground Effect

Figure 6: Flow Velocity Acceleration in Ground Effect Outwash Region

c. Changes in Airflow Near the Fuselage

Figure 7 presents an example of the induced velocity distribution around the rotor disk. In this example, areas of higher flow velocity are concentrated near the blade tips. This is because the relative velocity of the rotating blade is higher at the tips than at the roots, resulting in a greater induced velocity below the blade tips compared to the average induced velocity across the entire rotor disk. Also, Figure 8 illustrates the airflow pattern when a helicopter is hovering near the ground. Since the rotor disk is typically not perfectly horizontal, the streamlines as seen from the front of the helicopter (as shown in Figure 8) indicate that the airflow is affected by the fuselage. The airflow around the fuselage is complex; the flow characteristics differ on either side of the mast axis and can result in localized acceleration. Moreover, the airflow is further influenced by proximity to the ground, creating an overall more complex flow pattern.

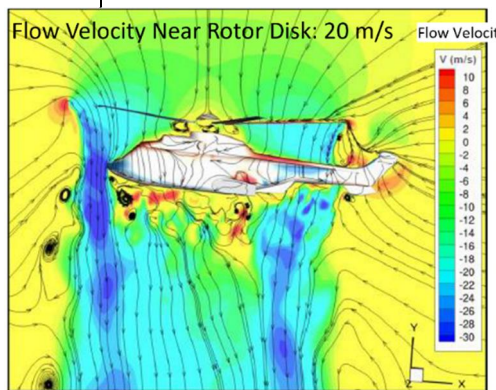


Figure 7: Distribution of Induced Velocity near the Rotor Disk

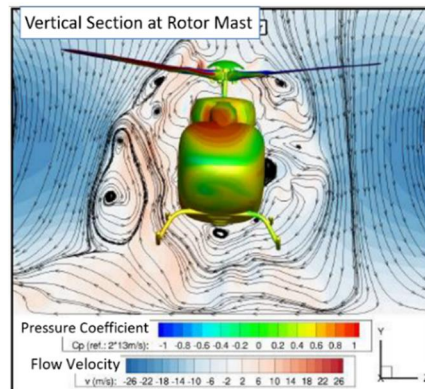


Figure 8: Airflow Changes around the Fuselage during Hovering

3.ANALYSIS

(1) Influence of Weather

The JTSCB's conclusion regarding the Influence of Weather is as follows:

According to the pilot's statement, a light wind was blowing from the west-northwest near the

accident site at the time of the accident. Since this wind direction would place the wind coming from the left rear relative to the helicopter's estimated approach path, it is possible that the downwash was carried toward the stage, which was downwind, and that the wind speed was affected as a result.

(2) Area of Downwash Flow Over the Stage

The JTSB's conclusion regarding the Area of Downwash Flow Over the Stage is as follows:

The stage next to the hopper tank, as shown in Figure 1, was located on a mountain slope. It was constructed from steel pipes and had an open structure that allowed air to flow underneath. According to Figure 9, the distance from the point at which the tip of the main rotor blade reached directly above the stage to the point where the helicopter hovered above the hopper tank was approximately 11 m. During the approach, excluding the effect of wind, most of the downwash would flow toward the valley side of the slope until the main rotor disk overlapped the stage. Therefore, it is more likely that the formwork panels were not affected by the downwash until that point. Additionally, according to the pilot's statement, the helicopter approached from approximately 20 m in front of the hopper tank at a ground speed of less than 15 kt. Assuming the helicopter hovered directly over the hopper tank, a deceleration rate of approximately 3 kt per second would have been required. Based on this deceleration rate, it is estimated that it took approximately 3.5 seconds to travel the 11m during which the main rotor disk overlapped the stage. During this period, it is probable that strong downwash flowed over the surface of the stage.

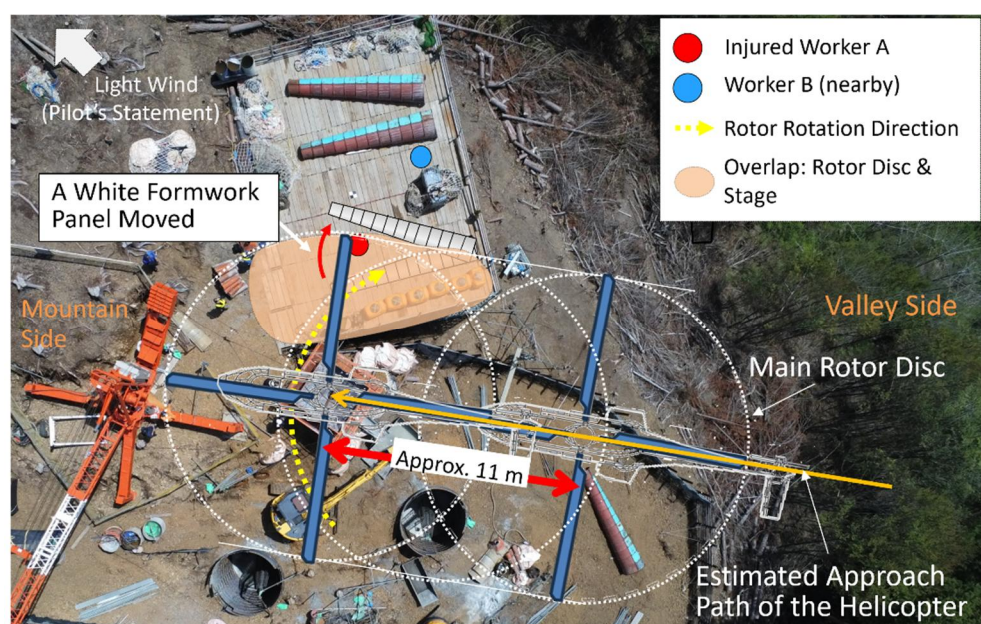


Figure 9: Area on the Stage Affected by Downwash

(3) Comparison of Downwash During Approach

The JTSB's conclusion regarding the Comparison of Downwash During Approach is as follows:

Although GPS-based speed and position data were not properly recorded in the helicopter's flight recorder, a comparison was made, as shown in Figure 4, for the approximately 3.5 seconds immediately before hovering over the hopper tank during four approach runs, including the accident flight. The comparison was based on engine torque, pitch attitude, and radio altitude—factors related to differences in downwash strength.

Comparing the four approaches, during the approach at the time of the accident, the radio altimeter indicated approximately 4 feet higher than in the other three approaches at about 3 seconds before hovering over the hopper tank, and the helicopter approached while descending. In addition, a

comparison of engine torque changes immediately before releasing the RMC showed that the engine torque at the time of the accident remained approximately 10% higher than in the other three approaches for about 1.5 seconds. Furthermore, the pitch attitude was shallower and showed less variation.

Regarding the approach immediately preceding the accident, although the change in pitch attitude was small and the change in radio altitude was similar to that during the accident, the engine torque was significantly lower overall compared to the other three approaches including the accident. It is possible that, in addition to a reduction in aircraft weight due to fuel consumption, the helicopter was temporarily affected by wind, resulting in a lower engine torque requirement for flight.

In contrast, during the approach at the time of the accident, it is probable that a stronger downwash continuously flowed onto the stage compared to the other three approaches. This is due to the combination of higher engine torque, faster downwash wind speed, a descending approach, and a shallow and stable pitch attitude, all of which would have caused the downwash to be more concentrated downward. This assessment is consistent with the statement made by two workers who noted, “The downwash felt stronger than during the previous transport.”

(4) Downwash Flow Over the Stage

The JTSB’s conclusion regarding the Downwash Flow Over the Stage is as follows:

As shown in Figure 10, the height from the rotor disk to the top surface of the stage was approximately 19 meters when the bucket was in contact with the hopper tank. During the approach prior to contact, the height from the rotor to the stage exceeded the rotor diameter of 15.6 meters. At this height—where downwash wind speed is known to double—it is estimated, based on the environmental conditions at the time of the accident and as shown in Figure 11, that the helicopter’s induced velocity was approximately 26 kt, and that the average estimated downwash wind speed, accelerated by this height, reached approximately 53 kt (27 m/s). Furthermore, under the aircraft weight during RMC transport before refueling (with approximately 454 kg of fuel onboard), the average estimated downwash wind speed was about 51 kt. Additionally, as shown in Figure 9, the location where the formwork panel lifted off was near the tip of the main rotor disc. As described in section 2.7(3)c, it is

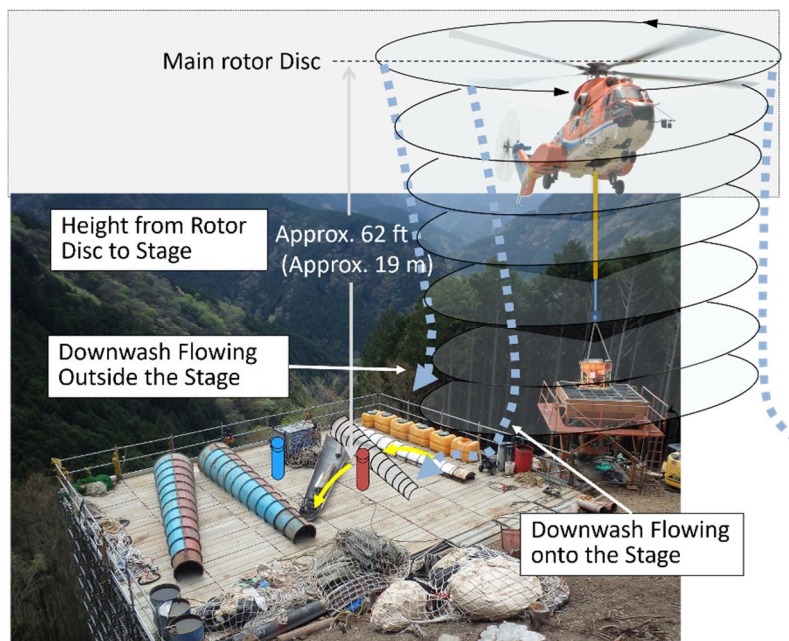


Figure 10: Downwash Flow on the Stage

Aircraft Weight :	8,707 kg
Flight Altitude :	1,500 ft
Estimated OAT :	14.5 °C
Air Density :	1.216 kg/m ³
AS332L Rotor Diameter (D):	15.6 m

Induced Velocity :	26.3 kt (13.6 m/s)
Downwash Velocity :	52.7 kt (27.1 m/s)

Figure 11 Wind Velocity of the Downwash During the Accident

probable that the downwash in this area exceeded the estimated average wind speed and reaches its maximum velocity. Moreover, a water tank was positioned in front of the white formwork panels, and the downwash passed through the space between them. It is possible that this caused additional acceleration of the wind due to the Venturi effect*8.

The behavior of downwash flow is difficult to simulate accurately, as it is influenced not only by the complex airflow patterns around the fuselage but also by the structures present on the stage. However, during the helicopter's approach at the time of the accident, the formwork panels on the stage were observed to vibrate with a rattling sound and then lifted off and flipped over. It is most likely that temporarily accelerated downwash generated sufficient force to lift off the panels, flipped over them, and subsequently move them to the point of impact by means of the outwash.

(5) Avoidance of Downwash Effects

The JTSB's conclusion regarding the Avoidance of Downwash Effects is as follows:

Downwash generated by a helicopter can become highly complex and may increase rapidly, even during repeated operations, due to slight variations in rotor thrust and aircraft attitude, as well as the influence of surrounding winds and nearby ground structures. Therefore, in areas where a helicopter passes at low speed, measures must be reliably implemented to prevent objects—even heavy ones—from being blown away by the downwash. In addition, personnel involved in the operation should take cover as far as possible from directly beneath the main rotor and from the vicinity of potentially displaced objects.

(6) Response to Incident

The JTSB's conclusion regarding the Response to Incident is as follows:

The injured worker A felt pain near the knee where the formwork panel had struck but did not report the injury, as there was no visible bleeding. Additionally, nearby worker B did not report the incident involving the flipped-over panel to the site supervisor, nor was approval obtained from the supervisor for the countermeasures taken to prevent further scattering. As a result, material transport by the helicopter continued for approximately three hours and a total of 51 runs.

In construction sites, when an irregularity or incident occurs, workers must not make judgments on their own but report it to the site supervisor. The site supervisor, in turn, must promptly report the irregularity to the site manager, temporarily suspend operations, and assess whether the work environment remains safe and whether operations can continue.

4. PROBABLE CAUSES

The JTSB concludes that it is highly probable that, while the helicopter was approaching at low speed over the hopper tank for ready-mixed concrete, strong downwash was generated near a curved formwork panel, causing it to lift off and strike a nearby ground worker, resulting in injury.

5. SAFETY ACTIONS

5.1 Safety Actions Required	(1) Downwash generated by a helicopter may rapidly increase due to changes in rotor thrust and aircraft attitude, as well as the influence of surrounding wind and ground structures. Therefore, in areas where a helicopter passes at low speed, thorough measures must be implemented to prevent objects from being scattered. In addition, personnel involved in the operation must take
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*8 "Venturi effect" refers to the phenomenon in which narrowing the cross-sectional area of a fluid flow increases its velocity, resulting in a region of lower pressure compared to the slower-flowing sections.

	cover as far away as possible from directly beneath the main rotor and from the vicinity of potentially displaced objects. (2) In the event that an unsafe incident occurs during work, operations must be temporarily suspended, and if there are any injuries, appropriate measures must be taken. After that, it is necessary to assess whether the work environment is properly maintained and whether it is safe to continue operations.
5.2 Safety Actions Taken after the Accident	The operator and the consortium responsible for the construction project implemented the following recurrence prevention measures: (1) When placing steel column formwork panels within the construction site during helicopter transport operations, measures to prevent scattering—such as securing with wire ropes, iron wire, or covering with nets—must be implemented. (2) During pre-deployment training, the site manager shall instruct workers that if there are signs of flying debris or cargo collapsing during helicopter transport, they must immediately evacuate to avoid being caught. (3) During pre-deployment training, the site manager shall instruct workers that if they are injured during the work, regardless of the severity, they must immediately report it to the site supervisor.