LESSONS AND CHALLENGES IN AIRPORT OPERATION DURING A DISASTER: CASE STUDIES ON IWATE HANAMAKI AIRPORT, YAMAGATA AIRPORT, AND FUKUSHIMA AIRPORT DURING THE GREAT EAST JAPAN EARTHQUAKE

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During the initial stage of a disaster, aircraft operate intensively and simultaneously use several airports as bases, given their mandate to promptly perform their duties. Previously, disaster management faced challenges such as insufficient airport apron space, shortage of aircraft fuel, and inadequate information sharing among various involved organizations. During the Great East Japan Earthquake, aircraft—primarily civilian and government helicopters—used the Iwate Hanamaki Airport, Yamagata Airport, and Fukushima Airport as bases immediately after the disaster struck. These aircraft performed tasks such as information gathering, emergency rescue, and personnel and goods transport. For this study, we interviewed personnel in the organizations involved in operating these aircraft and airports during the disaster. Further, we considered the operational realities of disaster response activities at each airport to identify the lessons learned and challenges met. We present our findings and detail the role of an airport as a disaster management facility and the challenges faced by an airport during a disaster.

Key Words : The Great East Japan Earthquake, airport, helicopter, lessons learned

1. INTRODUCTION

After the Great East Japan Earthquake, airports began to immediately play an important role in various activities such as conducting helicopter rescue operations and using commercial aircraft to provide back-up transport to land transport. Since the land transport network is expected to be severed imme-
diately after a disaster, such as an earthquake, a tsunami, or a flood, when the damage extends over a wide range of area, airports play a significant role because they are relatively disaster-resilient. The broad range of aircraft missions during a large disaster includes: information gathering regarding the state of the damage, search, rescuing the injured, emergency medical transport, firefighting, personnel transport, goods transport, and so on. Many of these missions are carried out by helicopters, whereas fixed-wing aircraft are primarily utilized to transport personnel and goods over a long distance. The entities that operate aircraft include the police; the fire department; disaster management agencies; operators of medical helicopters; the Japan Self-Defense Forces (JSDF); the Japan Coast Guard; and the Ministry of Land, Infrastructure and Transport in Japan. To safely and efficiently operate these aircraft, which fly in from all over the country, air stations that serve as bases are set up at airports. During the initial stage of a disaster, aircraft operate intensively and simultaneously use several airports as bases as they must promptly perform their duties. Previously, challenges existed, such as insufficient airport apron space, shortage of aircraft fuel, and inadequate information sharing among various involved organizations.

This study aims to: 1) identify the lessons and challenges that resulted from the operational realities of disaster response activities under the missions at the airports during the Great East Japan Earthquake, and 2) to clarify the role of the airport as a disaster management infrastructure. The Iwate Hanamaki Airport (Hanamaki Airport hereafter), Yamagata Airport, and Fukushima Airport were selected as case study airports. Interview surveys were conducted among personnel of the organizations involved in operating those airports and aircraft during the Great East Japan Earthquake, including each office branch of the Japan Civil Aviation Bureau (JCAB) and various aircraft operators.

The locations of these three airports, Sendai Airport, Ibaraki Airport and Honda Airport are shown in Fig. 1. The Sendai Airport located in the Miyagi Prefecture was seriously damaged by a huge tsunami and could not be used for one month after the Great East Japan Earthquake. The ceiling of the terminal building of Ibaraki Airport had fallen on the floor. The privately owned Honda Airport located in the Saitama Prefecture was used as a forward base. A 100-kilometer-long flight takes about 30 minutes by a helicopter.

2. DISASTER RESPONSE ACTIVITIES IN AIRPORT OPERATIONS

(1) Overview of the interview survey

We interviewed many organizations involved with Hanamaki Airport, Yamagata Airport, and Fukushima Airport as listed in Table 1, regarding the realities of disaster response activities in airport operations after the Great East Japan Earthquake on March 11, 2011. Using the interview results, this section summarizes for each airport: 1) the damage sustained by the airport, 2) the airport operations after the disaster, and 3) the realities of disaster response activities. In addition, notable activities at each airport are described.

(2) Hanamaki airport

a) Damage

The intensity of the Great East Japan Earthquake as measured on the Japanese seven-level seismic scale was “level 6 or lower” in Hanamaki City. Except for the collapsed parts of the maintenance road surface, basic airport facilities such as runways, apron, and aviation lights sustained no damage. Therefore, after confirming that no damage would disrupt operations, airport operations were resumed. Meanwhile, some cracks appeared on the walls and floors in the passenger terminal building. Some parts of the equipment mounted on the ceiling also fell and two of the three transformers were completely damaged. Considering this damage, the terminal building was kept closed until the morning of March 16 for restoration works and safety checks. Essential utilities such as electricity was restored at 9:00 AM on the 13th; water and sewerage, telephone, and gas were restored on the 14th, 15th, and 17th, respec-
Table 1 List of interviewed organizations.

<table>
<thead>
<tr>
<th>Airports</th>
<th>Hanamaki Airport</th>
<th>Yamagata Airport</th>
<th>Fukushima Airport</th>
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<td>Date of Interview</td>
<td>February 27, 2012</td>
<td>July 25, 2012</td>
<td>December 7-8, 2011</td>
</tr>
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</table>

- Iwate Prefecture Hanamaki Airport Office
- JCAB Hanamaki Airport Branch
- Hanamaki Airport of Japan Airlines Co., Ltd.
- Iwate Prefecture Disaster Prevention Aviation Corps
- Iwate Prefectural Police Aviation Unit
- Yamagata Prefecture Transporrtatio Policy Division
- Yamagata Prefecture Air and Sea Ports Division
- Yamagata Prefecture Airport Office
- JCAB Yamagata Airport Branch
- Yamagata Airport Building Co., Ltd.
- Yamagata Prefecture Air Rescue Team
- J-Air Co., Ltd.
- Yamashin Travel Service Co., Ltd.
- Fukushima Prefecture Airport Facilities Management Unit
- Fukushima Prefecture Airport Division
- Fukushima Prefecture Airport Office
- JCAB Fukushima Airport Branch
- Fukushima Airport Building Co., Ltd.
- Fukushima Prefecture Fire and Disaster Prevention Aviation Center
- Fukushima Prefecture Police Aviation Unit
- Fukushima Medical University

Fig. 2 Facility allocation map of Hanamaki airport.

Table 2 List of interviewed organizations.

- Iwate Prefecture Hanamaki Airport Office
- JCAB Hanamaki Airport Branch
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- Yamagata Airport Building Co., Ltd.
- Yamagata Prefecture Air Rescue Team
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- Fukushima Airport Building Co., Ltd.
- Fukushima Prefecture Fire and Disaster Prevention Aviation Center
- Fukushima Prefecture Police Aviation Unit
- Fukushima Medical University

Efficiently park disaster response aircraft and passenger aircraft after the disaster, four parties—the JCAB Airport Branch, the Hanamaki Airport of Japan Airlines (JAL), the JSDF, and the Prefectural Hanamaki Airport Office—coordinated with one another. Four spots on the new apron on the east side were assigned to JAL and the JSDF, and 19 spots in the old apron on the west side primarily to public agencies’ disaster response helicopters. Because aircraft parking space was still insufficient, the dead space on the west apron and the parallel taxiway that were not in service were used as temporary tarmacs for JSDF helicopters.

In addition, the JSDF utilized the garage for snow removal vehicles on the east side as its command center as well as a relief supply storage, whereas the Disaster Medical Assistance Team (DMAT) utilized the fire truck garage on the west side as its staging care unit (SCU). The disaster response headquarters of the Prefectural Hanamaki Airport Office used the electric power substation on the east side given the power outage issues they faced.

c) Experience from the 2008 Iwate–Miyagi Nairiku Earthquake

An earthquake of 7.2 magnitude struck the inland area of Iwate Prefecture on June 14, 2008 (the Iwate–Miyagi Nairiku Earthquake), and the Iwate Disaster Prevention Aviation Corps, the Iwate Prefectural Police Aviation Unit, the Japan Coast Guard, and the JSDF performed rescue operations using helicopters. As issues related to receiving support from other prefectures and ensuring mutual cooperation among aircraft of various relevant entities became clear during this event, the Iwate Prefectural Government subsequently implemented countermeasures. The formulation of the “Activity Plan of Iwate Prefecture Helicopter Operation Coordination Team” in January 2010 is a particularly important example of such countermeasures. It is a discussion forum (Coordination Meeting for Helicopter Operation) set up within the prefectural disaster response headquarters where representatives of disaster response aircraft

Effectively.

b) Airport operation after the disaster

Although the ordinance specifies that airport operating hours are from 8:00 AM to 7:30 PM, the airport operated virtually 24 hours a day from the day of the disaster. Afterward, the airport operated from 7:00 AM to 8:30 PM between April 1 and 20, from 8:00 AM to 8:30 PM between April 21 and May 31, and resumed normal operating hours from June 1. Restrictions were imposed on airport usage: media-related aircraft were banned until March 31 to give priority to disaster response aircraft.

In April 2009, the Hanamaki Airport began operating a new terminal on the east side (Fig. 2). However, although construction of the parallel taxiway was completed before the disaster, it was not in service as of the day of the disaster (it was put in service in July 2011). The Iwate Prefecture Hanamaki Airport Office, the JCAB Hanamaki Airport Branch, the Iwate Disaster Prevention Aviation Corps, and the Iwate Prefectural Police Aviation Unit were still located in the old terminal area on the west side. To
operators, such as the Disaster Prevention Aviation Corps, the Prefectural Police Aviation Unit, and the JSDF, gathered to coordinate operations methods.

The Iwate Prefectural Government also formulated the “Plan of Iwate Prefecture for Ensuring Safe Operation of Aircraft such as Helicopter” in January 2011, just before the Great East Japan Earthquake. It stipulated the relevant entities that could use the 122.6-MHz frequency designated for communication between aircraft to ensure cooperation among them. Furthermore, as part of the emergency drill that the Prefecture holds every year in September, an SCU setup drill was conducted at the Hanamaki Airport in September 2010. The JSDF also participated in this drill. These experiences allowed relevant parties to build face-to-face relationships among themselves.

d) The realities of disaster response activities

The director of the Iwate Prefecture Hanamaki Airport Office made decisions pertaining to the operation of basic airport facilities by considering factors such as local arrangements made by the parties, including the JCAB Airport Branch, the Hanamaki Airport of JAL, and the JSDF, arrangements made by the Coordination Meeting for Helicopter Operation, and requests from the central JCAB.

The Disaster Prevention Aviation Corps, the Prefectural Hanamaki Airport Office, and JCAB Airport Branch were set up in the Intelligence Office within the Hanamaki Airport Office Building to jointly instruct and assign spots primarily for the helicopters of disaster prevention and police, and to prioritize aircraft refueling. These arrangements were made spontaneously based on the existing structural background. The Prefectural Hanamaki Airport Office had the authority to assign spots, the JCAB Airport Branch had the authority to conduct wireless communication to aircraft, and the Disaster Prevention Aviation Corps and the Prefectural Police Aviation Unit had the authority to operate the aircraft. The maximum wait time for fueling was approximately 15 minutes because fueling arrangements were made to establish a refueling system.

Speaking of refueling, the previous fueling system only included one fueling company that serviced small helicopters. However, after experiencing a fuel shortage problem during the Iwate–Miyagi Nairiku Earthquake, the Iwate Prefecture signed an agreement with JAL’s fueling company to provide emergency fuel, making simultaneous refueling by two companies possible and allowing refueling to occur without any problem, even during congestion.

Given the damage to the terminal building from the earthquake, the airport building company requested the tenants, including the airlines, to close their businesses until the building’s safety was confirmed. The company then closed the airport building from March 12 to the morning of March 16 to perform round-the-clock restoration work. After the building’s safety was verified, temporary passenger flights were started in the afternoon of the 16th.

The JSDF transported emergency supplies by air; they primarily transported the DMAT through March 15 and then water, food, and household goods after the 16th. The Hanamaki Airport served as a transport base for relief supply to Iwate Prefecture and to the northern region of Miyagi Prefecture when the JSDF Matsushima Base in Miyagi Prefecture was not available for use.

(3) Yamagata airport

a) Damage

The seismic intensity at Yamagata Airport was “level 5 or lower” and no damage occurred to basic facilities, such as the runway. The airport used a backup generator during a power outage on the day of the disaster. The air navigation facilities incurred minor damage, such as broken mounts on the terminal monitors of the flight service information handling system (FIHS) and some fallen light fixtures and water leaks in the JCAB Yamagata Airport Branch building. The Nippon Telegraph & Telecom (NTT) line dedicated to air traffic control authorities was cut off until the early morning of the 14th, affecting some air traffic control operations. In addition, the FIHS terminals were disconnected from the server from the morning to the early evening of March 12, disabling flight plan-related data entry. There was no noticeable damage to the airport passenger terminal building. The disaster did not occur during any scheduled flight landings so no aircraft were flying when it happened.

b) Airport operation after the disaster

The airport was closed on the day of the earthquake, as it was impossible to sufficiently inspect the aviation lights during frequent aftershocks and power outages. The facility inspection was completed after dawn broke on the following day of March 12, and the airport reopened at 7:59 AM. Afterward, based on a request from the Japan Fire and Disaster Management Agency and an inquiry from the central JCAB, operating hours were extended to 24 hours starting at 7:30 PM on the 12th. After continuing 24-hour operations through April 7, operating hours were changed to 6:30 AM to 10:00 PM on April 8 and then to the normal hours of 8:00 AM to 7:30 PM starting on April 29.

Because of a shortage of spots for some time after the disaster—given the numerous incoming and outgoing disaster management helicopters, JSDF aircrafts, and commercial passenger flights—a policy was implemented to restrict flights except for disaster management-related and commercial pas-
senger flights after March 17. Although no other option existed but to turn down many usage requests, commercial aircraft that were clearly meant to serve the public were accepted, such as air ambulances and the power line inspection helicopters of Tohoku Electric Power, even after initiating the restriction.

The airport facility allocation map of Yamagata Airport is shown in Fig. 3. When the decision was made to use Yamagata Airport as an alternative base for the Miyagi Prefecture helicopter base at the request of the Japan Fire and Disaster Management Agency, the Yamagata Prefecture Air Rescue Team needed to find spots for up to 10 helicopters. Because only six spots were available for small aircraft, spots for passenger aircraft were allocated for these aircraft. Although the spots allocated for helicopters were primarily used by support helicopters from other prefectures, the Yamagata Prefecture Air Rescue Team and Police Aviation Unit always used their dedicated apron in front of their offices. Meanwhile, the JSDF and US aircraft used the Japan Ground SDF 6th squadron apron adjacent to the airport.

c) The realities of disaster response activities

The disaster response guideline instructs agencies involved with the airport to gather when seismic intensity is 5 or higher and to launch the Yamagata Airport Joint Emergency Response Headquarters. The agencies did just that during the Great East Japan Earthquake. At the headquarters, discussions were held regarding the extent of the damage and whether 24-hour operations must begin.

The operation of the apron and its usage area by entity were roughly determined on the morning of March 12. The JCAB Yamagata Airport Branch carried out air traffic management that led up to the apron spot, whereas the marshalls of the Prefectural Air Rescue Team, personnel who guide helicopters on the apron, performed spot assignments within the apron area. To provide information to the marshalls, the Prefectural Air Rescue Team on the ground first communicated with the landing helicopter on radio frequency 131.925 MHz and then relayed the information to the marshalls using the fire department’s radio. Communication between helicopters was conducted on 123.45 MHz, the emergency frequency.

Through the air traffic management conducted by the JCAB Airport Branch, up to 17 round trips of passenger flights were made per day. Sometimes, passenger flights were provided with the information to give priority to disaster management helicopters. Because the Prefectural Air Rescue Team, the Prefectural Police Aviation Unit, and the JSDF also use the Yamagata Airport during normal times, they were accustomed to communicating with one another. The JCAB Airport Branch shared the 122.7 MHz airport tower frequency for local operations to communicate with one another immediately after the earthquake when they were unable to provide air traffic operation. The US aircraft encountered no problems because they were already advised to operate in accordance with the rules in Japan.

Refueling faced no major issues, and fuel shortage was not a concern. Three tankers were usually available as fueling vehicles for airlines’ use, and all of them had sufficient fuel as of the night of March 11. The tankers determined that no issue existed because the outdoor tank with a capacity of 200,000 liters was confirmed to have 180,000 liters of fuel remaining. The Japanese government contacted the airport and offered to supply fuel in drums if needed; however, the offer was turned down after checking with the fuel supply company and considering the matter of storing oil drums. The airlines made arrangements to ensure that flights such as temporary passenger flights would load return fuel at the airport of departure when flying to Yamagata Airport to avoid refueling at this airport. The Prefectural Air Rescue Team used its own fueling vehicle for its helicopters. The fueling process experienced no wait or congestion.

d) Handling secondary transport

The Yamagata Prefectural Government suspended all normal business operations after the earthquake and assigned all staff members of non-essential businesses to transport management to collect information on aviation, railway, and bus operations. Regular route buses within the Yamagata Prefecture operated on the day of the earthquake; however, all other public transport services were cancelled. Anticipating that passengers from the Miyagi Prefecture who would begin flocking to Yamagata on the following day, March 12, the Yamagata Prefecture established a system to flexibly handle the situation at all times.

After deciding to fully expand the initiative to secure transport for a wide area, on March 13, the Prefecture began providing information and guiding individuals in need of transport by using media such as its website and by coordinating with transport providers. The basic idea for the initiative was threefold: 1) to provide detailed information and
develop an information system for passengers, 2) to ensure that the transport system was as efficient as possible, and 3) to minimize the layover time at each location. For example, the Prefecture prepared an escape route map that summarized information on all public transport on one diagram, including the railways. In addition, an arrangement was made for buses to enable supporters of the disaster area to reach the local site immediately after arriving at the airport.

A large number of passengers rushed to the Yamagata Airport after March 12, and the airport terminal was filled with people on waiting lists. To accommodate those who could not get on a flight, Yamashin Travel Service, a company that handles business at the Yamagata Airport, operated night tour buses that went to the Osaka and Tokyo areas from March 13 to 16.

(4) Fukushima airport

a) Damage

During the Great East Japan Earthquake, the seismic intensity of “level 6 or lower” was observed in Tamagawa Village, located at the Fukushima Airport. The basic facilities of Fukushima Airport were not damaged, and operating the airport was not an issue. Although almost all windows on the airport traffic control tower broke, the JCAB Fukushima Airport Branch continued aircraft support operations using the emergency aircraft communication equipment. The elevation angle of the precision approach path indicator (PAPI) was also out of alignment but did not affect operations, and was restored the following morning. The water supply was suspended from immediately after the earthquake through March 14. During this period, clean water was obtained from the water tank and water trucks. Electricity, gas, and telephone lines incurred no major damage. The commercial power supply experienced a five-minute outage immediately after the earthquake; however, running a standby generator enabled facilities such as air support to remain available for use. Getting a phone connection was difficult, and only about one out of ten calls went through, even when using an emergency phone.

b) Airport operation after the disaster

Airport operations were suspended immediately after the disaster to allow inspection of the facilities. According to airport security management guidelines, the airport is supposed to inspect the runway and aviation lights after an earthquake of intensity level of 3 or higher; the air-drome and the elevation angle of PAPI at a seismic intensity level of 4 or higher; and the power distribution facilities and the precision of aviation lights at a seismic intensity level of 5 or higher. Performing these inspections after the Great East Japan Earthquake took approximately 30 minutes. Sending a notice to airmen (NOTAM: a notice filed with an aviation authority to alert aircraft pilots of potential hazards along a flight route or at a location that could affect the safety of the flight) was not possible because of the faulty phone and fax lines. After the inspection results confirmed that no damage was incurred that would cause interference with flight operations, these operations were resumed.

To allow the disaster rescue aircraft to operate, the operating hours of the runway and the terminal building—normally from 8:30 AM to 8:00 PM—were extended to 24 hours starting on the day of the earthquake. Twenty-four-hour operations continued through April 19, after which they were reduced to 6:00 AM to 10:00 PM through May 13, and then were returned to normal on May 14. Because the Ministry of Internal Affairs and Communications asked the news media to refrain from using aircraft to ensure the safety of the rescue aircraft and swift rescue activities, the airport turned down media helicopters on the day of the disaster. However, strong demand from news media agencies caused the airport to begin accepting media helicopters on the following day based on the rule of one helicopter per company. In reality, the airport was not always able to enforce the rule.

To divide the tarmac among all aircraft, the apron was assigned to passenger aircraft; the parallel taxiway and grass landing area on the north side were assigned to the JSDF transport aircraft (Fig. 4). In addition, the parallel taxiway and grass landing area on the south side near the Fukushima Prefecture Fire and Disaster Prevention Aviation Center were designated as temporary spots to park rescue helicopters and media-related aircraft. This arrangement was possible because it was already agreed on at the Hokkaido–Tohoku block joint emergency fire rescue team drill organized by the Japan Fire and Disaster Management Agency, which was held at the Fukushima Airport in November 2010. The agreement allowed using the taxiway and grass landing area as a temporary tarmac in the event that many aircraft, such as rescue helicopters, arrived. Using grass
landing areas as a tarmac without preparation was not possible because the level of withstanding load must be verified in advance. It must also be ensured that the incline is low and the ground is smooth, as it is in the Fukushima Airport.

The DMAT also arrived the day after the disaster struck and deployed the SCU in the garage for snow removal trucks. To efficiently transport patients, a heliport was set up in front of the garage. Air transport of relief supplies began on March 14, and the cargo warehouse along with the garage for snow removal vehicles were utilized as temporarily storage and sorting space. However, note that such utilization of the garage would be difficult if a disaster occurred during midwinter because snow removal vehicles cannot be parked outside. As for lodging for rescuers, conference rooms within the terminal building were offered to entities such as the Japan Coast Guard. The off-premises parking lot was provided to the JSDF as a camping site.

c) The realities of disaster response activities

A disaster response headquarters was set up at the airport after the disaster. The headquarters, which consisted of members of the airport liaison committee (the Fukushima Prefecture Airport Office; the JCAB Fukushima Airport Branch; Customs, Immigration and Quarantine (CIQ); the Fukushima Airport Building and airlines), held meetings and discussed status updates, made decisions on extending airport operation hours, and solved problems. However, the headquarters was not sufficient as a venue for coordinating the members; attendance was poor given insufficient human resources in each agency that responded to the emergency. In addition, because a coordination meeting for helicopter operation was not set up in the Fukushima Prefecture, helicopter operations faced poor arrangements, such as duplicate duties in certain areas.

After the earthquake, whereas some regular passenger flights were canceled, some temporary passenger flights operated. Furthermore, numerous helicopters from government agencies and news media flew in immediately after the earthquake; per-day takeoffs and landings hit a record high volume of 295 on March 12 and up to 20 aircraft flew in each hour during the busiest hours. In particular, 51 media helicopters landed at the Fukushima Airport on March 12 because the Yamagata Airport and Hanamaki Airport were rejecting commercial helicopters, including media helicopters, for some time after the earthquake.

After approaching the runway, aircraft were led to an appropriate parking spot according to the tarmac segments. The Prefectural Airport Office assigned spots on the apron, the taxiway, and the surrounding grass landing area on the north side to passenger and JSDF aircraft. Because the flight schedule for temporary passenger and transport aircraft was determined one day earlier, coordinating the overall spots including the ones on the taxiway and apron was a struggle. Initially, the JSDF transport aircraft, along with others, also unloaded on the taxiway; however, they switched to using the apron after some time to improve the efficiency of ground transport to the warehouse.

The Prefectural Fire and Disaster Prevention Aviation Center assigned parking spots to relief helicopters and small aircraft in the taxiway and the surrounding grass landing area on the south side by checking the size and location of the filler neck of the aircraft at those locations. Aircraft parking areas were divided into two to accommodate helicopters based on type: the taxiway area for the wheel-type and the grass landing area for the skid-type. In addition, the decision was made to divide the grass landing area into zones for rescue helicopters and media helicopters. However, in practice, confusion onsite ensued because the marshalls did not receive information on helicopters before they landed. Because the marshalls made judgments by visual inspection, they could only determine the helicopter’s type immediately before it was parked. Moreover, because the area was large, many marshalls were needed. In some cases, helicopter pilots moved back and forth in confusion because they did not understand where to park. However, despite these problems, no major congestion was experienced in parking aircraft because the parking areas were envisioned in advance, in the event that a large number of aircraft flew in.

In contrast, many complained about the refueling process. Because only one of the three refueling vehicles at the Fukushima Airport had a nozzle for small aircraft, sometimes the wait to refuel was up to one hour. Furthermore, as relief aircraft were prioritized, organizations with media helicopters that had to wait complained. Although refueling had no effect on mobilization requests, it needs to be improved because the delays interfered with urgent activities.

On the day of the earthquake, the staff of the Fukushima Airport Building waited until the shaking subsided and then directed site users to go outside the building, in accordance with the evacuation guidelines. The staff members checked the safety of the building in approximately 30 minutes and directed site passengers to return inside the building. Because the airport operation hours were extended to 24 hours a day, services were provided around the clock in terminals through March 17. Approximately 50 people stayed overnight on the day of the disaster; therefore, supplies such as blankets were distributed. The next day, passengers seeking refuge outside the
Prefecture began flocking to the airport. Passengers on the waiting list for temporary passenger flights and refugees from the surrounding areas stayed overnight in the terminal building after the disaster. The number of lodgers increased to 330 on March 15 after the Fukushima nuclear power plant accident. The number decreased once the highway opened on the 16th. The suspension of water supply in the terminal building continued until the 14th. Water usage was higher than usual because significantly more users were staying in the building. Although water trucks from the Tamagawa Village handled the situation after the water storage tank dried out, water usage restrictions, such as limiting the use of bathrooms at one location, were implemented.

3. THE ROLES OF, AND CHALLENGES FOR AIRPORTS DURING A DISASTER

This section summarizes the lessons learned from the operational realities and response activities of each airport during the Great East Japan Earthquake, as described in Section 2. Based on those lessons, we then summarize the challenges that airports face during a disaster and recommend the required role of an airport during disaster response.

(1) Lessons learned
a) Hanamaki airport

When the Iwate–Miyagi Nairiku Earthquake struck in 2008, numerous missions were carried out at the Hanamaki Airport during the first four days after the disaster. Although the period was relatively short and the number of inbound aircraft was smaller compared to that during the Great East Japan Earthquake, the tarmac space was insufficient and confusion ensued related to refueling because of the convergence of aircraft. Learning from this experience, the Coordination Meeting for Helicopter Operation was initiated and the “Activity Plan for the Iwate Prefecture Helicopter Operation Coordination Team” was formulated in January 2010. In January 2011, just before the Great East Japan Earthquake, emergency aircraft operation rules, such as the use of a radio frequency dedicated to common communication among the involved parties, were established. Furthermore, the Prefecture held an SCU setup drill at the Hanamaki Airport in 2010 as prefectural disaster prevention training.

As a result of applying the lessons learned from past experiences, no major confusion at the Hanamaki Airport occurred immediately after the earthquake, even though more than 100 aircraft landed each day. That said, the major factors that mitigated confusion included the fact that the new apron was placed in service at the start of the new terminal’s operations in 2009 and that aircraft parking capacity significantly increased when the parallel taxiway—which was not placed in service even though it was completed—was added to the old apron space. A series of operations related to takeoff and landing of aircraft, spot assignments, and refueling was conducted without a hitch immediately after the earthquake, by following the rules agreed on at the Coordination Meeting for Helicopter Operation. In particular, with respect to refueling, an agreement for fuel supply was signed as a result of advance discussions with both suppliers for aircraft with unscheduled flights and suppliers that normally supply fuel only to aircraft with scheduled flights. Because regularly scheduled flights were suspended for four days after the earthquake, refueling was handled smoothly during the first three days when many helicopters were landing and taking off. Turning away incoming and outgoing commercial aircraft not directly related to relief activities during the initial period after the disaster also seems to have contributed to smooth operations. However, whether the airport should turn down media helicopters that carry out important missions albeit not directly involved with relief efforts is debatable. The airport should handle the matter on a case-by-case basis through flexible operations, such as designating makeshift aircraft parking spaces in advance.

The Iwate Disaster Prevention Aviation Corp’s initial response was quick because four individuals involved had experienced the Iwate–Miyagi Nairiku Earthquake. In addition, two former members of the Disaster Prevention Aviation Corps and four members of the neighboring Akita Air Rescue Team joined the ground operations on the day of the disaster and the following day, respectively. Support from professionals experienced with helicopter operations turned out to be extremely helpful.

b) Yamagata airport

Unlike the Hanamaki Airport and Fukushima Airport, the Yamagata Airport has no parallel taxiway and it is one size smaller than the other two airports. In addition, the aircraft were able to park at the Fukushima Airport, but could not do the same on the grass landing area, because the ground was covered with snow during the disaster. Although 10 spots were secured for 10 helicopters, commercial helicopters from news media and NPOs were turned away because rescue helicopters from other prefectures filled those 10 spots, as requested by the fire department. Yet, the 10 spots were able to accommodate many rescue helicopters from throughout Japan during the initial period after the disaster.

In accordance with the stipulation of the mutual support agreement among Hokkaido and eight
Tohoku prefectures that the Yamagata Prefecture shall be the organizer of relief efforts in case the Miyagi Prefecture is affected by a disaster, the Yamagata Prefecture took aggressive measures to designate the Yamagata Airport as an escape gate for victims. JAL, which operates regular flight routes out of the Yamagata Airport, began operating temporary passenger flights the day after the disaster, as did All Nippon Airways (ANA), even though it normally does not operate regular flights. Therefore, the Yamagata Prefecture focused its efforts on streamlining access for these temporary passenger flights and operated buses that directly connected Sendai Station located at Sendai City as prefec tural capital city in the Miyagi Prefecture and Yamagata Airport. In addition, night tour buses traveled to the Tokyo and Osaka areas from the Yamagata Airport to transport victims who stayed at the airport and could not get on a flight. They provided victims and supporters smooth travel from the airport, and even offered one-stop information not just on air travel but on all public transport to victims who arrived at the airport. This was a great achievement.

c) Fukushima airport

Many commercial aircraft—primarily media helicopters—that were turned away from the Hanamaki Airport and Yamagata Airport flew to the Fukushima Airport, including approximately 40% of the inbound aircraft on March 12. The experience gained from the Hokkaido–Tohoku block joint emergency fire rescue team drill was put to good use during the congestion immediately after the disaster. The shortage of spots was solved by having skid-type helicopters utilize the grass landing area in addition to the parallel taxiway. Because training was conducted for helicopters landing and taking off in an emergency during this drill, the level of withstand load, as well as the low incline and smoothness of the ground, were already verified.

However, in some cases, aircraft had to wait nearly one hour to refuel because, unlike at the Hanamaki Airport, no operational agreement was in place between the airport administrator and flight operators in case of a large disaster, and only one private supplier provided fueling service. In addition, situations existed in which more than one organization conducted the same activity in a given area because no single organization coordinated aircraft operations.

In general, airport experts are rare among prefec tural staff members. According to the Fukushima Prefecture Airport Office, staff members engaged in road construction sometimes become responsible for airport management simply because both fields fall under civil engineering. Even though only individuals with experience can handle airport operations—because doing so often involves special tasks—for the prefecture as an organization to provide in-house training for airport specialists is not easy. In contrast, staff members in the national government manage one airport after another on job rotation to gain experience; they are in charge of airport management as specialists. In fact, the airport responded immediately to the disaster without a hitch because one of the JCAB Fukushima Airport Branch staff experienced the 2004 Chuetsu Earthquake and the 2005 Miyagi Earthquake. Therefore, involvement of the national government is essential to maintain disaster management functions at the airport.

(2) The required role of the airport during a disaster and recommendations

a) Cooperation among airport organizations

As shown in Table 2, several organizations are involved in the administration and operation of airports in Japan. During normal operations, the appropriate organizations manage cooperation among these facilities based on a division of roles. Cooperation is also managed through an organization such as the airport operation coordination during events that differ from the norm. Because the cooperation of these organizations within the airport is most important in situations such as a significant disaster causing sudden and major confusion, efficient daily communication and training are essential. At the Hanamaki Airport, the individuals in charge of the matter continued working for three years to make arrangements related to aircraft operations based on the lessons learned from the Iwate–Miyagi Nairiku Earthquake in 2008. Because the Great East Japan Earthquake occurred immediately after the arrangements were completed, the effort paid off. Other airports are also encouraged to take on a similar effort.

Key airport operations during a disaster are air traffic control, spot assignment, and refueling.

<table>
<thead>
<tr>
<th>Location</th>
<th>Type of Facility</th>
<th>Administrative Operator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Side</td>
<td>Runway, Taxiway, Apron, Lighting facilities</td>
<td>National government, Local government, Airport operator</td>
</tr>
<tr>
<td></td>
<td>Air navigation facilities (except lighting facilities)</td>
<td>National government</td>
</tr>
<tr>
<td></td>
<td>Ground-handling equipment</td>
<td>Airline</td>
</tr>
<tr>
<td>Land Side</td>
<td>Air traffic control and aviation information receiving facility</td>
<td>National government</td>
</tr>
<tr>
<td></td>
<td>Terminal building</td>
<td>Airport building company</td>
</tr>
<tr>
<td></td>
<td>Parking lot</td>
<td>Public organizations, Local government, Airport building company</td>
</tr>
<tr>
<td></td>
<td>Oil depot</td>
<td>Refueling company</td>
</tr>
</tbody>
</table>
Working on arrangements and regular training are important to ensure that the JCAB Airport Branch in charge of air traffic controls and provides information; that the local government acts as airport administrator; and that aircraft operators and managers of airport facilities can quickly handle a series of flight operation tasks, even in an emergency. Furthermore, coordination among fuel suppliers, distributors, refueling companies, and the airport administrator is necessary in diversifying sources of aircraft fuel and securing procurement routes during an emergency.

b) Cooperation among organizations that operate aircraft

Aircraft that are required to take quick action during the initial period of a disaster include government aircraft, such as those in the JSDF and Japan Coast Guard, local police, fire department, and paramedics; disaster response, medical, and media helicopters; and so on. Commercial aircraft that provide emergency transport and regular service also play an important role. After the Great East Japan Earthquake, Japanese aircraft were not the only ones that flew in. US military forces played a significant role in the search and rescue mission and emergency services, and other foreign military aircraft and commercial aircraft flew in to transport relief supplies. Because the JSDF and foreign military forces are structured to undertake activities in a self-contained manner without requiring support from others, they have significant capacity to take action. Meanwhile, because the daily experiences of the local government’s aviation unit make it extremely familiar with the area affected by a disaster, this unit demonstrates great competence for collecting information on the disaster area and implementing emergency response measures. Assistance from other local governments and helicopters of the police, fire department, and disaster management are quickly deployed in accordance with the agreement between the neighboring prefectures and through instructions issued by the National Police Agency and the Ministry of Internal Affairs and Communications. Furthermore, news coverage activities to communicate disaster situations to the Japanese public and foreign countries are undertaken by a number of incoming helicopters from newspaper and television companies.

In this way, aircraft operations are deployed within a certain area through the involvement of various organizations. Therefore, implementing a comprehensive system that coordinates all organizations immediately after a disaster is virtually impossible. Understandably, each involved organization handles the situation by dispatching a liaison to the disaster response headquarters and collecting information not just for a particular earthquake, but also for other disasters. However, it is difficult for disaster response headquarters to give specific and detailed instructions to the aviation department because a general administrative organization is seldom involved in aviation activities. As a result, each organization seems to be doing what it can on its own without fully understanding which organizations are doing what.

To some extent, it is unavoidable for each organization to independently and immediately respond after a disaster because quick decisions and actions are required. However, a mechanism to share minimum useful information, such as activity status, with each organization is probably necessary. In addition, after a certain period and after setting up a temporary organization, if an aviation taskforce team can be established within the disaster response headquarters, a system with a chain of command to allow sharing information, implementing measures, and providing instruction across organizations would enable the launch of more effective aviation activities. Another effective measure is to hold discussions and trainings in advance for the aviation taskforce team in preparation for a large disaster.

c) Communication between aircraft during a disaster

During a disaster, many organizations launch flight activities simultaneously and their activities are concentrated in a specific area. Although certain rules exist to ensure flight safety, securing a common communication method among aircraft and between aircraft and the ground station is ideal to gather information and conduct rescue activities more safely. With respect to communication among aircraft, the JSDF aircraft and commercial aircraft use different radio frequencies during normal periods. The ground station and aircraft are able to communicate through a radio frequency specified by each airport if the airport is public. However, non-public airports and heliports that more commonly use a company wireless network to communicate are less accessible to outside parties. Furthermore, securing regular communication methods in a temporary landing field set up outside the airport is difficult.

In these cases, some radio frequencies can be used during emergencies; however, for a large disaster such as the Great East Japan Earthquake, no predetermined means of communication existed between JSDF aircraft and commercial aircraft, and between the government aircraft providing emergency services and commercial aircraft, such as media helicopters. Given its experience with the Iwate–Miyagi Nairiku Earthquake, the Miyagi Prefecture used the 123.45 MHz frequency, which allows for communication not only between disaster management helicopters, but also between aircraft and the ground
station as a means of communication between aircraft during a disaster. The Fukushima Prefecture did similarly. Meanwhile, the Iwate Prefecture used the 122.6 MHz frequency, which commercial aircraft can also access freely, as the communication frequency between aircraft during a disaster. However, this frequency does not allow communication with the ground station. Although separate radio frequencies are considered easier to use because no interference occurs in such a setup, setting up a single frequency that can be monitored by all aircraft involved in communication among aircraft and between the ground station and aircraft must be considered because numerous aircraft from various organizations converge to a specific area during a disaster.

d) Preparation and training for disasters

Airports played an extremely important role as emergency support bases after the Great East Japan Earthquake. There were situations in which lessons learned from past experiences were applied, and yet the temporary convergence of aircraft immediately after a disaster could not be handled properly. Based on the realities of disaster response activities in Section 2, the following items are required for the proper operation of airports during a disaster:

(1) Establishment of a structure to operate the airport 24 hours a day;
(2) Arrangements with former staff members with expertise in aviation/airport to provide support and act as supplement personnel;
(3) Identification of the extent to which various aircraft—JSDF aircraft, Japan Coast Guard aircraft, fire and paramedic helicopters, disaster management helicopters, medical helicopters, media helicopters, and scheduled commercial flights—can be accommodated, along with setting their order of priority;
(4) Identification of aircraft parking spots and their usage during a disaster;
(5) Spot assignment rules for scheduled flights, fixed-wing aircraft, and helicopters during a disaster;
(6) Means and channels for securing fuel, execution of agreements for fuel accommodation, refueling procedures, and their order of priority;
(7) Coordination among parties involved in airport operation, such as airlines, ground-handling companies, the airport building company, and refueling companies;
(8) Identification of public transport to various destinations that are not normally serviced, such as affected areas, major neighboring cities, and neighboring airports, in addition to transport to the airport and to the city;
(9) Identification of lodging spaces and food supplies for flight passengers, support staff such as policemen and fire and disaster management helicopter operators from other prefectures, and support staff involved in airport operations;

(10) Establishment of a structure to quickly accommodate the activities of rescue aircraft at commercial airports that restrict access from JSDF aircraft and military aircraft from other countries in normal times.

In addition, conducting regular training to activate these measures is necessary. As previously mentioned, the Fukushima Airport applied the outcome of the Hokkaido–Tohoku block joint emergency fire rescue team drill held approximately four months before the disaster, and used the taxiway and grass landing area that are not normally used for parking, to accommodate additional aircraft. The Hanamaki Airport quickly and effectively utilized area facilities such as the old terminal area for conducting disaster training every September, and for holding SCU setup training with the JSDF immediately before the disaster. These regular training sessions paid off when various missions were conducted during the disaster. The results of such daily training sessions were demonstrated in various missions related to this earthquake. The daily efforts of the involved parties who repeated training and who focused on operating the airport as a disaster management base allowed the aircraft to demonstrate their capabilities. This example effectively illustrates the benefits of repeat training when the need arises, which should be emulated by other airports.

c) Establishing airports as disaster response bases prepared to handle disasters

This study showed that the airports that were primarily focused on their role as a commercial airport may be effectively used as a disaster management base. Unlike railways and roads that secure transport through a continuous physical network, air transport is characterized by its wide connectivity to both domestic and international destinations, made possible by maintaining nodes at the airport. Japan is vulnerable to natural disasters such as typhoons and torrential rains, in addition to periodic Tonankai earthquakes. Therefore, preparing the nation’s airports as disaster response bases is recommended. Specifically, preparation of the following facilities is suggested. Because these facilities will not be used regularly, establishing them as multi-purpose facilities rather than special facilities for disaster management is recommended.

(1) Ensuring the availability of aircraft parking space: In addition to using the tarmac to handle ordinary flights, ensure that spaces such as grass landing areas (the shoulder part) are available, which can be used for parking in the
event that numerous aircraft fly in during a disaster. In addition to drainage, these spaces must have the soil-bearing capacity to park aircraft when needed. Furthermore, giving access to large trucks is needed to ensure that refueling is possible.

(2) Ensure the availability of spaces for temporary storage of fuels in drums, in addition to using regular fuel tanks.

(3) Ensure the availability of temporary lighting facilities to enable night work on the tarmac.

(4) Ensure the availability of storerooms to sort and store relief supplies.

(5) Ensure the availability of spaces for setting up an SCU.

At least one airport in the Hokkaido, Tohoku, Tokai, Chugoku/Shikoku, and Kyushu regions can be designated as a disaster management base airport with disaster management functions to ensure that each region is prepared for disasters. Because the airports in high demand are more likely to be used for commercial aircraft operations during a disaster, positioning other airports as disaster management base airports is recommended. The airport must assume the role of an emergency transport base immediately after a disaster. At the same time, how it can quickly return to its role as a normal commercial airport must be considered.

Because a disaster can strike anywhere and at any time, conducting training is essential to enabling these disaster management base airports to cooperate and respond to an emergency. Simultaneously, neighboring airports, heliports, and other airfields should be positioned as support facilities. Likewise, regular simulations and training on aircraft operation by utilizing these various facilities during a disaster should be conducted. In particular, because airports are required to handle the media during the initial stage of a disaster, designating airports other than the disaster management base airports to handle media helicopters is recommended. During the Great East Japan Earthquake—based on a request from the Ministry of Internal Affairs and Communications issued on the day of the disaster—the privately owned Honda Airport located in the Saitama Prefecture was designated and utilized as a relay point for support helicopters as a forward base because it was equipped with night lighting facilities. The Honda Airport immediately responded to the request and prepared to accommodate helicopters. This example shows the effectiveness of crossing the public–private line to utilize nearby airports. Clarifying the roles of disaster management base airports, neighboring airports, heliports, and other airfields throughout the region is probably necessary, as is conducting various simulations on how and at which stage after the occurrence of a disaster, as well as for what purpose these facilities should be coordinated.

4. CONCLUSION

This study interviewed various organizations involved with the Hanamaki Airport, Yamagata Airport, and Fukushima Airport and summarized the operational realities faced by various organizations, and the disaster response activities implemented by these organizations during the Great East Japan Earthquake. The objective is to articulate the lessons learned from past experiences and the challenges faced by an airport during a disaster. This study also presented recommendations for preparing and establishing disaster-responsive base airports. In addition, this study revealed that helicopters and other aircraft play significant roles during a disaster.

Efficient communication to quickly share the information generated onsite among different organizations is necessary. These organizations then need to engage in discussions to clarify their respective roles and take actions based on this information. To make this series of actions possible in an emergency, training and preparation must be conducted regularly. By proving that airports play a significant role during a great disaster, this study provided invaluable insights from a perspective different from those gathered when viewing airport operations in normal times.

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