AIRCRAFT ACCIDENT INVESTIGATION REPORT

INJURY TO A GROUND OPERATOR DURING CARGO SLING OPERATION

SHIKOKU AIR SERVICE CO., LTD.

BELL 412EP (ROTORCRAFT), JA6977

MIYAKONOJO CITY, MIYAZAKI PREFECTURE

AT ABOUT 10:52 JST, NOVEMBER 28, 2022

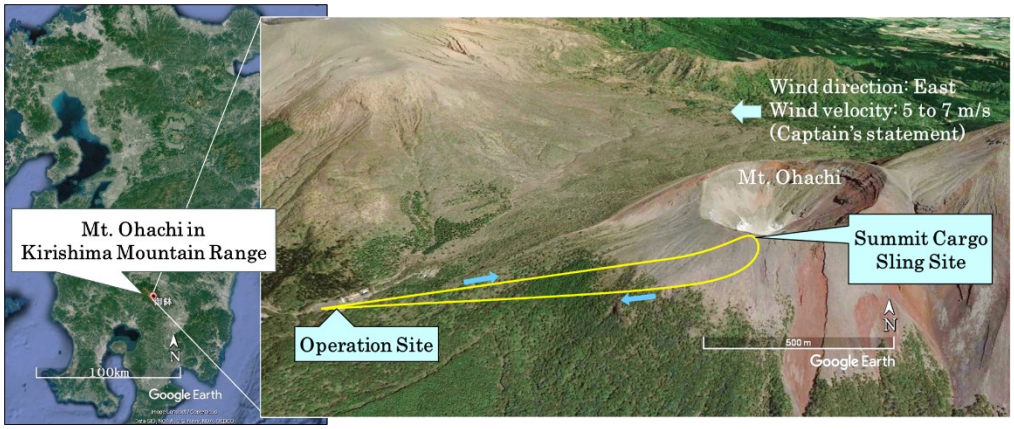
July 19, 2024
Adopted by the Japan Transport Safety Board
Chairperson TAKEDA Nobuo
Member SHIMAMURA Atsushi
Member MARUI Yuichi
Member SODA Hisako
Member NAKANISHI Miwa
Member TSUDA Hiroka

1. PROCESS AND PROGRESS OF THE AIRCRAFT ACCIDENT INVESTIGATION

1.1 Summary of the Accident	On Monday, November 28, 2022, when a Bell 412EP, JA6977 operated by Shikoku Air Service Co., Ltd., was lifting a cargo during cargo sling operation near the summit of Mt. Ohachi in the Kirishima Mountain Range, Miyakonojo City, Miyazaki Prefecture, the cargo away from the ground came close to a ground operator. Unable to avoid the approaching cargo, the ground operator grabbed it by his hands and his body was lifted along with the cargo. The ground operator left the hands from the cargo immediately after that but was injured when landing on the ground.
1.2 Outline of the Accident Investigation	On November 29, 2022, upon the reception of the accident occurrence, the Japan Transport Safety Board (JTSB) designated an investigator-in-charge and an investigator to investigate this accident. Although this accident was notified to the United States of America as the State of Design and Manufacture of the helicopter involved in this accident, the State did not designate its accredited representative. Comments on the draft Final Report were invited from the parties relevant to the cause of the accident and the Relevant State.

2. FACTUAL INFORMATION

2,1 History of the Flight	According to the statements of the captain, the onboard operator, and the ground operators as well as the records of the flight data recorder (FDR) and

	the video image taken by the person in charge of the site to record the work, the history of the flight is summarized as follows: On Monday, November 28, 2022, with the captain in the right cockpit seat and the onboard operator in the left aft seat in charge of the helicopter guidance and cargo release operation, in order to transport and unload cargo from the cargo sling site near the summit of Mt. Ohachi in Kirishima Mountain Range (hereinafter referred to as "the Summit Cargo Sling Site"), the helicopter was scheduled to transport with underslung external cargo (cargo covered by Mokko*1 (hereinafter referred to as "Mokko") (hereinafter referred to as "the Heli Cargo Transport") from the Summit Cargo Sling Site to Takachihogawara Operation Site (hereinafter referred to as "the Operation Site") five times (see Figure 1). It was the first time for the captain to fly between the sites.  Figure 1: Estimated Flight Route The helicopter took off from Takamatsu Airport for its ferry flight at 08:00 Japan Standard Time (JST: UTC + 9 hours, all times are indicated in JST on a 24-hour clock) and landed at the Operation Site at about 10:00. After landing, the helicopter took off from the Operation Site to perform the confirmation fight at about 10:03, confirming that there were no obstacles from near the eighth station through the Summit Cargo Sling Site, the position of ground operators, and along the flight route. However, as clouds began to cover around the summit, the helicopter landed at the Operation Site at about 10:08 to stand by there to wait for the weather recovery afterwards.

*1 "Mokko" refers to a tool used to wrap and suspend loads by attaching suspension straps to the four corners of the rope woven nets.

As the weather improved, the helicopter took off from the Operation Site at about 10:48 for the 1st Heli Cargo Transport, hovering over at a heading of about 70° about 20 m short (west side) of Mokko 1 among five pieces of Mokko (called Mokko 1 to 5 in order from the west). At this time, it was confirmed that there would be no problem with the five-meter length of sling to be used (see Figure 2 and Figure 3).

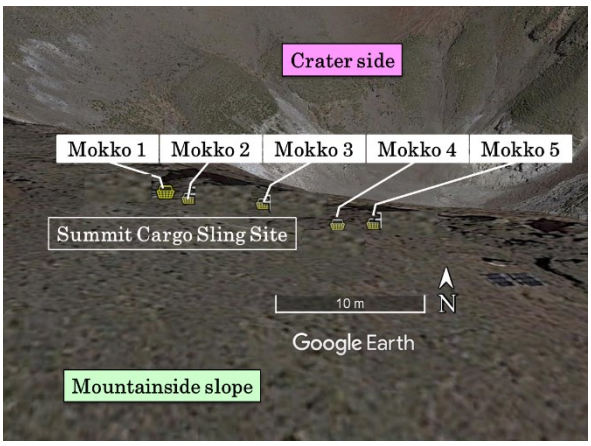


Figure 2: Mokko Location

The captain was anxious about rather unfavorable air currents but judged that with careful Heli Cargo Transport carried out, there would be no problem.

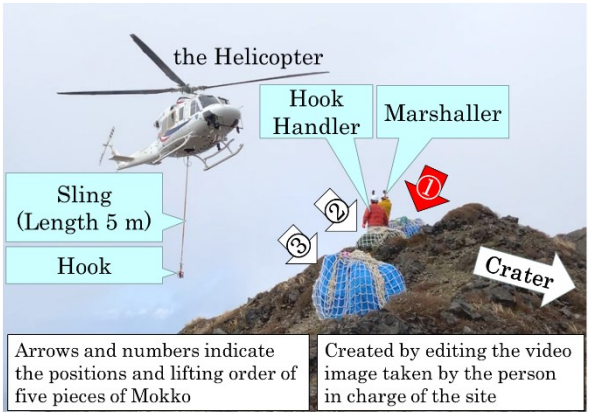


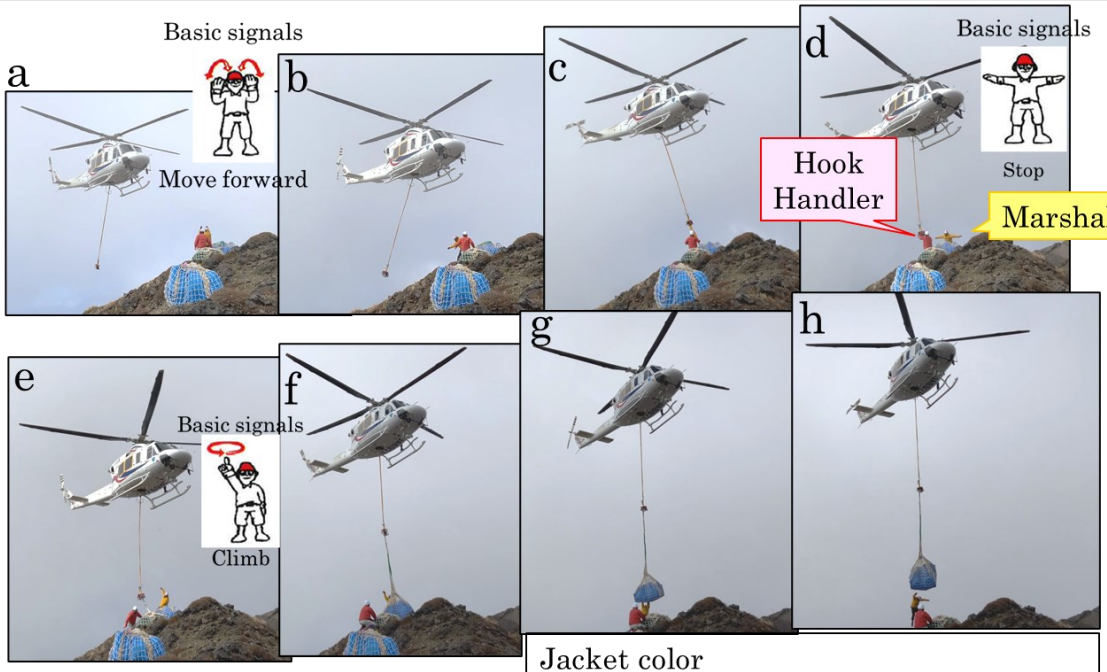
Figure 3: Marshaller and Hook Handler

At the Summit Cargo Sling Site, five ground operators including the person in charge of the site (described later in Table 1 in 2.7 (1)) were deployed, among whom are a summit marshaller (hereinafter referred to as "the Marshaller") and a handler hooking cargo (hereinafter referred to as "the Hook Handler"), two people in total were engaged in the work by entering in the area underneath the helicopter. In addition, from the helicopter, the Marshaller was located viewed on the left side of Mokko 1 (west side) and the Hook Handler on the right side (hereinafter, the descriptions indicating the directions, which are used for explaining the position and their movements of Mokko 1 and operators working around it, such as (front, back, ahead of, behind, right and left) shall be described as viewed from the helicopter unless specified otherwise.) (See Figure 3).

The captain confirmed the Marshaller's signal to "move forward" and began moving forward so that the hook was positioned directly above Mokko 1. As approaching Mokko 1, the helicopter was subject to the wind blowing up from the crater, it became difficult for the helicopter to move forward when reaching over the vicinity of Mokko 1.

From the position about 5 m short of Mokko 1, the onboard operator called saying "Distance 5 (m), 4, 3", providing guidance to the helicopter, but called saying "Forward, 2 m, 1 m" to provide guidance repeatedly after it was difficult for the helicopter to move forward at the vicinity of 2 to 3 m short of Mokko 1. In addition, as the altitude became higher as the helicopter had moved forward, the onboard operator provided guidance saying, "Go down".

According to the video recording (see Figure 4), the Marshaller was sending a “Move forward” signal to the helicopter at the left side of Mokko 1 (Figure 4, a)



a, b The helicopter was approaching
c Marshaller caught the hook
d Hook Handler hooked Mokko 1 on the hook
e Hook Handler moved away, Taking up the slack (start climbing)
f Mokko 1 was lifted
g Marshaller grabbed Mokko 1
h Marshaller left the hands

Figure 4: Still Image of Video Recording

The helicopter stopped moving forward slightly behind rather than directly above Mokko 1, however, as the hook was swinging back and forth (Figure 4, b), the Marshaller went to get the hook to its timing of swinging forth (Figure 4, c and Figure 5), and after handing the received hook to the Hook Handler, the Marshaller moved away for safety by taking three or four steps back (moved to ahead of the left side) while sending a “Stop” signal (Figure 4, d and Figure 6).

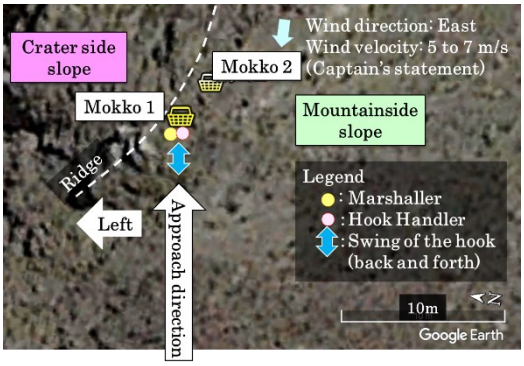


Figure 5: Positions at the time of Catching the Hook (estimated)

Turning around from the right side of Mokko 1 to its left side where the Marshaller was, the Hook Handler received the hook from the Marshaller and hooked it on Mokko 1 and moving again to the right side of Mokko 1 and further moving away for safety to the right side of Mokko 2 about 3 m away (Figure 4,

e and Figure 6). The Marshaller confirmed that Mokko 1 was hooked up and sent a “Climb” signal at the position (Figure 4, e).

The captain confirmed through the mirror installed around the lower right foot position outside of the helicopter that the Hook Handler located on the right side moved away for safety but unable to confirm for the Marshaller on the left side who was located at the blind spot of the mirror.

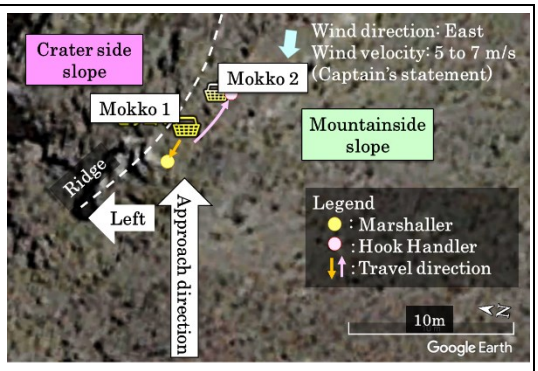


Figure 6: Positions after Moving Away (estimated)

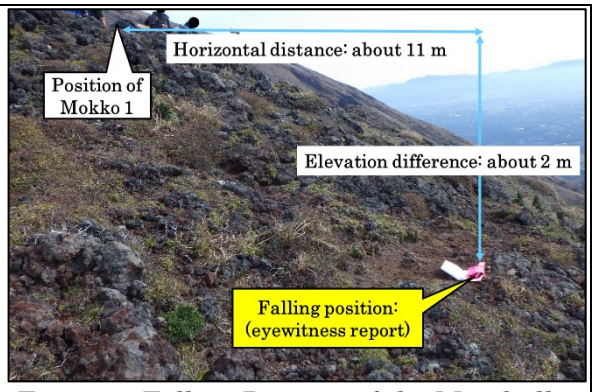
After confirming that the Hook Handler had placed the hook on Mokko 1, locked the hook and moved away for safety to the right side after , the onboard operator called out to the captain, saying “Take up the slack (to continue climbing until the slack in the cable would be eliminated with the cargo in contacting with the ground) ” as the Marshaller had sent a “Climb” signal after stepping back slightly.

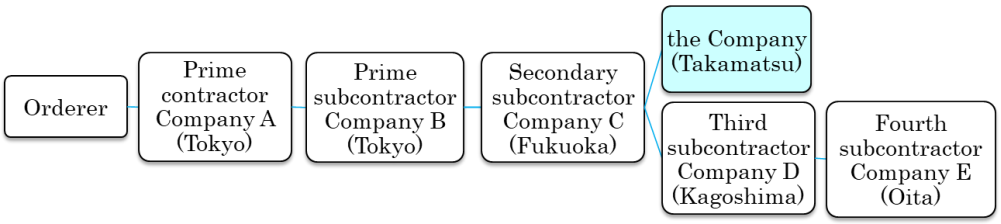
Normally, after the cargo is hooked, the captain would move the helicopter to the position immediately over the cargo and make a climb operation, however, at the time of the accident, it was difficult for the helicopter to make slight adjustments on the hovering position due to the influence of the wind from the crater direction and Mokko 1 was lifted at the position where the helicopter was hovering slightly backward from immediately above Mokko 1.

When reporting the situation to the captain, saying “Soon tension shall be applied (meaning that the sling wire cables will be taut)”, “The cargo will be lifted” (see Figure 4, f), the onboard operator confirmed that Mokko 1 came close to the Marshaller, and the Marshaller grabbed Mokko 1 by hands but immediately left the hands, and fell (Figure 4, g and h). After that, in the next time when the onboard operator saw the Marshaller, the Marshaller was lying on the mountainside slope. The captain confirmed through the mirror that the Marshaller located in the left side contacted with Mokko 1 to fall and slide down on the slope in face down.

The Mokko 1 was looming against the Marshaller when lifted away from the ground, but there was no space for the Marshaller to escape because the site was surrounded by craters, mountainside slopes and a lofty rock, therefore, the Marshaller grabbed Mokko 1 as if to hold it so as not to be collided and thrown off by Mokko 1. In addition, as being educated not to enter in the area underneath a cargo, the Marshaller did not least think of entering the area underneath a cargo such as crouching down. The Marshaller realized that its body was lifted, thus released the hands without looking down when thinking the body was lifted. The Marshaller did not remember how he fell.

According to the ground operator who witnessed the Marshaller’s falling, the falling position of the Marshaller was on the mountainside slope about 11

	m ahead of the center position of Mokko 1, the elevation was about 2 m lower than the ground surface where Mokko 1 was placed (see Figure 7). Despite feeling pain in the right leg after the fall, the Marshaller, from experience thought, thought that the injury was only a dislocation, therefore, lying down to rest until the Heli Cargo Transport was done would make it possible to descend the mountain on their own. Therefore, the Marshaller reported to the person in charge of the site that the Marshaller could tolerate with pain, and with lying down to rest for a while, the Marshaller would be able to descend the mountain as well as suggested that they should continue the Heli Cargo Transport by changing to assign the Hook Handler at the accident as a new summit marshaller (hereinafter referred to as "the New Marshaller") and a summit operator as a new hook handler (hereinafter referred to as "the New Hook Handler"). Judging that it would be possible to continue the Heli Cargo Transport based on the degree of pain from the injury which the Marshaller had reported and from the suggested change of the assignment, the person in charge of the site continued the work while attending to the Marshaller who was lying down. Confirming that the Marshaller who had fallen continued to lie down in the same place, the captain confirmed the condition of the Marshaller several times by radio and received the information from the person in charge of the site saying, "The Marshaller would be all right, so please continue the operation", thus continued the operation. The Marshaller thought that with a little rest until the 5th Heli Cargo Transport was done, it would be possible to descend the mountain on their own. However, at about 11:15, as soon as the Heli Cargo Transport was completed, as the pain in the leg increased probably due to a relief, the Marshaller became unable to stand up on their own and reported this to the person in charge of the site. The person in charge of the site reported to the local fire department and the Marshaller was rescued from the accident site by a rescue helicopter, on the way, taken over by an air ambulance, and transported to the hospital in Kagoshima City. This accident occurred at about 10:52 on November 28, 2022, near the summit of Mt. Ohachi in the Kirishima Mountain Range, Miyakonojo City, Miyazaki Prefecture (Latitude 31 ° 53 ' 01 " N, Longitude 130 ° 54 ' 33 " E).  Figure 7: Falling Position of the Marshaller
2.2 Injuries to Persons	One ground operator was seriously injured (pelvic fracture).
2.3 Damage to the	None

Aircraft	
2.4 Personnel Information	(1) Captain: Age 60 Commercial pilot certificate (Rotorcraft): March 31, 1989 Type rating for multi-engine turbine (land) Bell 212: July 21, 2006 Class 1 aviation medical certificate: Validity: August 11, 2023 Total flight time: 7,021 hours 43 minutes Total flight time on the type of aircraft: 1,454 hours 33 minutes Flight time in the last 30 days: 12 hours 38 minutes (2) Onboard operator: Age 31 Cargo transport experience: 9 years 5 months Onboard operation experience 4 years 6 months (3) Marshaller: Age 51 Number of times of experience as a marshaller in helicopter cargo transport: More than 300 times (based on statement)
2.5 Aircraft Information	Aircraft type: Bell 412EP Serial number: 36586 Date of manufacture: November 30, 2011 Airworthiness certificate: No. Dai-2022-154 Validity: June 15, 2023 Total flight time: 2,947 hours 17 minutes When the accident occurred, the weight and balance of the aircraft were within the allowable range.
2.6 Meteorological Information	(1) According to the statement of the captain, weather observations at the Summit Cargo Sling Site around the time of the accident were as follows: Weather: Cloudy, Wind direction: East, Wind velocity: 5 to 7 m/s Air currents were turbulent due to the wind blowing up from the crater. (2) In the Operations Procedures for Cargo Transport (hereinafter referred to as "the Manual") established by Shikoku Air Service Co., Ltd., (hereinafter referred to as "the Company"), the weather conditions regarding the cargo transport operation are described as follows: (excerpt) i) Wind direction and wind velocity at the operation site: In principle, wind velocity shall be 7 m/s or less. ii) Non-flight conditions: In the presence of strong turbulence
2.7 Additional Information	(1) Contractual Relationship and Division of Roles The relationship between the orderer, the prime contractor who directly undertook the project subcontractor, and the subcontractors are shown in Figure 8, and the Company had a contract with Company C for helicopter transport involving the materials handling.  Figure 8: Contractual Relationship At the time of the accident, the ground operator team at the Summit Cargo

Sling Site were composed of personnel dispatched from each company shown in Table 1, but not including employees of the Company. The division of roles of the Marshaller and the Hook Handler was discussed between them after the meeting held on the morning of the accident and decided it taking into consideration the type of helicopter and hooks to be used.

In addition, the "Preliminary Education" in Table 1 refers to the "Education in accordance with the Education Guidelines for Ground Operators" based on the Manual (details are described later in in 2.7(4) a).

Table 1: Ground Operator Team Formation at the Summit Cargo Sling Site

Assignment at the accident	Assignment after the accident	Heli cargo transport experience	Company	Preliminary education *
Person in charge of the site	No change	—	Company A	○
On-site representative	No change	—	Company C	○
The Marshaller	(Injured)	Yes	Company E	△
The Hook Handler	The New Marshaller	Yes	Company C	△
Summit Operator	The New Hook Handler	None	Company D	×

* Preliminary education: ○ (It was taken in the previous month before the accident), △ (It had been taken several years before the accident), × (It had never been taken)

(2) The Summit Cargo Sling Site

Mt. Ohachi is an active volcano, and under Article 63 of the Basic Act on Disaster Management, the area inside the crater is designated as a restricted area by Kirishima City where shall be off limit.

The Summit Cargo Sling Site is set up along the ridge of the crater within the restricted area, the ground surface is slippery with large and small volcanic gravel piled up, and rough terrain.

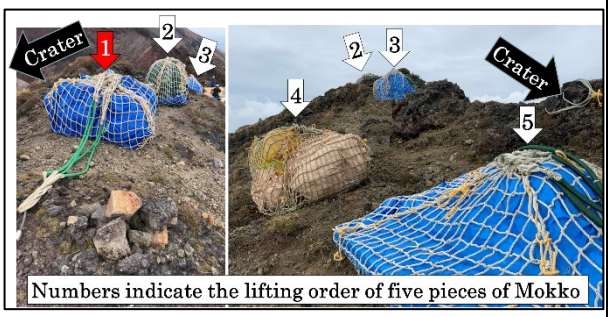


Figure 9: Summit Sling Cargo Site

Five pieces of the Mokko were placed in the range of about 23 m in the direction of east-southeast looking from Mokko 1, and Mokko 1 was placed at the highest elevation among them (see Figure 9).

(3) Mokko 1 and the Surrounding Area

According to the materials created by the Company for the Heli Cargo Transport, the removed equipment was packed in Mokko 1, weighing about 310 kg.

The Mokko 1 had been placed selecting relatively plane place of the summit ridge. Around Mokko 1, there was a slope on the crater side from the left to behind and a slope on the mountainside from the right to ahead of it (see Figure 10). In addition, about 70 cmahead of Mokko 1, there was a rock with about a height of 60 cm ("a lofty rock" according to the statement of the Marshaller) (Figure 11 a).

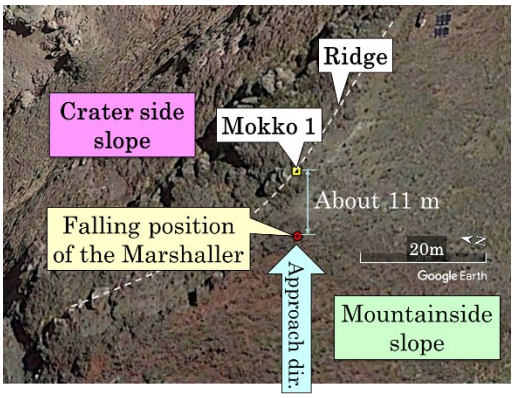


Figure 10: Topography around Mokko 1

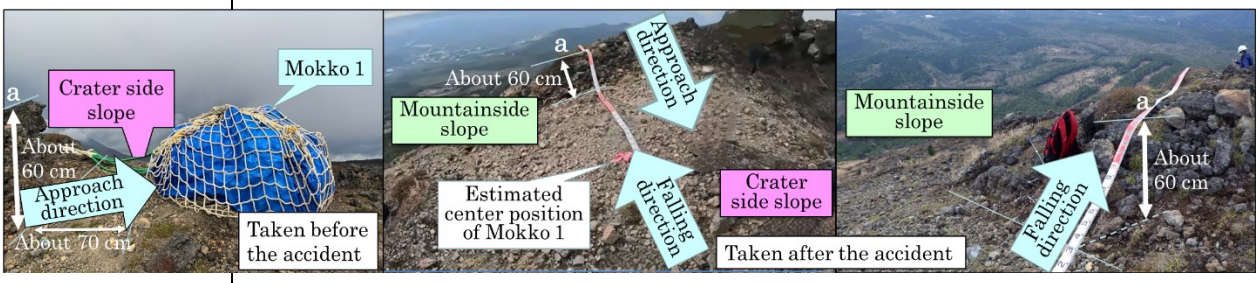


Figure 11: Mokko 1 and its Surrounding Area

The Marshaller felt that the area around Mokko 1 was narrow and had no room topographically in comparison to the site of other many Heli Cargo Transport the Marshaller had ever experienced.

(4) About the Manual

The Manual is stipulated for the purpose of eradicating work-related accidents in the cargo transport operation conducted by the Company.

i) Preliminary Education

In the Manual, it is specified that among cargo transportation workers, those engaged in the ground operation (the persons responsible for the work, ground operators, and work contractors and others) shall receive preliminary education specified separately (Education in accordance with the Education Guidelines for Ground Operators). In addition, it is stated that among cargo transportation workers, those engaged in the ground operation shall receive the periodic education and training once a year to maintain their skills.

The material for preliminary education includes safety precautions as follows:

・Always act in securing refuge area while working

・Secure your footing (check your refuge area)

Company A requested the preliminary education for the Heli Cargo Transport to the Company, and the Company informed to Company C, the contract source, that the Company would provide the preliminary education and asked them to arrange for all engaged in the on-site work to take the course.

On October 13, 2022, the Company conducted the preliminary

education in a hybrid format of in-person and online classes at the Company D's office, where 11 people from four companies engaged in the Heli Cargo Transport took the course. However, as Company E decided to gain a contract on part of the Heli Cargo Transport after the preliminary education, the Marshaller, employee of Company E had not taken the preliminary education course. And neither did the Hook Handler (Company C) and the New Hook Handler (Company D take the preliminary education course on October 13, 2022. The Marshaller had taken the preliminary education course about 6 years ago, the Hook Handler about 10 years ago, but never taken it afterwards. The New Hook Handler had never taken the preliminary education course.

ii) Grasp of the Names of Assigned Personnel

In the Manual, it is specified that the Company and work contractors shall make a careful plan in accordance with the flow chart of cargo transport operation, and the Cargo Transport operation plan stipulates the contents and other to be described such as the names of assigned personnel for each role.

However, the format of the Cargo Transport operation plan for the Heli Cargo Transport cannot contain all the required contents, accordingly, some part of the required contents, such as the names of assigned personnel for each role, were unable to be written down. Therefore, with this plan, it was unable to check the participation status of the preliminary education lecture.

iii) TBM-KY*2

In the Manual, it is described that the work contents shall be thoroughly informed to all persons engaged in the work on the day in order to accomplish the cargo transport operation in a safe and smooth manner, and unsafe elements deriving from the work contents and work environment shall be extracted and the TBM-KY shall be conducted to prevent an accident in advance. Besides, It is stipulated that TBM-KY shall be conducted in each working group, in which however it was not required to confirm each result one another among working groups. Furthermore, on the day of the accident, TBM-KY was conducted by the working group at the Operation Site and that at the Summit Cargo Sling Site separately.

a Confirmation of the participation status of the preliminary education course

According to the records of the TBM-KY at the Operation Site on the day of the accident, in the item to check the participation status of the preliminary education course, put was a "○" indicating that it was confirmed that the preliminary education course had been taken. However, this confirmation was made only for the workers at the

*2 "TBM-KY" refers to the activities for all members of the team to confirm in advance the information regarding the hazardous risk entailed in the work, following the meeting held at the site before the work starts. So called because the meeting (M) is held near the toolbox (TB) and confirmed by KikenYochi (KY) means hazard prediction in Japanese.

Operation Site, and the participation status about the workers at the Summit Cargo Sling Site was not confirmed.

The records of TBM-KY at the Summit Cargo Sling Site were unable to be confirmed, however, according to the statements of its ground operators, in the TBM-KY at the Summit Cargo Sling Site, following the explanation about the precautions from the meeting leader (Company B), the supervisor in charge of the Summit Cargo Sling Site (Company A) and the on-site representative (Company C) talked about the work to them. In addition, according to the supervisor in charge of the site, they did not have the course participant list, so they considered that regarding the participant status of the preliminary education course, the Company who had the participant list had confirmed with Company C about it.

b Confirmation of the image of the site

According to the Manual, it is stipulated that before the TBM-KY, the images of the Operation site shall be taken from the helicopter using a digital camera, tablet, and others (hereinafter referred to as "Digital Camera and Others"), all persons concerned shall see the taken images to share the same perception and then start the Heli Cargo Transport. However, in fact, the ground operators at the Summit Cargo Sling Site started to move toward the Summit Cargo Sling Site before the helicopter was ferried to the Operation Site, besides due to the communication environment at the summit, it was difficult to share the taken images during the work proceeding, therefore, they did not share and see them.

In addition, it is stipulated that Digital Camera and Others shall be brought by the onboard operator to the site, and the images of the entire operation site and each sling cargo site shall be taken with Digital Camera and Others after the helicopter's ferry flight from an airport to the Heli Cargo Transport site. However, According to the records of the TBM-KY at the Operation Site on the day of the accident, in the confirmation column about the item of "Did you take images of the cargo sling site with a digital camera?", it was described that "Impossible to approach there due to the fog". According to the captain, at the time of the confirmation flight on the day of the accident, as clouds began to cover around the summit, they confirmed there was no obstacles from near the 8th station through the cargo sling site, the position of ground operators, and along the flight route, but did neither take images, nor perform hovering over the cargo sling site.

iv) Duties and Others of Helicopter Crew

The Manual contains the following description:(excerpt)

The cargo transport operation is a comprehensive operation by the captain, onboard operator, ground operators and others, by mobilizing their cooperation, it is necessary to ensure its safety and reliability. Accordingly, it is required to make a careful preparation, plan, and

meeting in advance.

The cargo transport operation entails many risks possible to threat the safety over the wide range. Thus, a moment of laxness may lead to a serious accident. It is necessary for the onboard operators engaged in those operations to always train and improve themselves so as to report reliable information to the captain in order to conduct the operation in a safe and reliable manner.

(5) Changes in Pitch Angle at the Time of Hovering

Based on the records on the FDR, regarding the change in pitch angle at the time of hovering which affects the slung hook and the back-and-forth swing of the Mokko, Figure 12 shows for nine seconds before the hook was slung at the Summit Cargo Sling Site and for about nine seconds before the cargo was unloaded at the Operation Site, respectively, from the first through fifth times separately.

As a general trend, up and down changes in pitch angle at the time of hovering were remarkable at the Summit Cargo Sling Site where the range of change was 8° at the maximum (the 1st: +3°to +11°) and rather large, on the other hand, at the Operation Site, up and down changes in pitch angle were gentle and the range of change was 4° at the maximum (the 1st: +4°to +8°) and rather small.

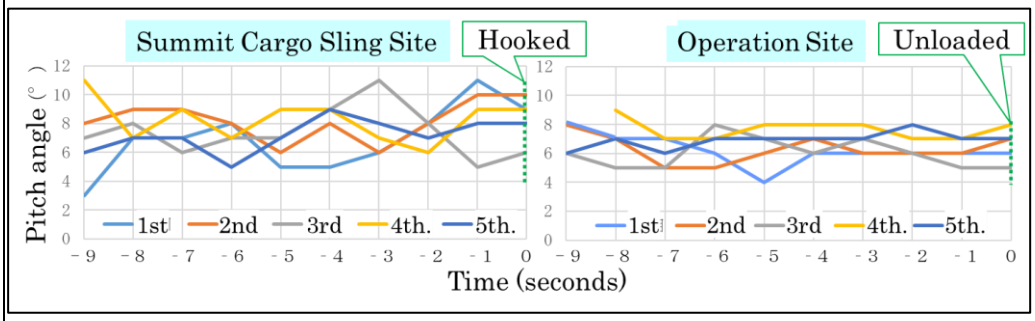


Figure 12: FDR Records
(Comparison of Changes in Pitch Angle at the Time of Hovering)

3. ANALYSIS

(1) Injury to the Marshaller

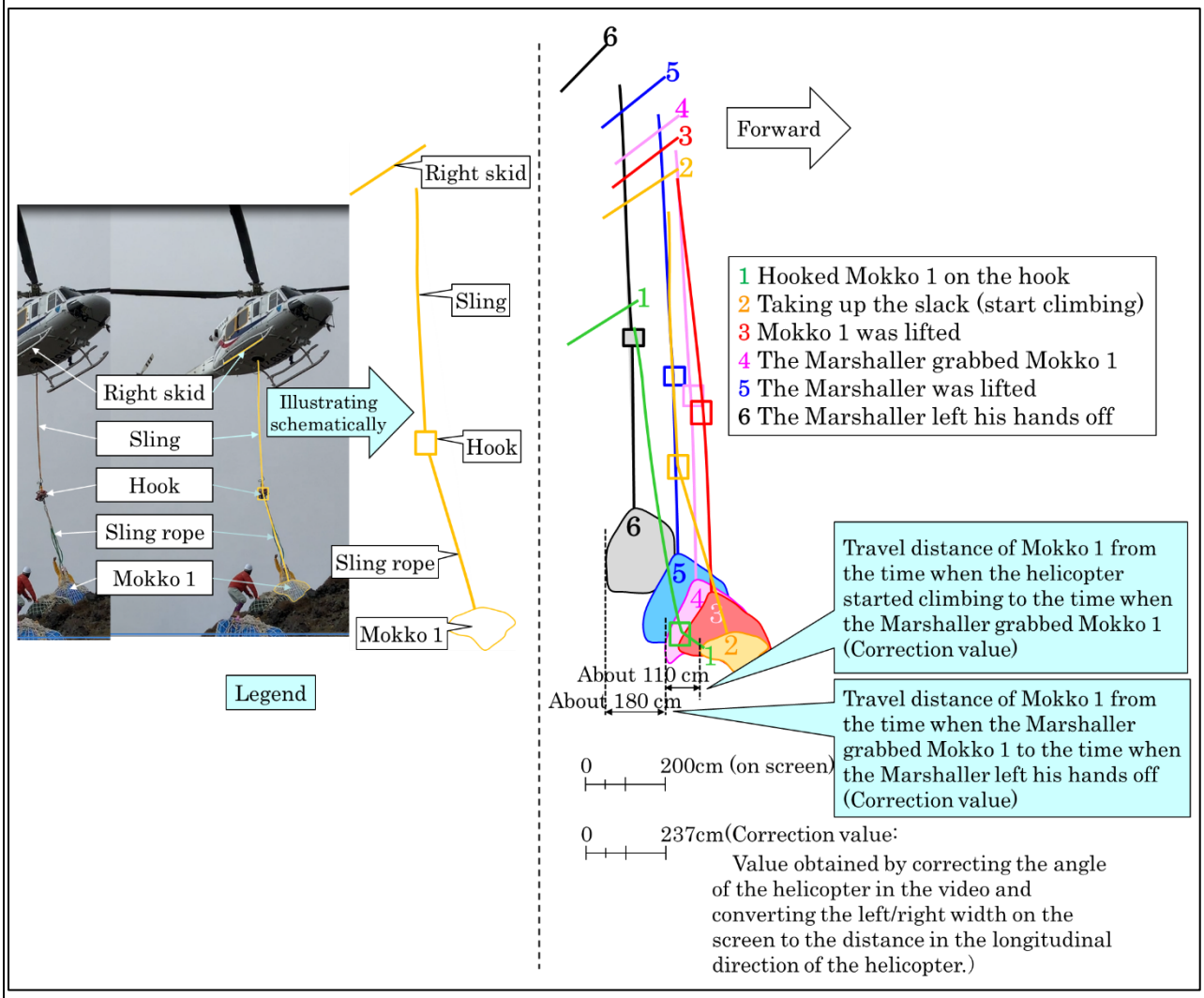
The JTSB concludes that according to the statement of the witness and the records of the video image, it is highly probable that the Marshaller grabbed Mokko 1 lifted by the helicopter, but left the hands from Mokko 1 immediately after being lifted along with Mokko 1 and fell, resulting in sustaining injuries in landing on the ground.

(2) Video Analysis

The JTSB concludes as follows:

Figure 13 illustrates schematically the position relation between the helicopter and Mokko1 by extracting still images from the recorded video to indicate the travel distance when Mokko 1 was lifted. As shown in the legend on the left, the positions of the helicopter's right skid, sling, hook, sling rope, and Mokko 1 extracted from one frame of the video was put into the form of a diagram, which is color-coded from the time when "1 Mokko 1 is hooked up" to the time when, "6 the Marshaller left the hands from Mokko 1", as shown on the right side, and aligned based on a

common terrain with no change on the screen to be overlaid in layers. In addition, from the heading recorded on the FDR and the shooting direction, the angle of intersection was calculated and the right and left width on the screen was converted to the longitudinal distance of the helicopter, which



was analyzed as correction values.

Figure 13: Travel Distance of Mokko 1

When the Hook Handler hooked Mokko 1 on the hook, the helicopter was most likely in the position shown in Figure 13, 1, back to Mokko 1. After that, although the helicopter Moved forward while climbing to Figure 13, 2 from to Figure 13, 1. in order to eliminate the slack, it was highly probable still back to Mokko 1. It is most likely that the helicopter continued to climb, thus Mokko 1 was away from the ground being swung backward at the same time, coming close to the Marshaller (Figure 13, 3).

Unable to avoid the approaching Mokko 1, the Marshaller more likely grabbed Mokko 1 reflexively, and at this time, the position of Mokko 1 was likely about 110 cm backward the position where Mokko 1 had been originally placed (Figure 13, 4).

After that, the Marshaller was lifted along with Mokko 1 (Figure 13, 5), and left the hands from Mokko 1 immediately after that, but Mokko 1 had been probably moved further about 180 cm backward while being lifted (Figure 13, 6). In addition, Mokko 1 was lifted while being swung backward, and the helicopter climbed while moving backward, which possibly caused the Marshaller to fall as if being thrown away further backward from the position when the Marshaller had left the hands. The height to which the helicopter climbed from the time when the Marshaller

grabbed Mokko 1 to the time when the Marshaller left the hands from it, was likely about 1 m because of analysis from the length of sling (about 5 m) and the change in the position of Marshaller's hands (Figure 14). From this, the heigh the Marshaller had fallen was possibly about 3 m, calculated by adding the difference in altitude of about 2 m to the helicopter's climb of about 1 m, therefore, when landing on the ground, the Marshaller most likely had a strong impact, resulting in sustaining injuries.

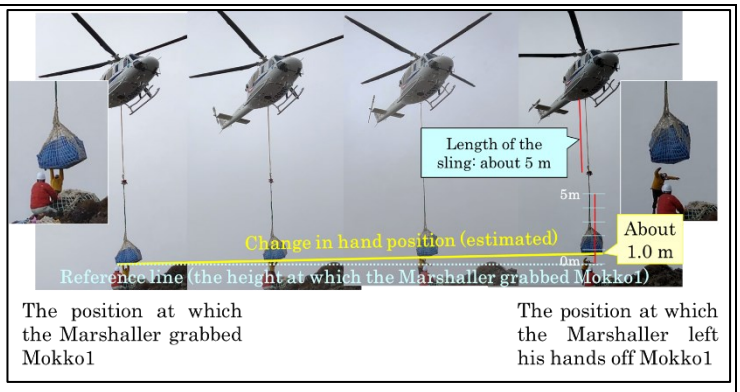


Figure 14: The Height from which the Marshaller Fell

(3) Refuge Area for the Marshaller

The left of Figure 15 shows the situation around Mokko 1 before the accident, and when additionally drawn were a rock with about 60 cm height located about 70 cm to the left front of Mokko 1 in yellow, crater side slope in left back in pink and mountainside slope right front in green, it is as shown in the center of Figure 15. Besides, when additionally put the travel direction (opposite to the approach direction), in which Mokko 1 probably moved after being lifted at the accident, in red, it is as shown in the right of Figure 15, showing that the Marshaller was probably unable to secure enough space for refuge in the area on the left side of Mokko 1 where the Marshaller was sending signals. Furthermore, according to the video recording, the Marshaller had only taken three or four steps back before sending a climb signal to the helicopter, thus, the Marshaller was more likely unable to take necessary refuge action when Mokko was lifted.

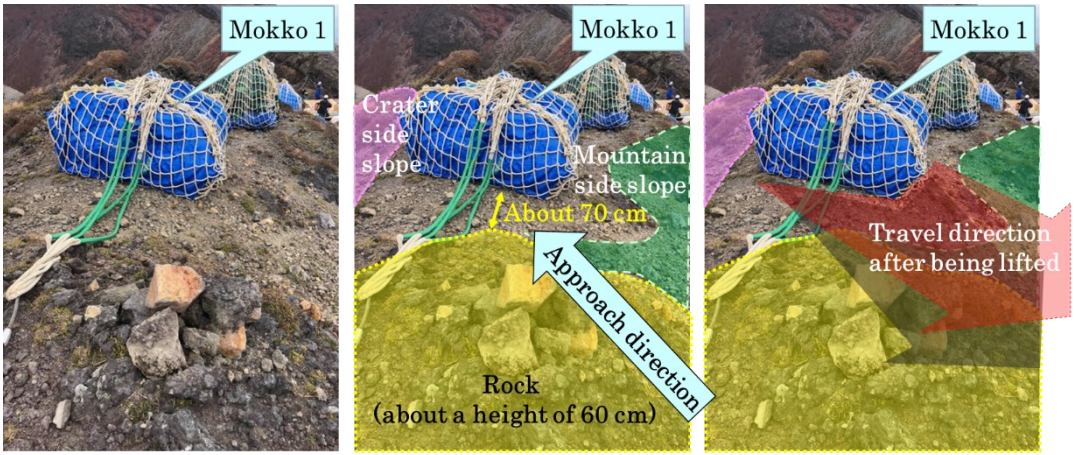


Figure 15: The Position of Refuge near Mokko 1

Before the helicopter started climbing for eliminating the slack, the Marshaller should have moved away for safety with the Hook Handler to the vicinity of the second Mokko located on the right side, however, the Marshaller probably stayed on the left side of the helicopter because of necessity to send signals to the onboard operator seated on the left side on the helicopter.

(4) TBM-KY

The JTSB concludes that the reason that the Marshaller forced to remain in the position constrained topographically was possibly because all persons concerned did not properly perform hazard prediction for the sling operation such as confirming refuge area around Mokko 1.

The helicopter's approach direction during sling operation is decided according to the wind

direction on the day, therefore, in the TBM-KY conducted on the day of work, it is important that the helicopter flight crew and ground operators should consider together the position and traffic line for the ground operators to move away for safety and the position to send signals by taking consideration into the approaching and leaving direction of the helicopter and topography, and reflect them in the sling operation. Therefore, when the weather improved, the Company should have conducted the TBM-KY after grasping the terrain features by confirmation flight or photographing the operation site by a digital camera and others again. At this time, even it is difficult to share the taken images with the ground operators at the cargo sling site, when the work environment is different from the usual one, it is desirable for the ground operators at the Operation Site and the cargo sling site to work together to confirm by sharing the information on the terrain and planned refuge position confirmed visually by the ground operators at the cargo sling site.

(5) Status of Preliminary Education

The JTSB concludes that the Company did not know which employees should take the preliminary education course among those engaged in the Heli Cargo Transport. Therefore, it is certain that those who had not taken necessary preliminary education course were engaged in the Heli Cargo Transport as ground operators at the summit. At the time of the accident, although there were several ground operators at the summit who had not properly completed the preliminary education, only the workers at the operation site were subject to confirmation of the status of their preliminary education on the day of the Heli Cargo Transport, which was more likely inadequate management. These factors possibly contributed to the declining consciousness of the importance of taking refuge action (when transporting cargo by helicopter, the selection of a refuge area and the flow line to the refuge area should be confirmed in advance to allow for unexpected movement of the externally slung cargo, etc.) included in the preliminary education contents.

Based on the Manual, among those engaged in the Heli Cargo Transport, the Company should have provided the preliminary education to those who had never taken it and those who had not taken the periodic education and training to maintain their skills within a year. At this time, the Company needs to devise ways to allow all those engaged in the work to take the course when coordinating with the work contractor regarding the preliminary education by considering the fact that it is often the case that for the work contractors in charge of many operation sites, the shifts of individual workers are not decided until the last minute.

(6) Weather Conditions

The JTSB concludes that from the statement of the captain, video recording and the change in pitch angle recorded on the FDR, it is most likely that at the Summit Cargo Sling Site, the helicopter was subject to the wind blowing up from the crater (disturbance), thus its hovering attitude and position were not stable. And this probably created the deviation between the positions of Mokko 1 and the helicopter, which probably contributed to Mokko 1 coming closed to the Marshaller side when Mokko 1 was lifted away from the ground.

It is probable that the helicopter should have determined whether to continue the flight or not from the viewpoint of the safe operation when hovering over the cargo sling site by considering that in the cases where if it was difficult to lift the cargo vertically, there was a significant change in attitude, and the hook was swinging around largely, they should fall under the category of “In the presence of strong turbulence” indicated in the non-flight weather conditions in the Manual.

(7) Cargo Sling Operation

The JTSB concludes that at the time of the accident, the captain was unable to confirm through the mirror that the Marshaller took evasive action for safety, therefore, the captain should

have confirmed with the onboard operator about the evasive action status before lifting Mokko 1. And when reporting the signals from the Marshaller, to the captain, the onboard operator needs not to report to the captain the signals as they are confirmed, but to confirm the safety around the ground operators and the helicopter's stable hovering immediately over the cargo, and sometime consider waiting for the report about eliminating slack (start climbing) depending on circumstances such that the ground operator's evasive action is deemed insufficient or the cargo may swing largely when being lifted from the ground.

(8) Peculiarities of the Site where Different Companies from Different Industries Work Together

The JTSB concludes that this accident occurred in the site where different companies from different industries (Work Contractors and Air Transport Services Operator) worked together, and even in the same work team, there were more likely differences in work contents, experiences, and safety awareness of each worker. In addition, this suggests that there is likely a common characteristic of similar accidents that have occurred recently.

On the other hand, considering these background and peculiarity, operation planning, each education course, meetings, and TBM-KY and others are likely specified in the Manual from a viewpoint of the necessity of closely coordinated work based on mutual understanding among each company and person to prevent accidents at operation sites.

The company needs to ensure that the items described in the manual are implemented for companies in different industries with which it does not have a contractual relationship.

In addition, it is desirable that the Company should assign personnel with expertise in aircraft operations, identify hazards and evaluate risks from an objective perspective, without being immersed in the work in case of expecting the work environment different from the usual one such as the Summit Cargo Sling Site.

4. PROBABLE CAUSES

The JTSB concludes that the probable cause of this accident was that a cargo (Mokko) lifted by the helicopter swung backward when being away from the ground and came closed to the Marshaller, then the Marshaller unable to avoid the Mokko grabbed it by his hands, but left the hands from the Mokko immediately after being lifted along with the Mokko, and fell, most likely resulting in sustaining injuries in landing on the ground.

The Mokko swung backward was probably because the helicopter was subject to the wind blowing up from the crater (disturbance), thus its hovering attitude and position were not stable and the deviation between the positions of the Mokko and the helicopter was created, but despite of this situation, the helicopter started the sling cargo operation, which probably contributed to it.

Besides, the Marshaller had fallen into the situation where the Marshaller was unable to avoid the approaching Mokko was likely because while the Marshaller was unable to secure enough safe space to move away in the surrounding area, the Mokko was lifted, furthermore likely because they did not properly perform hazard prediction and preliminary education for the work environment peculiar for the cargo sling operation by helicopter such as confirmation of the helicopter movement at the summit and the refuge area to move away around the Mokko.

5. SAFETY ACTIONS

5.1 Safety Actions Required	(1) As described in "ANALYSIS", from a viewpoint of preventing accidents attributed to the peculiarities of the cargo transport by helicopter in which different companies from different industries work together, the Company

	needs to ensure to perform the items specified in the Manual, such as hazard prediction including confirmation of refuge area to move away, and preliminary education for the workers. (2) As described in "ANALYSIS", it is desirable that the Company should assign personnel with expertise in aircraft operations, identify hazards and evaluate risks from an objective perspective, without being immersed in the work in case of expecting the work environment different from the usual one such as the Summit Cargo Sling Site.
5.2 Safety Actions Taken after the Accident	Safety Actions Taken by the Company (1) The followings were thoroughly informed to pilots, onboard operators, and ground operators engaged in the cargo transport by helicopter. i) Confirm whether refuge area is selected in the sling site at the time of the TBM-KY. ii) Confirm conditions of air currents, way of swing condition of the helicopter and the hook by observing from the helicopter and the ground to decide whether to conduct the cargo sling operation by hovering over the cargo sling site before the work begins. In addition, even after the operation starts, when turbulence is observed, the helicopter shall leave the cargo sling site once to determine whether to continue or suspend the operation. (2) The followings were taken regarding the preliminary education for outside workers. i) In the preliminary education materials, this accident case was showcased, and it was described additionally to secure refuge area, and send a climb signal after the ground operator has moved away for safety, as especially important safety cautions. ii) Ensured that additional education is provided to the ground workers who had been unable to receive it directly among those required to receive the preliminary education the Company provides. iii) Thorough confirmation on the day of work a The persons responsible for the work in the Company shall confirm the attendance status of preliminary education of all those engaged in the work, or the attendance status of the additional preliminary education provided to those who had been unable to receive it, and provide temporarily the preliminary education on the spot, if there are any workers who have not receive the necessary preliminary education. b At the time of the TBM-KY, the leaflets describing especially important safety cautions shall be distributed to inform again to all those engaged in the work. (3) Other Actions The company's employees are assigned as needed when operators are unfamiliar with the cargo sling site or when the work environment is different from their usual work environment.