Inhabitant's Behavior and Disaster Information-Dissemination in an Urban Flood

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Preface

Japan is a country very susceptible to natural disasters such as floods, compared to other developed countries. This is due to the high rainfall and steepness of the terrain. Consequently, Japan has for many years given great emphasis to river improvement schemes in order to decrease the risk of flooding.

Nevertheless, cases of severe flooding in urban areas still occur frequently to this day. Notable instances include landslides in Hiroshima, and flooding in the vicinity of JR Hakata Station in Fukuoka, both of which were caused by heavy seasonal rains in June 1999, and flooding in Tokyo in July 1999. In Fukuoka and Tokyo especially, underground spaces were flooded, giving raise to unprecedented damage, including the first ever cases of death by drowning in flooded underground facilities.

These flood disasters gained much attention due to the extent of the damage (including fatalities) and because they occurred in urban areas, which were not thought to be prone to such disasters.

Already in 1998, the necessity of flood prevention countermeasures for underground spaces had been pointed out in a report of an official Japanese government organization (a report entitled "Towards Risk Management of Flood and Sediment Disasters" issued by the General Policy Committee of the River Council). Also in November of the same year, a committee had been formed collectively by four ministries and agencies of the government

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in order to investigate countermeasures against flooding in underground spaces. Furthermore, in a report of the Committee for Floodplain Risk Management of the Tone River, new risks in subways and underground spaces were identified as items for investigation from now on. The first cases of death due to submergence of underground spaces occurred before any such countermeasures had been implemented.

These losses caused by flooding in underground spaces drew attention to both "hard" and "soft" aspects, i.e.:

(1) Weaknesses in the physical functioning of the urban environment (the so called "hard" aspect)

(2) Weaknesses in inhabitants' perception of urban flood disasters, and inadequacies of disaster prevention countermeasures in underground spaces (the so-called "soft" aspect).

These two points require urgent further consideration, in order to mitigate the losses from this new form of flood disaster caused by intensive land use.

From this perspective, this paper first reports on the flood disaster in and around JR Hakata Station in Fukuoka City in June 1999. Next, we look at the current state of disaster countermeasures in underground spaces. Finally, we report on the results of a survey we conducted among users of underground facilities in the Asakusa district of Tokyo and in the vicinity of JR Hakata Station in Fukuoka.

Chapter1. Disaster Information Dissemination in the 1999 Fukuoka Flood

1. Outline of the Disaster

A highly active seasonal rain front caused heavy rain to fall over northern Kyushu beginning before dawn on June 29th, 1999. A record hourly rainfall measurement of 77mm was recorded for the hour between 8am and 9am in Fukuoka (Table 1).

Table 1: Rainfall in Fukuoka Flood

Observation point	Fukuoka City (observed by AMEDAS at Fukuoka Regional Meteorological Agency)
Continuous rainfall	166.5mm(from 4pm on 28th of June to 7am on 30th of June)
Maximum rainfall per day	160.0mm(from 4pm on 28th of June to 4pm on 29th of June)
Maximum rainfall per hour	77.0mm(from 8am on 29th of June to 9am on 29th of June)

Overflows occurred on twenty-eight rivers in Fukuoka Prefecture. In Fukuoka City itself, the Mikasa River, which runs through the city center, burst its banks at three points and flooded the city. The flooding was especially serious in the vicinity of Hakata Station, where water reached a maximum depth of about one meter. As a result, one person died, 708 houses were flooded over the floor, 703 were flooded under the floor, and two houses were half destroyed in Fukuoka City alone. In addition, there was serious disruption to daily life in the city: trains were cancelled, roads were closed, and underground shopping centers and hotels were forced to close (Table 2).

Table 2: Major damage in the Fukuoka flood disaster (temporary report at 2pm, July 1st by the Fire Fighting Disaster Prevention Section of Fukuoka Prefecture)

In Fukuoka City	death toll	1 person
	houses flooded over the floor	708
	houses flooded under the floor	703
	half-destroyed houses	2
In other areas of Fukuoka Prefecture	injured persons	5(severely injured 3, slightly injured2)
	partially destroyed houses	16
	houses flood over the floor	354
	houses flood under the floor	1802
	Disused houses	7

What was most significant in this flood disaster is that a restaurant employee failed to evacuate in time, and drowned in the underground floor of a building near Hakata Station, as a result of the overflow of the Mikasa River and the consequent flooding around the area. This was the first ever case of death due to flooding in an underground space in the entire history of disasters in Japan, and drew attention to the problems posed by this new type of urban disaster.

As regards the mechanism giving rise to this flood disaster, its root cause was localized severe rainfall over a short period of time. It began to rain at 4pm on June 28th. The total rainfall for the period of continuous precipitation was 166.5mm (until 7am on the 30th), half of which poured down during a period of only one hour (8am to 9am on the 29th). The heaviest hourly rainfall amounted to 79.5mm, which is the heaviest hourly rainfall ever observed by

the Meteorological Agency for the month of June in Fukuoka.

In the press, the greatest cause of the flooding was said to be the fact that this localized severe rain far surpassed the capacity of the sewerage disposal system (which can deal with a maximum of 52mm rainfall per hour).

However, according to expert opinion, even when rainfall surpasses the ability of the sewerage disposal system, floodwater will recede within an hour. It rained heavily until 9pm, but thereafter fell only lightly (the rainfall from 9am to 10am was 15mm). Nevertheless, the flooding which brought about the damage described below occurred after 10am.

For example, a manager of the building where the fatality occurred, stated as follows: "It was 9 o'clock when I came to the office. At that time, the road in front of the building had been like a river for some time. The water then was almost as high as the 40cm water-stopping board. Cars were still running in the roads then. When cars passed, the waves of water ran over the water-stopping board. Around 10 o'clock the water had begun to recede. So, I thought about opening the water-stopping board, but then the water started to increase again. This must have been just about when the river overflowed. Meanwhile, the water gradually surpassed the water-stopping board. Then I heard a big sound of water rushing from over there. Water had come in through the ventilation windows of the car parking garage."

According to what this person said, the depth of water once decreased at about 10 o'clock and then the depth increased again. This second increase of water brought about the fatality in the underground floor. The first inundation was caused by the limited capacity of the drainage system. When the rain became lighter around 10 o'clock, the water began temporarily to recede. However, just about at that same time, the Mikasa River, which runs some hundred meters away from the building, overflowed, resulting in the second increase of water with fatal consequences. This interpretation is supported by further eyewitness accounts:

"It was after 9 o'clock in the morning when I saw that it was raining severely. Water had accumulated on the road outside, but the water was still clear then. Pedestrians were rolling up their pant legs. The depth of the water was about up to the calves. I simply thought it was raining heavily. I finish work at 10 o'clock, so at about half past ten I went downstairs to the locker room on the second basement level. Water had already flowed into the basement then. At that time, very muddy water was flowing in through the stairwells used by employees."

This is the account of an employee of a hotel in front of Hakata Station (Hakata Miyako Hotel) who narrowly escaped being shut into the basement.

We should pay attention to the fact that the water which had accumulated just after 9 o'clock was clear, but the water which flowed in after half past ten was muddy. The floodwater which had accumulated just after 9 o'clock was due to the insufficiency of drainage capacity, and was therefore clear. However, the water coming in at around half past ten was overflow from the river and was therefore muddy.

The main cause of the flood disaster in this case was the overflow of the Mikasa River.

In order to investigate this flood disaster further, in particular the problems of evacuation behavior and information dissemination in underground facilities, we conducted an interview survey with respect to the following organizations and individuals. First, we surveyed seven organizations and individuals who directly experienced the effects of this flood disaster. These were the manager of Toufuku Daini Building, the company responsible for managing Hakata Terminal Building (Deitosu), two tenants in the underground shopping area of Hakata Station, a hotel receptionist at Hakata Miyako Hotel, Kyushu Electrical Power Company, and the station master of Hakata Subway Station. We also surveyed four organizations responsible for information dissemination or rescue. These were the Fukuoka Prefecture River Authority, the River Information Center, the Fukuoka City Fire Department, and the Fukuoka City Civil Affairs Section.

2. The Situation in Toufuku Daini Building

The death by drowning took place in the underground floor of an office building called "Toufuku Daini Building", located in Hakataeki Higashi 2 chome, Hakata Ward, near the Chikushi Exit of Hakata Station. This area is now thoroughly urbanized with many office buildings. However, according to local people, it used to be poorly drained low wet land before Hakata Station was moved to its present location along with the opening of the Shinkansen Line. Even today the area around the station is low-lying land, and after heavy rains the area has often been flooded due to the bad drainage conditions.

On the other hand, the area close to the Mikasa River, which overflowed this time and runs some hundred meters away, had not experienced any recent damage caused by river overflow (although there was overflow damage upstream in 1975).

In the underground floor of Toufuku Daini Building are a car parking garage and two

restaurants (a cafe and a fried food restaurants). The employee who drowned was preparing food in the fried food restaurant prior to its opening. According to the manager of the building, the water level around the building began increasing again after 10am. At about ten fifteen, the water rose above the 40cm-high water-stopping board, and also gushed into the underground floor through the parking garage ventilation window (fig. 1). The building manager, Mr. A, told the restaurant employee to move the restaurant's car from the garage so as to avoid the inundation, but she could not move it because she did not have the key. According to Mr. A, she at that time showed no sign of anxiety and was as usual. At about ten twenty, the manager of the cafe next door called out to her after laying sandbags around the outer staircase, but she continued her food preparation as usual. Then, at about ten thirty, when Mr. A went down to the underground floor, water was coming in from the parking garage and had become ankle-deep. After that, water poured rapidly into the underground floor, and at about ten forty the electricity was cut. At that time, the cafe manager evacuated to ground level through the staircase inside the building, but apparently he did not see the restaurant employee. It is around that time that she appears to have met her death by drowning.

According to the press, the victim phoned the restaurant owner, asking to be rescued, "Water is coming in and I may not be able to escape from here," she said.
Then there was a scream, and the telephone went dead (*Asahi Shimbun*, July 30th 1999). (According to the newspaper, the owner said the phone call was at about half past ten. However, considering Mr. A's account and the timing of the flooding around the station, it seems likely that it was close to ten forty.) Mr. A then heard from the cafe owner and immediately tried to call 119 (fire and emergency service), but could not get through.
This is maybe because the telephone exchange machine in the building was not functioning due to the electrical power cut. A while later, another employee of the fried food restaurant came and called the owner by cellular phone. The owner also called 119.

According to Fukuoka City Fire Department, it was eleven fifteen when the owner called the emergency services.

Receiving the emergency call, the firefighting team arrived on the spot at eleven twenty-four, but they had difficulty carrying out the search. They finally recovered her body at twelve thirty-four. The search was prolonged due to the late arrival of a team with diving equipment, the muddiness of the water, and the complex structure of the building which obstructed their work.

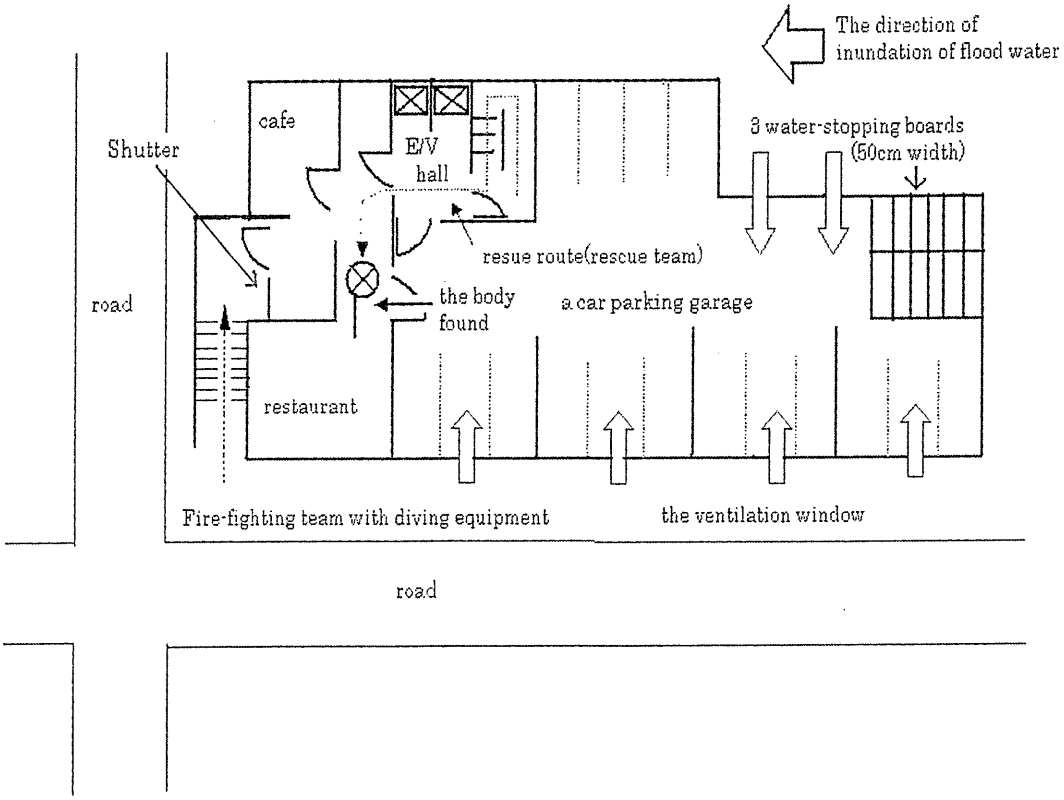
But still the main cause of this disaster was that the information that the Mikasa River had overflowed was not passed to the victim and the people around her, thus delaying their evacuation. Mr. A, the manager of the building spoke as follows on this point:

"When I asked her to take the car out, Ms. M (the victim) was preparing food for the restaurant, and did not seem to be particularly concerned about the situation. She was as usual. When I saw the cafe owner after his evacuation from downstairs, he did not seem to be in a panic. I had no sense of danger at all either. I thought the water would stop at a certain level. We did not have any information that the river had overflowed. It is hard to imagine that the water would rise above the riverbank. When the water rose, some people did say the banks might have burst. But I thought that could not happen.

This building was flooded once before in 1996 or 1997. That time it was not because of the river overflowing, but because of rain. We stopped it with water-stopping boards and sandbags. So if the river had not overflowed this time either, the water would have begun to recede at about ten o'clock and nothing would have happened. Even when the water came up knee high, I thought it would recede just as it did the last time. If I had received information that the river had overflowed from the Fire Department or the television, I would have had everyone evacuate immediately. By microphone. The lack of information was the main cause of this disaster, I believe. I went upstairs and put the television on, but there was nothing about it on the television either It was not until the afternoon that I knew the river had overflowed."

Thus, there was prior experience of flooding from rainwater in Toufuku Daini Building, and it was assumed that the water would soon recede as it had on the previous occasion. As a result, the building manager and the employees did not sense any serious danger until the last minute. This is because, as Mr. A pointed out, they did not have any information at all that the Mikasa River had overflowed, and so they did not realize the water around them was flood water from the river, not rainwater as in the former case. One can say that it was this lack of information that delayed their evacuation, and brought about the loss of life.

Fig1.The underground floor of Touhuku Daini Building
and the inundation direction of flood water



3. The Situation in Other Underground Spaces

Flooding also occurred in other underground spaces in the vicinity of Hakata Station, although not to the extent of causing loss of life. How was the situation in these places?

(1) Hakata Miyako Hotel

Muddy water - presumably river water - flooded into the Hakata Miyako Hotel around half past ten. According to the hotel receptionist then on duty (Mr. M), the water came in mainly through the parking garage entrance, flowed through the parking area on the underground 1st floor, and accumulated in the underground 2nd floor, on which are located an employee's locker room, a storage room and a bakery. Mr. M described the scene he found when he tried to go down to the locker room, as follows:

"In the emergency staircase used by employees, quite muddy water was flowing in then. Sandbags had been laid, but the water was flowing through them and pouring down the

staircase. I rolled my pant legs up to the knee and went downstairs, but I didn't feel the situation was so bad. I never thought it would become serious. On the contrary, I thought "wow!", and went downstairs.

On the underground floor the water was already up to my calves. Garbage and empty cans were floating in it. I waded to the locker room and tried to push the door open, but couldn't. I didn't know why it did not open, whether it was water pressure or something was stuck. I stayed there trying to open the door for about five minutes. Meanwhile the water rose as high as the knees. I thought the door would never open however much I tried, so I decided it would be better to go back up with the other people on that floor. In the corridor, there was someone who worked in the linen room. I called them to come with me. But when we were about to go, the fire prevention screen had come down. It was not down when I came, but probably it came down together with the water from the sprinkler. There were two people who worked in the hotel bakery pushing the fire prevention door. There was another catering related person talking on the telephone in the basement, so in total there were five of us down there. We pushed the door really hard, and after about a minute it opened. There were people on the other side. I guess the strength of three people worked well and it just happened to open. The floor level was a little lower there, and the water was up to the knee. Maybe the high water pressure prevented the door from opening, I suppose. Then we climbed up the emergency staircase to the ground floor. While we were going up it was dark, because the electricity had been cut. (We learned later that the circuit breaker had been lowered.) There were emergency lights on, so it was not completely dark."

When Mr. M went downstairs, he couldn't open the locker-room door, and after a while when he tried to come back, the exit door for the ground floor did not open, and it seemed for an instant that he had been shut in. Some people came from outside and luckily he was able to escape. Had they been just a little later, a tragedy like that which occurred in Toufuku Daini Building could have happened. This eyewitness account reveals that when an underground floor is flooded, doors may not open due to high water pressure or the presence of obstacles floating in the water.

A point particularly worthy of attention is the lack of any sense of danger. On this, Mr. M said as follows:

"I was scared when the fire prevention door didn't open. It was then that I begun to feel the situation was serious. When I first went downstairs and tried to open the locker-room door, I was not scared at all. I had not imagined at all this could happen when I went down the

emergency staircase. If someone had not come from the other side of the fire prevention door (and opened it), or if there had not been anyone else with me, I have no idea what would have happened to me. It would be different if I had experienced this kind of thing once before, but usually you just don't think this kind of thing could happen to you."

If water pours in making a great noise, it is possible to imagine that being on an underground floor with no escape route could be very dangerous. However, people at the scene had no way of imagining such a thing, and did not perceive danger until the situation became absolutely critical.

(2) Hakata Terminal Building

Leaks caused by accumulated rainwater occur with a frequency of about once a year in the terminal building at Hakata Station. Various kinds of tenants rent space in the two underground floors. According to the company responsible for the buildings maintenance, water leaked in once at about eight fifteen that day, and sandbags were laid to stop it. However, just after 10 o'clock, the water had become thigh-deep, and around half past ten had begun seeping into the basement. Power from the local electricity company (Kyushu Electrical Power Co.) was cut off at half past eleven, and all the shops were closed as a result. Apart from a few restaurants that open at eight o'clock in the morning, most of the shops usually open at ten o'clock in the morning, so there were apparently almost no customers in the building at the time.

According to a waitress (Ms. B) who worked in a cafe, which opened at eight in the morning, on underground floor 1, the situation that day was as follows. The seepage of water at around eight o'clock did not reach the underground floors, but after nine o'clock it had began leaking through the ceiling. At that time, there were not many customers in the cafe, but some did came in to pass the time due to the cancellation of trains. One customer ran up through the corridor at about ten, but the reason is unknown. Although the cafe remained open, there were no customers at eleven. The people working in the cafe were puzzled by the absence of the usual lunchtime customers at eleven o'clock. Then it became noisy in the corridor. There were customers running around, announcements through the communication system, and everyone was frantic, including employees in other shops and restaurants who were helping to stop the water leaking in. There were announcements several times, asking for help to stop the water leaking in. According to Ms. B's account, they had no idea that the river had overflowed, let alone that the entire area above them was

covered in water.

According to the owner of a sushi restaurant on the first floor (who was also president of the tenants' self-government association), water was surging in at about ten forty.
At that time, most of the shops were not yet open. He tried with other people to stop water pouring into the basement floor by surrounding the escalators with cardboard boxes and other objects. However, these efforts were in vain. He had no idea at the time that the Mikasa River had overflowed. From these accounts, we can see that even in the station building there was no information at all about the overflow of the Mikasa River, and there was no sense of danger among the people there.

(3) Hakata Subway (Underground Railway) Station

According to the stationmaster, Mr. C., flooding of the station began at ten forty-two.
Water came in from the Chikushi Exit side only, pouring in like a water-fall through the entrance from a neighboring hotel. There were no water-stopping boards at the station, so they tried to stop the water by piling sandbags at the station entrance. 117 people in total came to help from other departments. At just past 11 o'clock, guards were stationed at six locations (including three entrances from buildings) on the Chikushi side to stop people from entering or leaving. Access to the station was thus restricted to the four entrances on the Hakata side. The station had no manual directing that flood prevention measures should be taken when the Mikasa River reaches a certain level. Disaster prevention measures were taken according to ad hoc judgments.

On that day, there was no perception that passengers were in any special situation of danger. Although the mainline (JR) train services were suspended due to an electricity cut, the subway continued to run for a while. However, the service between the airport and Nakasukawabata station was suspended at 12:05, when the track became submerged to a depth of about 20cm. At that time, the number of passengers was smaller than usual, about one third of usual. Furthermore, most of these were people getting off the trains and leaving the subway. Very few had come to board trains. Drained with four drainage pumps at Hakata Station, train service was resumed at fifteen forty-six.

By then, the roads were severely flooded to waist-depth. The water was flowing about as fast as a river. Although it is little more than four hundred meters (as the crow flies) from the Chikushi exit of the subway station to the Mikasa River, no one at the station knew about the river overflowing. Since the rain had stopped, it was assumed that water level would soon

fall. It was not until the afternoon that the stationmaster learned about the river overflowing. By then the crisis had passed.

Thus, even somebody like a stationmaster, who is in a position to access disaster information easily, did not know that the cause of the flooding to waist-depth was the overflowing of the river.

We have seen from the above accounts that no one at any situation at any place knew the cause of the flooding was the overflow of the Mikasa River. As a result, they had an extremely low perception of risk. Then, why was the information of the overflow not disseminated?

We turn now to the issue of information dissemination.

Table.3Major losses in basements caused by flood disaster in 1998
(from Statistical Survey of Flood Disaster, etc.)

date	prefecture	city,town,village	damage	remarks
Jul.27～28	Aichi	Nagoya city	an apartment house	underground floor
Jul.30	Kanagawa	Yokohama city	an apartment house	underground floor
			a buliding with various tennants	farmer or fishery
			an apartment house	underground floor
			a buliding with various tennants	farmer or fishery
Aug.3	Tokyo	Ohta ward	an apartment house	underground floor
Aug.4	Nigata	Nigata city	hotel	service and other industry
			a buliding with various tennants	parking
			hotel	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			hotel	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			a building of an electric appliance store	whole sale･retail sale,restaurant
			a buliding with various tennants	service and other industry
			a buliding with various tennants	service and other industry
			a buliding with various tennants	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			a buliding with various tennants	whole sale･retail sale,restaurant
			hotel	service and other industry
			hospitak	service and other industry
Sep.15～16	Tokyo	Nakano word	collective houses with tenants	whole sale･retail sale,restaurant, service and other industry
Sep.22	Hyogo	Kobe city	a buliding with various tennants	whole sale･retail sale,restaurant
Sep.24～25	Kouchi	Kouch city	a buliding with various tennants	whole sale･retail sale,restaurant
			west wing of a prefectural office	whole sale･retail sale,restaurant, service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant, service and other industry
			a building of retail shop	whole sale･retail sale,restaurant
			a buliding with various tennants	underground floor
			a buliding with various tennants	whole sale･retail sale,restaurant, service and other industry
			a buliding with various tennants	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			a buliding with various tennants	whole sale･retail sale,restaurant
			other 10 facilities	
Oct.17～18	Okayama	Tuyama city	a buliding with various tennants	whole sale･retail sale,restaurant
			a buliding with various tennants	underground floor
total			43	

4. The Fukuoka City Fire Department's Response

Before considering the problems of information transmission, let us make clear the basic facts of the Mikasa River overflow. The prefectural authorities in charge of the management of the Mikasa River confirmed the occurrence of an overflow at Itatsuki Bridge in the northern part of Fukuoka City at ten minutes past ten. Confirmation of the overflow at Hie Bridge (in the vicinity of Hakata Station) came at ten twenty. Since local residents had already reported to the authorities that the river was in danger of overflowing at nine forty-five, it seems likely that it overflowed at ten past ten at that location too. Assuming that the one case of death by drowning happened at about ten forty, the intervening time was about thirty minutes.

When floods occur, it is the Fukuoka City Fire Department that is mainly responsible for disaster countermeasures, and it is there that the disaster response headquarters is set up. How was information about the overflow of the Mikasa River dealt with by the Fire Department?

According to our survey, the situation was as follows. On receipt of a heavy rain and flood warning from the Meteorological Bureau, the Fire Department set up a disaster warning head quarters at six fifty. Before eight o'clock, information was being received from emergency calls about flooding of roads and houses. In response to these calls from the public, fire brigades were dispatched, and the Department became pre-occupied with the task of confirming the safety of inhabitants and laying sandbags. However, it was assumed that these cases of inundation were caused not by the river overflowing but simply the accumulation of rainwater.

At nine forty-five, there was a telephone call to Hakata Fire Station from Mr. Mitsuaki Nishimaru, a headmaster of Katakasu primary school nearby, saying that the Mikasa River was about to overflow. However, Hakata Fire Station was unable to respond to this call because all its vehicles at were out then. Instead they requested the local Katakasu Fire Brigade to go out. Receiving this, the local fire brigade went out at ten o'clock. Having reached the scene, they sent out a request for reinforcements to the fire department at ten past ten. However, for some reason, the fire department received only a request for reinforcements. They did not receive any information about the overflow. In response to this request, a fire department brigade was dispatched at ten nineteen, arriving on the scene at ten thirty. They were going to lay sandbags in order to prevent the overflow, but soon gave up because of the overwhelming quantity of the water.

Precisely at that time, about ten thirty, the Fukuoka City Fire Department made inquiries on the situation of the river to the Fukuoka Prefecture River Bureau. The information then received was only that the river was in danger of overflowing. For some reason, even the River Bureau had no clear information that the river was already overflowing. (It seems that neither the prefectural River Bureau nor the municipal Sewerage Bureau contacted the Fire Department.)

The fire department finally realized the serious situation of the Mikasa River at ten thirty-nine when they flew a helicopter over it. Even then the information they had was that the river was in danger, not that it had already overflowed. Thus, the fire department perceived that the river was in a dangerous situation at about ten thirty. They were probably in contact with the fire brigade at the scene of the overflow, but it is unclear when exactly the fire department received the information about the overflow of the Mikasa River. In any case, it is certain that the Fire Department, who is in charge of disaster management, did not receive the information about the Mikasa River's overflow until a very late stage.

In the event, despite the occurrence of such a flood disaster, the Fire Department set in place neither a flood prevention headquarters, nor a disaster response headquarters.
Later, the Fire Department was criticized in the media for its failure to act in this way. Nevertheless, one of the reasons for this failure was the delay in obtaining information about the Mikasa River's overflow, and the resulting inability to perceive how serious the situation would become.

5. The Prefectural Government's Response

None of the rivers flowing through the city of Fukuoka fall into the category of "grade-one" rivers managed by the national government. The Mikasa River and other rivers are "grade-two" rivers managed by Fukuoka Prefecture. We will now examine how Fukuoka Prefecture responded in its capacity as a river managing authority to this flood disaster.

(1) Rivers in Fukuoka Prefecture and their System of Management

First, we will briefly describe the river situation in Fukuoka and organizational structure of river management. As stated before, there are no grade-one rivers in Fukuoka City, and the major rivers in the city are grade-two rivers, such as the Zuibaiji River, the Jurou River, the Muromi River, the Naka River, the Mikasa River, the Usami River, and the Tatara River.

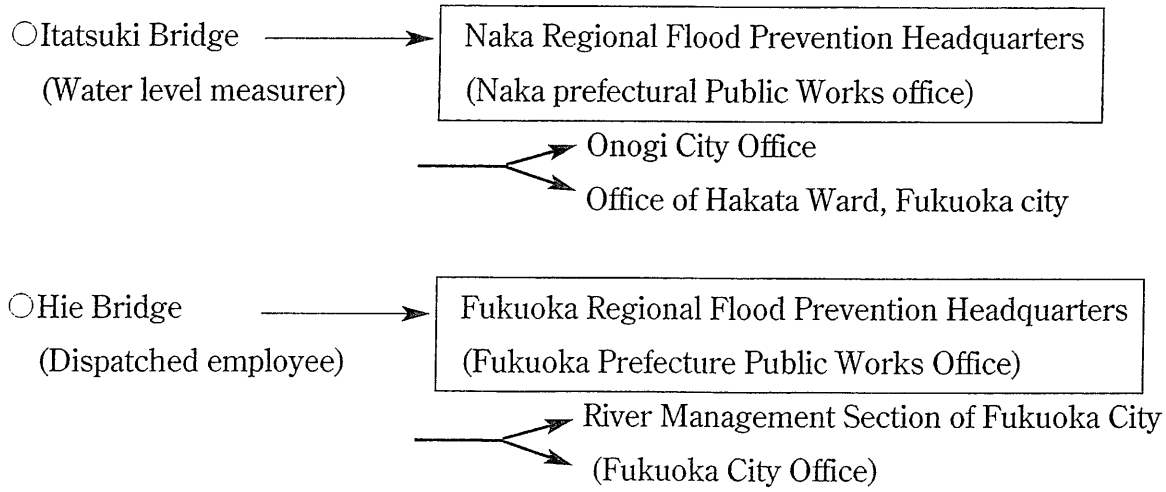
These rivers are managed by the Rivers Section of the prefectural Public Works Department. Gathering and transmission of information on rivers is mainly done by the local prefectural public works offices, which are branches of the prefectural Public Works Department. The head office of the prefectural government has a supervisory role. When flood disasters occurs, or seem about to occur, the prefectural head office acts as a "flood-prevention (levee protection) headquarters", while the local public works office becomes a "regional flood-prevention headquarters". The head of the public works office becomes the head of the regional flood-prevention headquarters. Fukuoka Prefecture defines each river to be managed by each city, ward, town, or village on the basis of river "catchment areas".

In the case of the Mikasa River, which overflowed and caused flood damage this time, the designated river "catchment areas" are Hakata Ward in Fukuoka City, Dazaifu City, Kasuga City, and Onogi City (total population about 435 thousand people).

There are two gauging stations for monitoring water levels on the Mikasa River, one at Hie Bridge under the control of Fukuoka Public Works Office (beside Hakata Station in Hakata Ward, Fukuoka City), and one at Itatsuki Bridge under the control of Naka Public Works Office (south of Fukuoka airport in Hakata Ward, Fukuoka City, close to Onogi City). However, only the Itatsuki Bridge gauging station is permanent. The other at Hie Bridge is a temporary one, to which personnel from the public works office are dispatched only when needed. Thus, under normal circumstances, a flood warning is issued by the governor of the prefecture on the basis of the water level at the Itatsuki Bridge gauging station. The water level at Itatuski Bridge is usually measured twice daily, at six o'clock in the morning and six in the afternoon. Additional measurements are taken at other times when it rains.

As a rule, flood prevention is the responsibility of the city authorities, with the prefecture playing a supporting role. The information about the river level at Hie Bridge is transmitted to Fukuoka City, while that at Itatsuki Bridge is transmitted to Hakata Ward in Fukuoka City, and Onogi City. The stated objective of the prefecture's flood prevention activities is "to organize for the transmission of information in order that flood prevention activities can proceed smoothly" (fig.2).

Fig.2 The flow of information on the water level of the Mikasa River



(2) The Response When Disaster Occurred

Now we will see how the prefectural authorities responded when this flood disaster occurred.

The Fukuoka Regional Meteorological Bureau issued a severe rain caution for the entire area of Fukuoka Prefecture at 16:10, on June 28. At the same time, the prefectural government set up an initial preparatory flood-prevention headquarters (disposition level 1) with respect to all the rivers in the prefecture. Even after the regular finish of work at five fifteen in the afternoon, personnel were kept on standby at both the prefectural head office (4 people in the River Section, and another 4 in other sections, such as the Road Maintenance Section and Erosion Control Section) and the Fukuoka Public Works Office (5 people). At this stage, no personnel were stood by at the Naka Public Works Office in Onogi City.

At six fifty on the following day, June 29, the Fukuoka Regional Meteorological Bureau issued a severe rainfall warning for all areas in Fukuoka Prefecture. At this time, the prefectural government upgraded its emergency setup to disposition level two, which resulted in twice as many personnel being put on standby.

Major overflows of the Mikasa River took place at three points on the 29th: near Tsutsui bridge in Onogi City (close to Onogi City Office), near Itatsuki Bridge in Hakata Ward in Fukuoka City (south-west of Fukuoka Airport, close to Onogi City), and at Hie Bridge in Hakata Ward in Fukuoka City (close to Hakata Station). We will now consider how the prefectural government understood the situation at these three points and how information

about them was transmitted.

As regards Tsutsui Bridge, according to the records of River Section of the prefectural Public Works Department, information about the overflow at Tsutsui Bridge was transmitted to Naka Public Works Office at 9:40. Tsutsui Bridge is not a gauging point, with no permanent personnel stationed there. The overflow was discovered when an employee of the office saw it. Naka construction office immediately transmitted the information to Onogi City, and then at nine forty-five Onogi City spontaneously transmitted it to Fukuoka City. The overflow from the left bank of the river at Tsutsui Bridge ceased at 10:30, and the overflow at the right bank then also stopped at ten fifty.

At Itatsuki Bridge, according to the records of the River Section of the prefectural Public Works Department, the water level of the Mikasa River at Itatsuki Bridge was measured at 6 o'clock and 7, and the information was reported to Naka Public Works Office at nine. According to our survey, the usual water level of the Mikasa River is about 20cm. On June 29th, it was 80cm at six o'clock and 1m at seven o'clock. Then at nine o'clock the water level was measured at 1.3m. The warning water level of the Mikasa River is 1.4m. It is specified in the Naka Public Works Office's flood prevention plan that city government offices in the river catchment area should be informed when an unusually high water level is observed. Thus, at 9:40, the Hakata Ward office was telephoned with the following request for action: "The present water level is 1.3m, as against the warning water level of 1.4m. This is a dangerous situation, so please go and investigate."

It is unclear whether the words "flood warning" were used on this occasion, but it was in effect a flood warning. As a general practice, a flood warning is issued when there is a danger that the water level will reach the warning level. Depending on the water level, there are several stages of flood warning. At this time, it was at stage one.

The prefectural authorities maintain that the above request for action was indeed issued. The Naka construction office did telephone a representative of Hakata Ward Office, but it is impossible to determine who received the call. The ward office was extremely busy at the time, and inquiries after the event have not produced any clear answer. As a rule, telephone calls are confirmed by facsimile, but on that day contact by telephone or fax was difficult and only a telephone call was made. In the event, this information was not transmitted to the fire department of Fukuoka City who actually takes countermeasures against disasters. It seemed to disappear somewhere along the line of transmission.

Subsequently, the water level near Itatsuki Bridge reached the warning level at nine

fifty. At ten o'clock, it surpassed the danger level of 1.8m and rose to 2m.
Then, at 10:10, the Naka construction office received the information that "the Mikasa River has overflowed". This overflow information was transmitted to Onogi City office directly by an employee of Naka construction office. The same information was also given to the prefectural head office at ten twenty. However, the overflow information received at ten past ten was not transmitted to the Hakata Ward Office. The reason given for not transmitting this information was that a request for action had already been issued and there was no need for further contact. Nevertheless, it seems doubtful that there was no need at all to contact the ward office at this time. Even if they had responded to the request for action, they should have been informed about the overflow, especially since the staff at the Itatsuki Bridge gauging station had by then been withdrawn due to the danger.

We will now consider the information on the water level at Hie Bridge. According to the River Section of the prefectural Public Works Department, an employee is dispatched from the office to measure the water level at Hie Bridge, since there are no permanent staff at the gauging station there. At nine o'clock, the employee was dispatched from the Fukuoka construction office at Hakozaki in Higashi Ward of Fukuoka City. It usually takes ten minutes by car from Fukuoka construction office to Hie Bridge, but on that day the employee arrived at Hie Bridge at ten twenty. When he arrived at Hie Bridge, the water had already risen above Hie Bridge, and he reported to Fukuoka construction office, "the water level is above Hie Bridge. The river is overflowing from both banks on the up-stream side, and the riverside area is already flooded" (according to our survey, he appears to have used a cellular phone).

The river section of the prefectural construction department gave the following explanation for the delay in the employee's arrival at the bridge:
Fukuoka construction office has jurisdiction not only over Fukuoka City, but also over a large area stretching from Maehara City in the West (on the border with Saga Prefecture) to Kogo City in the East, managing several rivers such as the Raizan River, the Muromi River, and the Tatara River. So his routine work is to gauge not only the water level of the Mikasa River, but also to go round to gauge those of the other several rivers they manage. He went away to observe three points, such as the Umi River in Higashi Ward, before he got to the Mikasa River. Hakata station and its surrounding area were submerged by the overflow of the Mikasa River, and there was a loss of life there. The Mikasa River received the greatest attention in the press. However, there were other reports in and around Fukuoka City on

submergence and sediment disaster, and floods caused by overflows of several rivers after 8 o'clock.

Since the area of heavy rainfall spread from the west to the east, the first information about dangerous river conditions came from the Raizan River in Maebara City. Information was received at eight forty-five that the water level of the Raizan River had reached to 1.8m (the danger water level is 1.7m), and there was a report of inundation from the Umi River in Umi Higashi Ward in Fukuoka City at nine fifty. In fact, as far as flood damage is concerned, the Umi River caused more damage than the Mikasa River. For these reasons he did not go directly to the Mikasa river. Furthermore, when he left the construction office, the city streets were already partly submerged, causing him to take more time due to traffic congestion. Thus, a problem underlying the prefectural government's organization and response was the difficulty in grasping the situation and gathering information rapidly at a time of crisis.

On receiving the information about the overflow around Hie Bridge, it is said that the head of the Land Section of the Fukuoka Public Works Office contacted the River Management Section in Fukuoka City. Fukuoka Public Works Office has relation to all the wards of Fukuoka City, in other words, the entire area of Fukuoka City, so it is required to give information to the River Management Section of the Fukuoka City office. However, the information on the overflow around Hie Bridge was not received by Fukuoka City Fire Department.

Overflow damage can also be forecast by measuring rainfall. On the banks of the Mikasa River in Dazaifu City, there is Dazaifu rain-gauging station managed by Fukuoka Prefecture.The self-recording rainfall gauge at this station recorded an hourly rainfall of 77.5mm between 9am and 10am. However, the information produced by this rain gauge is not transmitted automatically. Because it is a self-recording system, the measurements recorded are not reported immediately. Instead, the records have to be confirmed later on, and only then is the rainfall known. Apparently, it was not until the evening that day that the rainfall measurements were known.The rainfall measurements at Dazaifu gauging station are not used for making judgements about the imminent danger of rising water, but only for analysis after the event. The prefectural government's rainfall data was therefore of no use in forming a response to this flood disaster.

6. The Fukuoka City Government's Response

We have already dealt with the response of the Fukuoka City Fire Department in section 4. Here will look at the response of the other city departments responsible for disaster countermeasures.

In the case of Fukuoka City, the department in charge of disaster countermeasures is the Regional Development Department of the Citizen Affairs Bureau. However, this department does not specialize in disaster countermeasures. It just includes several personnel responsible for coordinating the response to disasters. The formal title given to such personnel is "General Liaison Officer for Disaster Prevention". Of the five individuals so designated, one doubles as head of the General Affairs Section, where he normally works, while two others belong to the Disaster Prevention Division of the Fire Department and normally work at the Fire Department. Therefore, there are in fact only two "General Liaison Officers for Disaster Prevention" in full service (one of them is also head of the Technical Management Section of the River Department of the Sewerage System Bureau). Furthermore, the main role of the "General Liaison Officer for Disaster Prevention" in the Regional Development Department of the Citizen Affairs Bureau is to coordinate disaster countermeasures, while the actual carrying out of disaster countermeasures are left to the Fire Department. In other words, the main role of the Regional Development Department of the Citizen Affairs Bureau is to form an overall picture of the situation from reports by the Fire Department and other related departments and sections, and their managing local agencies. Actual control of the disaster response is in the hands of the city Fire Department, among other agencies.

In addition, Fire Department employees also belong to the Citizen Affairs Department. Activities of the Fire Department are therefore also regarded as activities of the Citizen Affairs Bureau.

At six fifty on the 29th of June, the same time the severe rainfall and flood warning for Fukuoka Prefecture was issued, a disaster prevention headquarters was set up at the Fukuoka City Fire Department. Accordingly, personnel were called up en masse through the simultaneous communication system (popularly known as "Otsutaekun"). Information was also transmitted to various departments, such as the Citizen Affairs Bureau and the Traffic Bureau by the Meteorological Agency's simultaneous facsimile transmission system known as F-net. The countermeasures taken since then were under the direction of the City Fire Department.

According to the Regional Development Department of the Citizen Affairs Bureau, three of its personnel were so busy answering telephones until the afternoon that they had no time for other activities such as gathering information. In addition, since the rainfall peaked in the morning, and the sky cleared before noon, they could not imagine that the Mikasa River had overflowed and caused such damage. Apparently, it was only later in the afternoon that they found out about the flood damage around Hakata Station from watching the television news.

As we have already noted in the previous section, information was transmitted from the prefectural Naka Public Works Office (including information on the water level measurements at Itatsuki Bridge) to the Hakata Ward Office (which is a branch of the city government). According to the River Section of the prefectural Public Works Department, Naka Public Works Office reported the situation of the Mikasa River to Hakata Ward Office at nine forty in the morning on the 29th. However, this information was not transmitted to the city Fire Department, which is the agency directly responsible for disaster countermeasures. Information from the Fukuoka Public Works Office (including the river level observations at Hie Bridge) was transmitted to the River Management Section of Fukuoka City. However, this information did not get through to the city Fire Department. As mentioned before, the information about the overflow of the Mikasa River at Tsutsui bridge was transmitted from Onogi City to the River Management Section of Fukuoka City, but this information was not disseminated formally to the other departments of the Fukuoka City administration.

Thus, the information on the Mikasa River was transmitted to several sections and local branch agencies of Fukuoka City, but not to the Fire Department which actually undertakes disaster countermeasures, nor to the Citizen Affairs Bureau which is responsible for coordination. Consequently, information on the Mikasa River was not gathered properly by the proper section, and a rapid response to the situation could not be made.

Fukuoka City operates what is known as a "caretaker system". According to this system, the city entrusts ordinary residents with such things as public relations and information gathering. 144 individuals undertake this role as designated "caretakers" (one person for each of the public community halls in Fukuoka City). When disasters occur, or seem about to occur, these caretakers are required (according to the "Town Caretaker Ward District Disaster Communication Manual") to contact the general affairs section of their local ward office, by calling the emergency telephone number (119) or by using the wireless communication system installed in each public community hall, and report on their local

situation. That is, an information transmission system exists in which disasters as perceived by local residents can be transmitted to the city authorities. Although it is not known how much information was transmitted from caretakers to the ward offices in this disaster of the Mikasa River overflow, it seems that no information was transmitted to the Citizen Affairs Bureau or to the City Fire Department by this means as specified in the "Town Caretaker Ward District Disaster Communication Manual".

7. Conclusion and Proposals

We begin this section with a brief review of what we have said so far.

On the 29th June 1999, the whole of western Japan was struck by severe rainfall caused by a seasonal rain front. In the basement of a building in the vicinity of JR Hakata Station, a female restaurant employee drowned. This was not caused by flooding due to the heavy rainfall that fell between 8 to 9 in the morning, but by the inundation of the low-lying area around Hakata Station caused by the overflow of the Mikasa River close to the station that began around ten o'clock. At ten thirty, about the time the woman is assumed to have died, the heavy rain had ceased and it was raining only lightly. Nevertheless the water level continued to rise, and people in the area were not able to understand at all what was the cause of it. Information about the overflow of the Mikasa River was not transmitted to the people around Hakata Station. The major reason for this is was the lack of a system or communication media through which overflow information could be disseminated to ordinary citizens. This is a typical case showing the importance of disaster information.

Underground spaces, such as subways (underground railways), underground shopping areas, and the basement floors of buildings, abound in modern cities. They are not unique to Hakata Station, where the present disaster occurred. Cases of flooding in such underground spaces are not infrequent, and the patterns of damage caused are various. Other prominent cases of urban flood disaster, in which shops, parking areas, electrical installations, and telephone facilities were damaged, include the Nakgasaki flood disaster in 1982, the Kagoshima flood disaster in 1993, and the Niigata flood disaster in 1998. This Fukuoka flood disaster was the first case in which a fatality occurred, but there were as many as forty-three cases of flooding in underground shopping areas and basements in 1998 alone (see Table 3).

Table 3. shows the extreme importance and urgency of taking countermeasures against flood disasters in urban underground spaces, such as underground shopping areas and

basements. Nevertheless, plans for such measures have as yet progressed little.

For example, the Construction Ministry has put forward the following as countermeasures against flood disaster in underground spaces:

① measures to prevent the inflow of water (raising basement entrances, installation of water-stopping boards and protective walls, preparation of sandbags, raising the openings of ventilation shafts, surrounding ventilation shaft openings with walls)

② measures to stop the floors that people use becoming flooded even when the inflow of water underground does occur (installing facilities for the storage of water underground)

③ measures to prevent water which has entered underground spaces from spreading (stopping the flow of water with water prevention doors)

Some subways (underground railways) and underground shopping areas have formed their own disaster prevention plans, based on their own flood disaster experience. Generally speaking, however, flood prevention planning for underground spaces has not progressed much. Many buildings do not even have water-stopping boards or sandbags ready in order to reduce the inflow of floodwater into their basements.

According to the hearing survey conducted after the Fukuoka Flood by the Kyushu Regional Construction Bureau of the Construction Ministry and by Fukuoka Prefecture, among 109 buildings around Hakata Station, only 24 were equipped with "drainage pumps for pumping out floodwater", while 3 had "drainage pumps for purposes other than pumping out for floodwater". 17 buildings had "water-stopping boards and sandbags installed at entrances". 2 buildings had "raised entrances", 6 had taken "other countermeasures". 57 buildings, more than half of the total number, had taken no countermeasures at all. Of 49 buildings around the Tenjin area, 2 were equipped with "drainage pumps for pumping out floodwater", and 1 had "drainage pumps for purposes other than pumping out for floodwater". The remaining 46 buildings had taken no countermeasures at all (based on documents from the River Information Center). The problems of underground flood disaster do not concern individual buildings alone. These days, the various kinds of underground space, such basement floors of buildings, subways and underground shopping areas, are complexly interconnected. Even if subways and underground shopping areas take adequate countermeasures against flood disaster, flood water will flow in from connected underground spaces if these do not take their own measures. Therefore, a comprehensive set of

countermeasures is necessary in which subways, underground shopping areas and connected buildings work together in cooperation. The present situation is far from satisfactory. In order not to repeat the tragedy at Fukuoka, a comprehensive underground flood prevention plan is urgently needed.

Next, we will examine the information system.

As we have already mentioned several times, one of the reasons for the unfortunate loss of life in the Fukuoka flood disaster was the failure to transmit to citizens the information that the inundation of the areas around Hakata Station was caused by the overflow of the Mikasa River. According to our survey, no residents received the overflow information before noon.

This is because even the authority directly responsible for disaster countermeasures, the Fukuoka City Fire Department, did not have this information. If the relevant authorities do not have the information, it cannot be transmitted to inhabitants either. The press and media response will also consequently be delayed. There are a number of reasons for the overflow information not having been transmitted to the fire department.

Firstly, although the prefectural authorities in charge of river management transmitted the information that the Mikasa River was overflowing to Hakata Ward Office and the Fukuoka City River Management Section, they did not inform the Fire Department.

The lack of awareness that this could be a matter of life or death is surely inexcusable, even considering the difficult circumstances (i.e. the information was sent by telephone only due to the hurried circumstances of disaster response even though such information is normally confirmed by facsimile, and the receiving side was also very busy and could not process the information adequately). The problem here seems to be a case of systemic failure, rather than individual error. When transmitting information, there are basic procedures that should be followed, such as using facsimile without fail, and making sure that both sender and receiver confirm each others' name and status (this is necessary in order to make it clear who is responsible, and for the purposes of subsequent confirmation and inquiry). Another important problem is the route by which information is transmitted. In the case of the Japan Sea Earthquake on May 26, 1983, the Tsunami warning issued for the Japan Sea Coast of the Tohoku area, was disseminated via the following route: Tohoku Regional Meteorological Agency → Akita Local Meteorological Agency → Akita Prefecture → cities, towns, and villages in the prefecture. However, somewhere along this long route, a failure of transmission occurred and the lower authorities did not receive it. The reason was

that Akita Prefecture was so preoccupied with the dissemination of information on fire precautions after the earthquake that they did not transmit the Tsunami warning to cities, towns and villages under their jurisdiction.

Another similar case is that of the Unzen Fugendake volcanic eruption in 1991. Just before the pyroclastic flow occurred on 3rd of June, an employee of the Unzen Observation Station sent out information about abnormal signs from the mountain. This information was relayed from the observation station to a local branch of the Nagasaki prefectural government. From there it was to be transmitted to the City of Shimabara and then to the fire brigade. However, somewhere along the line the information simply disappeared. What we would like to emphasize here is not only that the transmission of emergency information (such as information on the overflow of the Mikasa River) takes time when it has to pass through many stages, but also that it is often not transmitted at all. A system needs to be constructed in which urgent and important information is transmitted directly to the place at which disaster countermeasures are being undertaken. We are not proposing that the current route of information transmission (Fukuoka Public Works Office → Fukuoka City Office and its River Management Section → Fukuoka City Fire Department, or Naka Public Works Office → Hakata Ward Office → Hakata Fire Station) should be done away with. Rather, we are suggesting that additional emergency transmission routes be instituted (for example, Fukuoka Public Works Office → Fukuoka City Fire Department). It is desirable that the routes for disaster information dissemination be as diverse as possible.

Secondly, the River Section of Fukuoka Prefecture itself had difficulty in obtaining information about the overflow. It is precisely at such times of high water levels that river information is of greatest importance. There is something seriously wrong if the necessary water level information cannot be obtained because it is too dangerous for people to approach the river and take measurements. A system whereby water level information is automatically transmitted needs to be put in place - for example, by the installation of a telemeter. At the time of the Fukuoka flood disaster, a principal of a near-by primary school reported to Hakata fire brigade by telephone that the Mikasa River was about to overflow. In the case of urban rivers where large numbers of people live in the floodplains, it is also important to construct a system whereby local residents can report information on rivers (a disaster prevention monitor system). On National Highway 229, where a serious accident occurred in Toyohama Tunnel in February 1996, a system was already in place whereby drivers or local residents could reports signs of rock slides to the Hokkaido Development

Department. Of course, it is not enough for such systems to be in existence; it is also important that they should function effectively.

As mentioned before, there is a "caretaker system" in Fukuoka City, whereby caretakers report to the authorities when a disaster occurs, or looks about to occur, but this system does not seem to have functioned effectively. To avoid this kind of case, such systems must be reinforced by regular training and disaster prevention drills, even after they have been put in place.

There are a number of further problems to note. The prefectural Public Works Office did not inform Fukuoka City about the overflow around Itatsuki Bridge because they had already issued a flood prevention warning. Even so, such important information should have been transmitted to the city authorities. The Fire Department had no clear idea about the flood disaster caused by the river overflow, and was preoccupied with answering 119 emergency telephone calls. Nevertheless, fire brigades or other personnel should have been dispatched to gather information on the water level of the Mikasa River. Finally we would like to emphasize the importance of information dissemination from city authorities to local residents.

When Fukuoka City and its river managing section, or Hakata Ward Office were informed about the overflow of the Mikasa River, did they even consider how such information could be transmitted to the people in the flood-prone vicinity of Hakata Station (especially in the underground spaces)? What form of communication media might they have used? A suitable medium of communication could probably not have been found.

Generally speaking, when we think about information transmission in urban flood disasters, there are two aspects that need to be considered: ① "information gathering" (how to gather information on rainfall and water levels, etc.), ② "information transmission" (how to disseminate the information gathered).
② can be sub-divided into two aspects: ② - ① "information transmission between official organizations or within organizations" and ② - ② "information transmission from official organizations to ordinary citizens" . So far, we have only dealt with ① and ② - ①. We have yet to mention ② - ②. However, this latter aspect is of great importance when considering disaster prevention.

Very little attention has yet been given to the issue of how to disseminate urgent information to the people in underground spaces. This is not surprising given that disasters in underground spaces have not gained much attention until quite recently.

However, if we are to give serious thought to disaster countermeasures in underground spaces, information dissemination and evacuation guidance must become a central consideration, together with the design and improvement of physical facilities ("hardware") for disaster prevention.

How then can we disseminate urgent information to people in underground spaces? In response to the Fukuoka flood disaster on June 29th, and the Tokyo flood disaster of July 21st, the Construction Ministry issued a paper "On the Enforcement of Urgent Flood Countermeasures in Underground Spaces" on 30th of August 1999. In the section on "Transmission of Flood Information and so forth to Managers of Underground Spaces", it is stated as follows: "It is important that managers of underground spaces take proper countermeasures when floods occur. (p.23)

In order to do so, those responsible for river management will transmit the flood information directly to managers of subways (underground railways). When those responsible for flood prevention (mayors and leaders of town and village administrations) deem it necessary on the basis of flood information from river authorities or citizens, managers of underground shopping areas and other underground spaces will consider ordering people in these places to evacuate, making use of disaster prevention wireless communication systems and in cooperation with local government associations. Information dissemination through the mass media also needs to be fully developed." In other words, since river managers transmit the information to subway managers directly, subway managers are requested to inform their passengers. For other underground spaces, the river manager gives the information firstly to a mayor, or other local government leader, who is then to pass the information on to the managers of the underground facility, who in turn passes it on to the people using that facility.

far as information transmission is concerned, the problems facing subways may not be so great, because they have well developed public address systems and they are accustomed to dealing with passengers. The problem is with the latter information transmission route (river manager → mayor, or local government leader → underground space manager → passengers or customers). This is again communication with many steps, like a chain. There is no knowing when and where this communication chain might be cut and the information not transmitted.

At the end of the passage from the Construction Ministry paper quoted above it is stated, "Information dissemination through the mass media also needs to be fully

developed". We believe it is extremely important to make use of this route of information transmission, especially NHK (the public broadcasting organization) and other broadcasting media. If one considers how information about the Mikasa River overflow was obtained by the mass media, it is clear that it became known as a media event, not as the result of information transmission from any official agency. If information about river overflows were transmitted directly from river managers to mass media, in the same way that severe rain and flood warnings or typhoon warnings are always simultaneously transmitted from the Meteorological Bureau, the public would be immediately informed about the situation. This information would also be transmitted rapidly to users of underground facilities, if managers of these facilities are informed and turn on their radios or televisions as they do when heavy rain falls or a typhoon approaches. Of course, such matters require detailed discussion among all the parties concerned, and there may be other minor changes that could be implemented.

However, it is our belief that use of the mass media is the way to make possible an effective transmission of information in underground spaces.

Chapter 2. The Existing Condition and Problems of Flood Countermeasures in Underground Spaces

1. The Existing Condition of Flood Damage in Underground Spaces

There are enormously varied forms of underground space, such as underground shopping areas, underground passage ways, basement selling floors of large department stores, underground car parking lots, underground railways and stations, and underground highways. Such spaces are very familiar, and used daily by an undetermined large number of persons. However, it has not until now been very well known that these extremely familiar underground spaces are at risk at times of heavy rainfall.

According to source data, it is reported that 43 such facilities all over Japan suffered inundation damage in 1998 (see table 1).

We see from this data that underground flood damage occurred in the basement floors of apartment buildings (most of which are presumably used as car parking lots), and underground shopping areas of buildings (principally mixed-use buildings occupied by

various kinds of tenants, such as wholesale outlets, retail shops, restaurants and other service businesses).

Thus inundation damage could well occur in an underground space familiar to any of us. However, measures against flood damage in underground spaces have not been seriously implemented until the recent accidental deaths in Fukuoka and Shinjuku (in Tokyo).

Table1: Conditions of damages in underground spaces due to flood disasters in 1998 (from survey data)

date	prefecture	city,town,village	damage	remarks
Jul.27～28	Aichi	Nagoya city	an apartment house	underground floor
Jul.30	Kanagawa	Yokohama city	an apartment house	underground floor
			a buliding with various tennants	farmer or fishery
			an apartment house	underground floor
			a buliding with various tennants	farmer or fishery
Aug.3	Tokyo	Ohta ward	an apartment house	underground floor
Aug.4	Nigata	Nigata city	hotel	service and other industry
			a buliding with various tennants	parking
			hotel	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			hotel	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			a building of an electric appliance store	whole sale･retail sale,restaurant
			a buliding with various tennants	service and other industry
			a buliding with various tennants	service and other industry
			a buliding with various tennants	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			a buliding with various tennants	whole sale･retail sale,restaurant
			hotel	service and other industry
			hospitak	service and other industry
Sep.15～16	Tokyo	Nakano word	collective houses with tenants	whole sale･retail sale,restaurant, service and other industry
Sep.22	Hyogo	Kobe city	a buliding with various tennants	whole sale･retail sale,restaurant
Sep.24～25	Kouchi	Kouch city	a buliding with various tennants	whole sale･retail sale,restaurant
			west wing of a prefectural office	whole sale･retail sale,restaurant, service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant, service and other industry
			a building of retail shop	whole sale･retail sale,restaurant
			a buliding with various tennants	underground floor
			a buliding with various tennants	whole sale･retail sale,restaurant, service and other industry
			a buliding with various tennants	service and other industry
			a buliding with various tennants	whole sale･retail sale,restaurant
			a buliding with various tennants	whole sale･retail sale,restaurant
			other 10 facilities	
Oct.17～18	Okayama	Tuyama city	a buliding with various tennants	whole sale･retail sale,restaurant
			a buliding with various tennants	underground floor
total			43	

Pigested from: River council General Policy Committee Risk Management Subcommittee 'The basic direction of risk management of flood disaster and sediment disaster'

2. Some characteristics of flood damage in underground spaces

New types of problems which had not been seen in previous urban flood disasters came to light in the underground flood disasters in Fukuoka and Tokyo. Here we will discuss the characteristics of flood damage n underground spaces as revealed by the results of a hearing survey we conducted with some of people directly concerned with the Fukuoka Flood. We will do this from the perspective of the following issues

people's perception of the underground disaster environment
city centers as areas of information shortage
architectural structures susceptible to water accumulation
serious damage caused by electrical power cuts

2-1 People's perception of the underground disaster environment

First of all, needless to say, underground spaces are located in areas lower than the ground level. Therefore, such spaces are at greater risk of inundation than other facilities. When water floods the ground surface it is liable to pour down suddenly into underground spaces unless countermeasures are taken. In the Fukuoka disaster, flood damage due to the down-flow of rainwater occurred in the Hakata Subway Station concourse, basement floors of hotels linked to underground shopping areas, and basement floors of mixed-use buildings. Countermeasures had been taken at some of the entrances to underground spaces, such as raising these entrances, or piling sandbags around them. However, since the water level reached waist-depth above ground, water flowed over these obstacles and into the underground spaces.

As for people's perceptions, including those of the users of the underground facilities, it is reported that some people descended the staircases down to the underground level with only a little hesitation, while the rain water was rushing down into the underground space. This is despite the fact that the water was pouring over the sandbags laid at the entrances and flowing down the stairways. One can assume that these users had little awareness of the risk of inundation damage in underground spaces. The restaurant employee who drowned in the basement floor of Fukuoka Daini Toufuku Building seems not to have felt any anxiety despite having been informed of the flood situation by the building manager. From this one can surmise that she had no conception of flood disaster damage in an underground space.

Table 2 shows the results of flood simulations in major underground shopping areas

throughout the country. This shows the minimum time in which flood water would reach the entrances of underground spaces and the maximum floodwater depth that would be attained if the banks of directly controlled rivers burst. In the case of the underground space in Asakusa, according to this simulation, it would take only 6 minutes for floodwater to reach the entrance. In the case of the underground space at Yaesu, it would take only 16 minutes. The reality is that people regularly use underground spaces without any awareness of the risk of flood disaster damage.

Table 2. The Results of Flood Simulation

river	underground mall	the minimum time in which floodwater would reach the entrance of underground spaces		the muximum floodwater depth	
		time(minute)	depth(m)	time(minute)	depth(m)
Ishikarigawa river	Odoori underground mall	30	0.6	30	0.6
	Sapporoekimaeodoori underground mall	60	0.1	60	0.1
	Sapporoeki south exit park underground mall	30	0.2	30	0.2
Arakawa river	Yaesu underground mall	16	0.6	20	0.7
	Miharabasi underground mall	21	0.3	24	0.4
	Sudamachi subway store	14	0.2	18	0.3
	Keikyuu shinntika	28	0.1	31	0.2
	Asakusa underground mall	6	1.7	7	0.1
Shinanogawa river	Nishihori Rohza	60	2.0	60	2.0
Shounaigawa river	Shinkansen underground mall Esuka	60	2.3	60	2.3
	Yunimall soto	120	3.1	10	3.1
Yodogawa river	Whity Umeda	54	3.3	54	3.3
	Hankyu 3bangai	48	3.5	48	3.5
	Dojima underground center	104	2.5	104	2.5
	Nakanoshima underground mall	167	1.7	167	1.7
	Dia mall Osaka	71	2.9	71	2.9
Yamatogawa river	nannan town	300	1.2	300	1.2
Asahigawa river	Okayama 1bangai soto	35	1.7	35	1.7
	nakanomati underground shopping mall	35	1.7	35	1.7

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2-2. City centers as areas of information shortage

Secondly, it is also a feature of underground spaces that users cannot grasp the situation of disaster damage above ground while they are using the underground space.

From the perspective of underground space managers, this can cause the initial response to flood disaster to be delayed. This can in turn delay the evacuation of users from the facility. Due to the structure of underground spaces, the only means by which users can receive information about disaster damage above ground is through public announcements by the underground space managers. Despite being located in city centers, such spaces are areas of information shortage susceptible to disasters.

2-3 Architectural structures susceptible to water accumulation

Thirdly, because of the structure of the facilities, it is possible that doors cannot be opened when water floods an underground space due to water pressure. In the Shinjuku flood disaster, a man drowned after becoming shut into the submerged basement of a house in a low-lying area, which he had entered to inspect. Although the basement was equipped with an external staircase, it seems that water pressure prevented the outward-opening door from opening. Generally speaking, an elderly person or a woman will be unable to open a door in a submerged space when the depth of the water reaches as far as the knees. Even for an adult man, it is far from an easy task.

According to the eyewitness account of the hotel receptionist, who went to inspect the flooded basement of the hotel in Fukuoka, it took the combined effort of three persons to force open a fire door that had closed. At that time, the water was up to their knees.

Once water enters an underground space, it tends to remain their for a time due to the difficulty of drainage. As a result, doors that open and close easily under normal circumstances can turn into lethal weapons.

2-4 Serious damage caused by electrical power cuts

The electrical power facilities of buildings are often located in the basement. Therefore, if the electrical power facilities are submerged, power failure may occur not only in the entire underground space, but can also affect other connected facilities.

According to our hearing survey among facility managers after the Fukuoka Flood Disaster, customers who use a great deal of power, such as corporations, are usually linked with the other heavy power users and transformer substations through high voltage cables

in what is known as a spot network. In this instance, six large power users, including the hotel whose electrical facilities were completely submerged, were linked in a spot network. Each of these power customers had PAS electrical leakage sensors fitted. When the hotel's facilities were inundated, power failure occurred in the other five customers as well. It is rare for damage in just one customer to affect the others, but in this flood disaster, the hotel's electrical power facilities were so completely submerged that it was not possible to restrict the damage only within one customer by cutting off the service wire into the hotel.

Due to the structure of underground spaces, electrical power facilities are often located underground. Therefore, inundation damage in underground spaces can spread to the extend of paralyzing urban functions, involving other large power users.

3. The Present Condition and Problems of Disaster Prevention Measures for Managers of Underground Spaces

As was already stated at the beginning of this chapter, inundation damage in underground spaces has gained attention as a new form of urban flood disaster. Debate has now begun on how to prevent and respond to such disasters in the future. We will now consider the present situation and problems of disaster prevention measures, on the basis of hearings conducted with managers of underground facilities in Fukuoka and Sapporo, and the results of recent research and analysis by the River Council General Policy Committee.

3-1. Information Gathering by Managers of Underground Spaces

The means which managers of underground spaces use when they need to obtain information in times of flood disaster are shown in table 3. According to this, most of the managers of underground space do not have any means of collecting information on weather, rivers and river overflows, and basically have to rely on mass media, such as radio or television. Thus, they are in no better position to obtain such information than the average citizen. Managers of underground space have almost no means of collecting information on river disaster damage. They have no system of grasping the situation on the ground or collecting information on rivers.

Usually the situation of water levels and so forth is monitored by river administrators in the Construction Ministry or prefectural government, but this information is not always transmitted to city, town or village offices in real time. So one can imagine to some extent

how it is that citizens or underground space managers are not given any information of this kind.

Here we will give an example of a case in Chuo Ward in Tokyo. In Chuo Ward a system is organized so that disaster information or evacuation advice is transmitted efficiently to the local inhabitants by ward offices, police and fire stations (fire brigades) with the cooperation of private groups, such as disaster prevention organizations or self-government associations, or through a disaster prevention radio communication system installed in public or private facilities in the ward (93 places) or loud-speaker cars. However, information can be transmitted through the disaster prevention radio system or loud-speaker cars only to the residents on the surface, not to those in underground spaces, such as the underground space in Yaesu.

On the other hand, table 4 shows that subway administrators are supposed to receive information via disaster prevention radio, or from the local meteorological office by facsimile. Nevertheless, in the Fukuoka Flood disaster, the station master of Hakata Subway Station was given no information at all about the Mikasa River overflow. Even someone like a subway station master, who has relatively easy access to information, was not informed that the cause of the flooding was the river overflowing.

This indicates that the present information transmission routes have some problems.

On August 30th 1999, the Construction Ministry issued a memorandum to the relevant parties on "Flood Disaster Information Transmission to Managers of Underground Spaces" in a document entitled "On the Enforcement of Urgent Countermeasures in Underground Spaces". According to this, river managers are to disseminate information to subway managers when there is the possibility of flooding. The subway managers should then give this information to passengers. Thus, one could say that the information transmission route of "river administrator → subway manager → users" has almost been established.

The problem lies in the information transmission route to managers of underground spaces such as underground shopping areas. There is no established direct transmission route to these underground space managers. Information is transmitted first to the city mayors, or leaders of town and village administrations, and is then passed on from them to underground space mangers. In this case information is disseminated along the following route: river manager → city, town or village office → underground space managers → underground space users. In the previous chapter, we presented a river overflow simulation. Are there any problems specific to cases where flood water arrives in a short time and urgent

countermeasures have to be taken? In the interests of rapid and accurate dissemination, disaster information should be transmitted directly from river managers to underground space managers. This is also necessary in order to avoid the kind of information transmission break-down as seen in the Fukuoka case, or the exacerbation of damage caused by delaying the public announcement of an accident, as occurred in the nuclear accident at the JCO plant in Tokai village. In order to avoid these kind of problems, transmission routes should be organized so that disaster information is disseminated as directly as possible.

Table3, Information Gathering by Managers of Underground Space

underground space	prefecture	city	manager	river	means of information gathering			notes
					weather info	river info	river overflow	
Aurora town	Hokkaido	Sapporo city	Sapporo toshi kaihatsu kousya. Inc	Ishikari gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Pole town	Hokkaido	Sapporo city	Sapporo toshi underground mall kaihatsu.Inc	Ishikari gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Sapporoeki meitenngai	Hokkaido	Sapporo city	Sapporo toshi under-Ground mall kaihatsu.Inc	Ishikari gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Station Deparyment	Hokkaido	Sapporo city	Sapporo toshi under-Ground mall kaihatsu.Inc	Ishikari gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Esuta 2bangai	Hokkaido	Sapporo city	Sapporo toshi under-Ground mall kaihatsu.Inc	Ishikari gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Yaesu underground mall	Tokyo	Chuuou ward	Yaesu underground mall .Inc	Arakawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Miharabasi underground mall	Tokyo	Chuuou ward	Shin Tokyo kanko.Inc	Arakawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Kandaekikounai shop	Tokyo	Chiyoda ward	Teito Rapid Transit Authority	Arakawa riv.	information from Eidan	information from Eidan	information from Eidan	Only in urgent case
Keikyu shintika	Tokyo	Minato ward	Keikyu Shinbashi undergound parking	Arakawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Asakusa underground mall	Tokyo	Taitou ward	Asakusa underpass.Inc	Arakawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Nisihori roza	Nigata	Nigata city	Nigata underground development.Inc	Syounai gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Shinkansen under-ground mall esuka	Aichi	Nigata city	Esuka.Inc	Syounai gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Yuni mall	Aichi	Nagoya city	Yuni mall.Inc	Syounai gawa riv.	TV and other Mass media, internet	TV and other Mass media, internet	TV and other Mass media, internet	
Whity Umeda	Osaka	Osaka city	Osaka underground mall .Inc	Yodo gawa riv.	Fax from river section of city office	Fax from river section of city office	Fax from river section of city office	
Puchi syanzerize	Osaka	Osaka city	Osaka underground mall .Inc	Yodo gawa riv.	Fax from river section of city office	Fax from river section of city office	Fax from river section of city office	
Dojima underground mall (dochika underground mall)	Osaka	Osaka city	Dojima underground mall .Inc	Yodo gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Nakanoshima underground mall	Osaka	Osaka city	Asahi buliding.inc	Yodo gawa riv.	TV and other mass media	TV and other mass media	TV and other mass media	
Nannan town	Osaka	Osaka city	Osaka underground mall .Inc	Yamato gawa.riv	Fax from river section of city office	Fax from river section of city office	Fax from river section of city office	
Osakaeki diamond underground mall (Dia mall)	Osaka	Osaka city	Osaka shigaichi kaihatu.inc	Yodo gawa riv.	Fax from Osaka city office	Fax from Osaka City office	Fax from Osaka City office	
Okayama 1bangai	Okayama	Okayama city	Okayama station center.inc	Asahi gawa riv.	TV and inquiry to prefecture, city, meteorol. observatory	TV and other mass media	TV and other mass media	Mainly from Toshi-Seibi section
Nakanomati underground shoping mall	Okayama	Okayama city	Okayama toshi seibi.inc	Asahi gawa riv.	none	none	none	
Hiroshimakamiyatyou underground mall (under construction)	Hiroshima	Hiroshima city	Hiroshima underground kaihatsu.inc	Ohta gawa riv.	underplanning	underplanning	underplanning	Will be completed in March,2001

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'The basic direction of risk management of flood disaster and sediment disaster'

Table 4:Information Gathering by Managers of Underground Space

underground space	prefecture	city	manager	river	means of information gathering			notes
					weather info	river info	river overflow	
Sapporo city subway	Hokkaido	Sapporo city	Sapporo city traffic dep.	Ishikarigawa riv.	Fax from Sapporo kannku meteological office	disaster prevention radio comunication	disaster prevention radio comunication	Via fire dep.(river)
Sendai city subway	Miyagi	Sendai city	Sendai city traffic Dep.	Natorigawa riv.	Fax from Sendai Kannku meteological office	TV and other mass media	TV and other mass media	
Eidan subway	Tokyo	----	Teito Rapid Transit Authority	Arakawa riv.	Fax from Japan Meteological Agency	direct from river information center	direct from river information center	
metropolitan subway	Tokyo	----	Osaka underground mall.Inc	Yamatogawa.riv	Fax from Japan Meteological Agency	TV and other mass media	TV and other mass media	Via general manegement Dep. (weather information)
Yokohama city subway	Kanagawa	Yokohama city	Yokohama city traffic Dep.	Tsurumigawa riv.	Fax from Meteological kyokai	TV and other mass media	TV and other mass media	
Nagoya city subway	Aichi	Nagoya city	Nagoya city traffic Dep.	Syounaigawa riv.	Radio FAX	Radio FAX	Radio FAX	only in encrgency case
Osaka city sub way	Osaka	Osaka city	Osaka city traffic Dep.	Yodogawa riv.	Fax from Osaka kannku meteological office	Radio FAX from shiei Dep.	Radio FAX from shiei Dep.	citizen Dep. Safety counter measure sec.

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3-2 Systems for Evacuation Guidance

First, we will explain the system for fire prevention management in underground spaces. In accordance with the Fire Safety Law, underground space managers are designated as fire prevention managers. They thereby become responsible for the formulation of a detailed fire safety plan for the facilities under their management. Such a plan provides for the establishment of a self-defense fire prevention organization formed by tenants and managers of the underground spaces themselves.

This fire prevention organization is divided into sub-groups with clearly defined roles in times of disaster, such as fire fighting, information dissemination, rescue and relief, and evacuation guidance.

Then, what kind of disaster is assumed in the fire fighting plan and what kind of disaster

prevention activities are conducted through the system for evacuation guidance? Table 5 shows a summary of an example of a fire safety plan formulated under the supervision of Tokyo Metropolitan Fire Fighting Agency.

First, the "purpose" stated in the "general provisions" of article (1) chapter (1) is "to prevent fire, earthquake, and other disasters and to strive for the safety of human life and the mitigation of damage". Likewise, under the heading of "organizing self defense fire fighting units" in article 33 of chapter 3 ("Self-defense Fire Fighting Activities and Countermeasures") it is stated as follows: "self defense fire-fighting units are to be organized in times of disaster such as fires or earthquakes."

All these indicate that flood disaster is not assumed in the disaster prevention organization of underground spaces. Furthermore, under "Evacuation Guidance" in chapter 39 it is stated as follows: "When fires occur, members of the central evacuation guidance unit will, in cooperation with local units, give priority to the evacuation of the floor where the fire started and the floors above that floor. ... While carrying out evacuation guidance, they will inform evacuees of the direction of the evacuation route and the condition of the fire using such equipment as loud-hailers, flashlights (electric torches), alarm whistles, and ropes, and carrying out the evacuation in such a manner as to avoid confusion."

As is indicated in the above, there is no mention of flood disasters in the fire safety plan, which suggests that they are simply not taken into account as one of the kinds of disasters that could occur. What are the dangers overlooked in such fire fighting plans that could occur in underground spaces when there is a flood disaster?

First, the exits to which evacuees are directed by evacuation guides are not always safe in times of flood disaster. When fires occur in underground spaces, people are usually evacuated to the surface under the guidance of the evacuation guidance unit of the self-defense fire prevention organization. In the case of disasters other than floods, once people reach the surface they are safe. However, in cases of flood disaster, it is different. As soon as they evacuate to the ground level, water may suddenly pour over them. Thus, according to the existing evacuation routes, some exits may be designated as "not to be used for evacuation". It is also necessary for evacuation guides to give information as to where to take refuge after evacuees reach the surface.

Furthermore, as already mentioned in our account of the characteristics of flood disaster in underground spaces, it is possible that doors may not open due to water pressure when water accumulates underground. In order to plan effectively for such flood disasters,

managers and tenants of underground spaces must take another look at evacuation guidance, bearing in mind the present structure and land conditions of underground spaces. This is true in relation to a number of points, including the location of the most appropriate routes in times of flood disaster, where the evacuee should go after they reach the surface, and whether there are any places from which people would be unable to evacuate due to the structure of existing underground spaces.

Table 5 Disasters as conceived in an example of a fire prevention plan (summary)

Item		Summary
Chapter 1 general provisions article 1 purpose		
	article 1 'purposes'	◆'to prevent fire, earthquake, and other disasters and to strive for the safety of human life and the mitigation of danger'
Chapter 3 self-defense Fire Fighting Activitions and contermeasures		
	article 33	◆'self-defense units are to be organized in time of disaster such as fires or earthwuakes'
	article39 (Evacuation Guidance)	◆'When fires occur, members of the central evacuation guidance unit will, in cooperation with local units, give priority to the evacuation of the floor where the fire started and the floors above that floor. ' ◆'While carrying out evacuation guidance, they will inform evacuees of the direction of the evacuation route and the condition of the fire using such equipment as loud-hailers, flashlights (electric torches), alarm whistles, and ropes, and carrying out the evacuation in such a manner as to avoid confusion.'

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3-3 Facilities and Equipment for Dealing with Floods

3-3-1. Flood Prevention Measures

Flood prevention measures are generally based on the following three concepts:

- Preventing water from going underground in the first place
- Not allowing the floors people use to become flooded even when water does flow underground
- Stopping water from spreading once it has entered

Measures designed to "prevent water from going underground in the first place" consist of both permanent facilities and structures, and facilities, which operate only in times of

emergency (i.e. when flooding seems about to occur). The inundation of the underground space at Hakata Station in the Fukuoka flood disaster of June 29th 1999 was caused by the entry of water through staircase entrances and ventilation shafts. The general prevention measures against such flood damage are as follows on table 6.

Table 6: Flood prevention facilities at entrances to underground spaces and ventilation shafts

examples of countermeasures	situation of setting
at entrances to underground	
1.raising the entrance	permanent
2.water-stopping board ・ prevention wall	permanent
3.water-stopping ・ water prevention wall	permanent
4.water-stopping ・ water prevention wall	in times of emergency
5.sand bags	in times of emergency
at ventilation shafts	
1.raising the shafts	permanent
2.building a wall around the dhafts	permanent
3.setting the shafts at higher place	permanent

Measures for "not allowing the floors people use to become flooded even when water does flow underground" consist of structures for the retention of rainwater which has flowed underground (rainwater reservoir layers). Alternatively, there may be a facility like a manhole shaft whereby rainwater that enters falls into a drainage tank or reservoir for spring water.

Measures "stopping water from spreading once it has entered" are such things as flood doors which prevent the circulation of water.

However, such flood prevention facilities have not been installed in all underground spaces. Indeed, at the present time, underground shopping areas and the basement floors of mixed-use buildings are generally not so equipped.

Some subways (underground railways) and underground shopping areas have implemented their own countermeasures based on prior experience of flood damage. But in most underground spaces, flood damage prevention measures have still not been sufficiently implemented. Indeed, most are not even equipped with the minimum countermeasures to prevent the entry of floodwater, such as water-stopping boards and sandbags.

Table 7 shows the results of a survey on the situation of flood disaster countermeasures in buildings with underground spaces in the vicinity of Hakata Station, carried out by

Kyushu Regional Construction Bureau and Fukuoka Prefectural Government after the Fukuoka flood disaster. According to this survey, among 109 buildings around Hakata Station, the number of buildings equipped with drainage pumps for pumping out floodwater was 24, while those with drainage pumps for other purposes were 3. Those with facilities for the placement of water-stopping boards or sandbags were 17, and those with raised entrances were 2. Six buildings had implemented other measures, while 57, a majority of the total, had no flood countermeasures at all.

Among 49 buildings in the Tenjin District, two were equipped with drainage pumps for pumping out floodwater, and only one had drainage pumps for other purposes. The remaining 46 buildings had no countermeasures against inundation at all. (from data provided by the River Information Center)

Underground spaces are in many cases linked to each other, so it is not enough for one to implement countermeasures individually. Even if a large-scale underground space implements thorough inundation countermeasures, this will come to nothing unless the buildings linked to it also take countermeasures. Therefore, there is a need for comprehensive flood countermeasures in which subways, underground shopping areas, and the buildings linked to them work together.

Table 7: The flood countermeasure situation in buildings that suffered damage in the Fukuoka Flood (from a survey by the Fukuoka Regional Construction Bureau and Fukuoka Prefecture)

the situation of innundation counterueasures of buildings	number of buildings
1.drainage pumps for pumping out floodwater	24
2.drainage pumpsfor other purposes	3
3.placement of water-stopping boards or sand bags	17
4.raised entrances	2
5.other measures	6
6.no countermeasures at all	57
Survey Total	109

3-3-2. Inundation Countermeasures for Electrical Power Installations

As mentioned in our account of the characteristics of flood disaster damage in underground spaces, the electrical power installations of facilities with underground spaces tend to be located on the basement level. At most, flood countermeasures for electrical power installations amount to the fitting of a water leakage sensor. This is far from being a

measure actually preventing flood damage. As a result, once an underground space is flooded, and the electrical power installation is submerged, the provision of electrical power to the whole facility is stopped. As regards the placement of electrical installations underground, it would seem that we should draw a lesson from the Fukuoka Flood, and thoroughly protect such installations from flooding, or simply not put such vital equipment in basements at all.

4. The Way Measures for Disaster Prevention Should be in Underground Space

Then, what is necessary when we think of disaster countermeasures in underground space? Here we will investigate how disaster countermeasures should be in the future, focusing on the following four points: advanced warning of danger, the information dissemination system, the evacuation guidance system, and flood countermeasures.

4-1. Advanced Warning of Danger

First of all, it is necessary to make users of underground spaces aware of the risks, and have them appreciate in advance of any disasters that "an underground space is not always a safe place". As mentioned at the beginning of this chapter, it seems that people use underground spaces with little or no awareness of the following risks:

- that water can flow into an underground space and cause it to become flooded
- that doors may not open or close due to water pressure
- that floodwater can reach in a very short time when a major river bursts its banks

Very few people have the ability to imagine what would happen if a disaster occurred while they are using an underground facility. Very few would know immediately what to do if such a disaster actually occurred. It is necessary to inform and enlighten such users about the risks when flooding occurs, by providing readily comprehensible information through television, radio, pamphlets, leaflets, and posters, including simulations of the types of damage that can occur, and guidance on the methods and routes of evacuation.

It is also necessary to make known to the public information on the environment of past disaster damage, including flood damage in underground spaces, the extent of the areas inundated, floodwater depth, the amount of rainfall, and land formations. It is necessary to

make it known that flood damage in underground spaces is not at all exceptional, but occurs in our everyday life, as is shown in the actual experience of flood damage in 1998.

Because many large Japanese cities lie below the planed high water level of rivers, and the underground spaces in these cities are therefore naturally located at even lower levels, the danger from flooding should be quite obvious. The area around Hakata Station in Fukuoka and around Umeda in Osaka (the very name "Umeda" is said to have originally meant, "buried rice field") are good examples of this. In particular, the area around Hakata Station used to be a low wetland, and its low-lying landform was retained even after it became urbanized. It therefore suffered serious flood damage from this overflow of the Mikasa River. While conducting our survey, we heard many people express the view that they just could not imagine that water from the Mikasa River would come as far as the vicinity of Hakata Station. We can assume from this that most of the inhabitants of that area do not even know that it is low-lying land. If only they had been aware of the local land conditions, they would have surely understood that the area is susceptible to flood damage and forms a dangerous disaster environment.

If information regarding the risks in underground spaces were always made available to the public, the inhabitants would become aware of the fact that the underground spaces they use daily are in danger of becoming submerged or inundated when floods occur, and that water accumulates easily in such low-lying land. In so doing, it is expected that the users will have better risk awareness with respect to underground spaces, and will respond to disasters in a rapid and orderly manner, and not take dangerous actions, such as entering underground spaces while water is pouring into them. Likewise, it is also necessary to inform the public about the areas where flooding is predicted and the actual circumstances of damage in underground spaces, while making efforts to raise users' awareness of disaster prevention measures.

4-2 The Information Dissemination System

One of the causes of the loss of life in the underground space in the Fukuoka Flood Disaster was that information about the overflow of the Mikasa River was not transmitted to the restaurant employee who died. Information about the overflow of the river was not disseminated to citizens at all until two hours after it happened.

In this flood disaster, one of the main reasons for the overflow information not being transmitted to the manager of the underground facility was that the information route was

not well organized. As mentioned before, managers of underground spaces depend largely on television and other mass media for information gathering. This is hardly a satisfactory situation. In the future, it has been decided that the information route in times of disaster will be as follows:

river manager → city, town, or village office → underground space manager → underground space users. Is this really sufficient?

In the case of the Fukuoka flood disaster, information about the overflow of the Mikasa River was transmitted from the prefectural river manager to the river managing section of the city office, but contrary to usual practice, this was done by telephone only. The usually procedure is to notify by facsimile, and then to confirm by telephone afterwards. As a result, the overflow information disappeared somewhere along the route of transmission and did not reach those at the end of the route. The reason for the information having been transmitted by telephone only is that the administration side was too preoccupied responding to the disaster situation.

Several similar cases, in which preoccupation with disaster response measures lead to information not being properly transmitted, have occurred in the past. For example, at the time of the volcanic eruption of Unzen Fugendake Mountain in 1991, the information about abnormal phenomena from the mountain disappeared somewhere along the route of its transmission from the observation station -> local prefectural office -> Shimabara City -> fire brigade.

How can disaster information be disseminated swiftly and accurately to the scene of the disaster response? What is necessary here is to organize a system by which information gathered by river managers is transmitted to the people on the scene as directly as possible, and to eliminate the possibility of transmission breakdown. It is certainly necessary to have an official transmission route from river managers → city, town, and village offices → underground space managers → underground space users. However, it also important to set up an emergency transmission route directly from river managers to underground space managers. Obviously it is better that information transmission routes be as varied as possible, in order to disseminate disaster information to underground space managers rapidly and accurately.

At present, most underground space managers rely on the mass media to gather disaster information. It will therefore be very important to make use of information transmission through the mass media, especially public broadcasting, such as NHK.

Information on the overflow of the Mikasa River was transmitted as "an event" in the mass media at the time of the Fukuoka flood disaster. Such information should instead be transmitted to viewers as "river overflow information", in the same manner as severe rain and flood warnings or storm warnings issued by the meteorological agency. Making use of mass media in this way would surely be very effective. If managers of underground spaces turn on the television or radio when it rains severely, or when a typhoon approaches, such use of the mass media, while simple, could be very useful.

In order to the complement the observation and information dissemination systems described above, cooperation in the local area is sometimes necessary. It was a local resident who first observed and reported the condition of the Mikasa River when it was about to overflow. It was a serious failure that this information was not disseminated to underground space managers. It takes much time and money to set up fully equipped observation systems. One effective disaster countermeasure would be to mobilize and organize local residents as "river monitors" (this name is tentative), thus forming a system for observing rivers from all sides.

At present, underground spaces tend to become areas of information shortage. Not only is it impossible to see the circumstances on the ground, but there are few available means of gathering information. We think the information dissemination system requires urgent examination in all the above mentioned aspects.

4-3 The Evacuation Guidance System

We found it necessary from our research results to examine the items below in order to set up an evacuation conduct system for the prevention of inundation damage in underground spaces:

- the carrying out of evacuation drills in preparation for flood disasters
- the carrying out of regular inspections to ascertain the safety of evacuation routes (preventing the risk of losses caused by doors not opening or closing)
- setting up places of refuge

First, as regards evacuation drills, in most underground spaces this is carried out about twice a year. However, as previously stated, these are based on the supposition of fires, earthquakes, or gas explosions, and not of flood disasters. The managers and tenants of underground spaces who form the volunteer self-defense fire-fighting units have no prior experience of disasters, and therefore have a very low risk perception. Flood disaster

especially is not taken seriously because it is beyond the supposition of the fire safety plan.

We think that one of the main reasons for risk perception of flood disaster being lower than any other form of disaster is that fire safety plans do not take into account the possibility of flood disasters. This is true to the extent that some of the underground space tenants responded in our in our survey with comments such as "I recognized for the first time the risk of flood damage in underground spaces." It will be important in the future for volunteer fire-fighting units to carry out evacuation guidance drills regularly, taking into account the risk of flood disasters in the fire-fighting plan.

Next, as regards the inspection of evacuation routes (preventing the risk of losses caused by doors not opening or closing), it can be said that the evacuation routes provided for in the fire safety plan are "routes for the rapid evacuation of underground space users to the ground surface" However, in the case of flooding in underground spaces, the evacuation route may be via the very same exits through which rainwater is pouring into the underground space, making evacuation impossible. It is therefore necessary to establish evacuation routes in consideration of the likely routes for the entry of rainwater during flooding. In order to do so, evacuation routes should be decided with reference to the information provided, including hazard maps. Finally, we consider the issue of places for evacuees to take refuge. Once volunteer fire-fighting units conduct evacuating users up to the ground floor, the risk to people's lives in underground space is averted. However, the problem will definitely be raised of where they should go in order to escape the floodwater on the surface after they are evacuated to ground level.

There are two sides to evacuation guidance. One is the problem of evacuation routes and the method of evacuation. The other is the problem of where people should take refuge once they have evacuated. Both need to be considered. In order to do this, it is necessary to examine evacuation guidance plans in times of flood disaster, based on a grasp of the conditions of the location and the architectural structures around it, and consider where the most appropriate place of refuge would be.

4-4. Countermeasures Against Inundation Damage

Based on the results of our research, we believe it necessary that the following two items should be examined in order to organize countermeasures against flood damage in underground space.

- promotion of the installation of flood prevention equipment

- countermeasures against the inundation of electrical power facilities

First, it is important to promote the installation of flood prevention equipment. Among the buildings around Hakata Station surveyed after the Fukuoka Flood by the Kyushu Construction Bureau and Fukuoka Prefecture, more than half had implemented no flood countermeasures at all. Looking at the country as a whole, the number of the buildings suffering inundation damage due to heavy rainfall is not small. Especially in large cities, the intensification of land use has lead to a situation in which retail outlets and other customer gathering facilities are concentrated in the underground floors of buildings. It is therefore necessary to equip these buildings with facilities that will lessen the damage caused by flooding, or delay the onset of inundation.

Furthermore, as regards urban underground spaces, it is often the case that buildings are interconnected at the underground level. It is therefore possible that water will enter from other buildings that have failed to implement inundation countermeasures, even if the building under one's own management has implemented countermeasures. In fact, in the Fukuoka flood disaster, a great deal of rainwater poured in from nearby hotels linked underground with Hakata Subway Station. Comprehensive flood countermeasures must be implemented in close corporation with neighboring buildings, bearing in mind the danger of suffering damage from buildings under different management.

Finally, there is the issue of measures against the inundation of electrical power installations. Buildings with underground floors are rendered susceptible to flood damage, because in many cases their electrical power facilities are located in the basement. Furthermore, since measures against the inundation of electrical power installations are almost never implemented, these installations become submerged almost as soon as floodwater enters. When electrical power facilities are installed in the basement, not only will power failure occur, but it will also take a long time to restore power after inundation.

It is extremely important to take measures so that electrical power facilities become water-resistant, in order to evacuate people quickly and safely from underground spaces to the ground surface.

Chapter 3. Survey Research on the Perception of Flood Damage Risk by Underground Space Users

3.1 Purpose of the Survey

The underground shopping areas around Hakata Station were severely damaged by the flood disaster in Fukuoka City on July 29th, 1999. Tenant businesses were not able to open due to the inundation reaching a maximum depth of 1 m. Electric facilities in the basements of hotels in the area were submerged, and trains on the subway and JR lines were cancelled due to the enormous amount of rainwater. Staff in the underground shopping mall and subway took various countermeasures in order to evacuate the shoppers and passengers safely to ground level. For example, the Fukuoka City subway prohibited the use of exits to ground level on the Chikushi-guchi side from which rainwater was flowing in rapidly, and instructed people to evacuate to the exits on the Hakata-guchi side where less water was flowing in, by erecting barricades and broadcasting repeated announcements. Some people nevertheless defied these instructions and climbed up the stairways where water was pouring down, citing reasons such as the desire to evacuate as quickly as possible, or that the Chikushi-guchi side exit was nearer to their homes.

The most severe aspect of this flood disaster was that a restaurant employee drowned to death in the basement floor of a building, thus reminding us of the risk to life posed by urban flood disasters. Fortunately there was no loss of life in Fukuoka Station and the surrounding underground shopping areas. Nevertheless, we should expect the risk of flood disasters in underground spaces to increase further and further as urbanization progresses.

The purpose of this survey is to examine what measures should be taken in order to realize safe and fast evacuation from underground facilities, such as railway stations and underground shopping areas, through understanding users' psychology and behavioral responses. This survey was conducted among users of two major underground facilities: the shopping area around the central railway station in Fukuoka, which was damaged in the flood disaster discussed above, and a similar underground space at Asakusa in Tokyo, representing an area of high risk of urban flood disaster. The subjects were interviewed so as to ascertain their psychological perceptions with respect to flood disasters. The interviews were conducted on two different days, on a weekday and on weekend, at each location respectively.

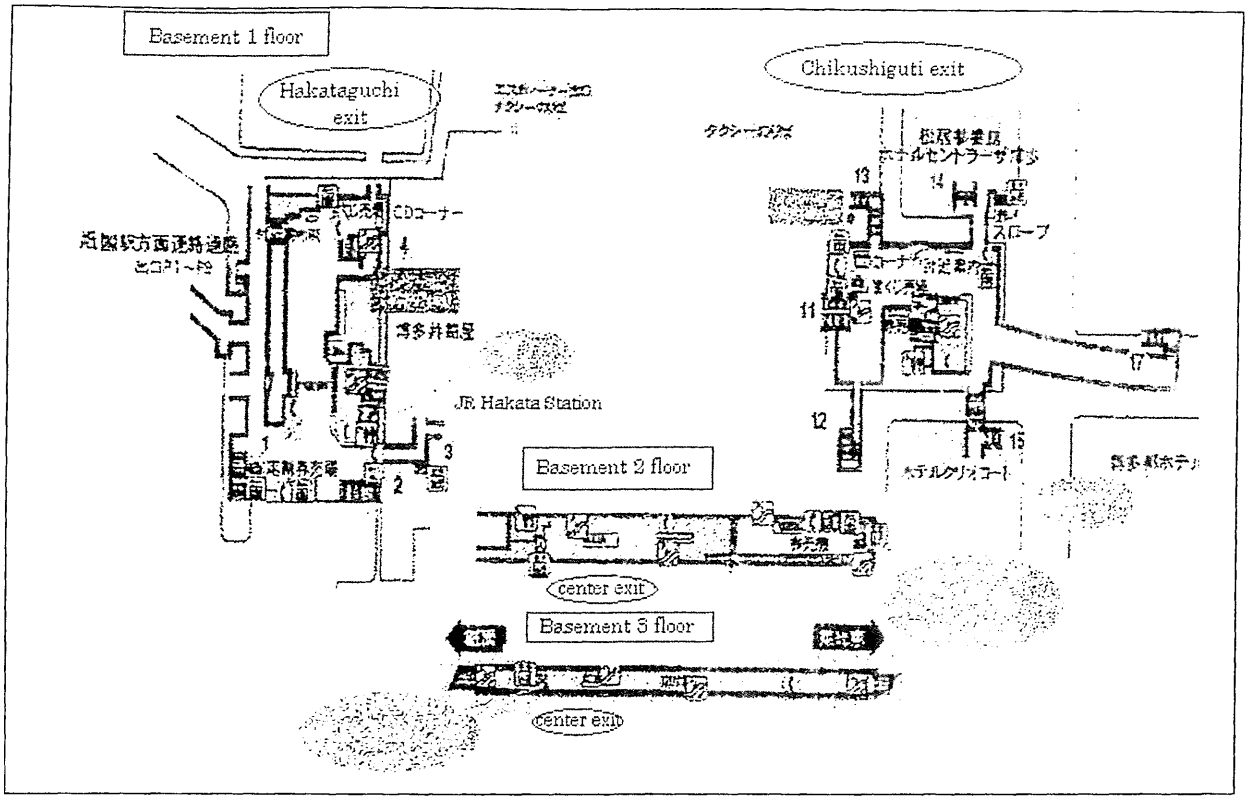


Fig.3-1

3.2 Outline of the Survey

1) title of the survey

Survey of people's perceptions relating to the advancement of river disaster Information and risk management

2) location of the survey

(1) Fukuoka City, Fukuoka Prefecture

Deitos underground shopping mall, in the vicinity of Hakata Station (Chikushi-guchi side),

(2) Asakusa, Taitou Ward, Tokyo

underground shopping mall at the exit of Matsuya department store

Asakusa Station concourse (Eidan line)

underground passageway connecting Asakusa Station (Eidan line) and Asakusa

Station (Touei line)

3) subjects surveyed

users, both male and female, 15 years old (high school students) and over, of the underground spaces above (1) and (2).

4) method of survey

face to face interviews, conducted aurally

5) Date and time

(1) Fukuoka: 11 am to 6 pm, February 27th (Sunday) and 28th (Monday), 2000.

(2) Tokyo: 11 am to 6 pm, March 12th (Sunday) and 13th (Monday), 2000.

6) Number of valid samples collected

(1) Fukuoka:

weekday	339 samples (male 125, female 214)
weekend	306 samples (male 113, female 193)
total	645 samples (male 238, female 407)

(2) Tokyo:

weekday	315 samples (male 152, female 163)
weekend	318 samples (male 143, female 175)
total	633 samples (male 295, female 338)

7) structure of the questionnaire

The questionnaire consisted of four parts, as follows:

Face sheet : F1~F4

Ⅰ : Underground space use (Questions 1 to 4)

The following variables were measured: how often the subjects of the survey use the underground space, for what purposes they use it, and how familiar they are with the physical layout of the underground space.

Ⅱ : Risk perception with respect to underground flood disaster (Questions 5 to 11)

The following variables were measured: how people perceive the risk of the occurrence of

flood disaster in the underground space, and how uneasy they would feel if floodwater came as high as their ankles.

Ⅲ: Information needs during evacuation (Question 12~Question 15)

The following information needs during evacuation were assessed: the need for broadcasts calling for evacuation and the need for evacuation guidance, and what kind of information people want to acquire when they evacuate from underground shopping areas to ground level.

The following is a list of the items included in the questionnaire:

F1: Sex
F2: Age
F3: Time of the interview
F4: Degree of susceptibility to disasters
Q1: Area of residence
Q2: Frequency and length of their use of the underground space
Q3: The purpose of their use of the underground space
Q4: The degree of their familiarity with the physical layout of the underground space
Q5: The kind of disasters they think could occur in the underground space Sub question 5: Reasons for the above
Q6: The degree of uneasiness felt towards earthquakes, fire, gas explosions, and flood disaster
Q7: Perception of the risk of flooding by the Mikasa River (in Fukuoka) or Arakawa River (in Tokyo)
Q8: Perception of the risk of submergence in the underground space
Q9: Degree of uneasiness felt when water inundates as high as the ankles
Q10: Behavioral responses to flooding
Q11: Degree of uneasiness when elevators or escalators are not in service
Q12: How they would react in response to broadcasts calling for evacuation
Q13: Degree of importance of broadcasts calling for evacuation
Q14: Degree of importance of evacuation guidance
Q15: Kind of information desired during evacuation

3.3 Survey Results

A comparison of weekday and weekend results from the Fukuoka survey

First, we summarize the results of the survey conducted in Deitos underground shopping mall at the Chikushi-guchi exit of Hakata Station.

The weekday data and the weekend data were gathered on the dates below.

Weekday: 28th February (Monday), 2000.

Weekend: 27th February (Sunday), 2000.

Face to face interviews were conducted continuously for about seven hours from 11 in the morning to 6 in the evening on both days.

<Face sheet>

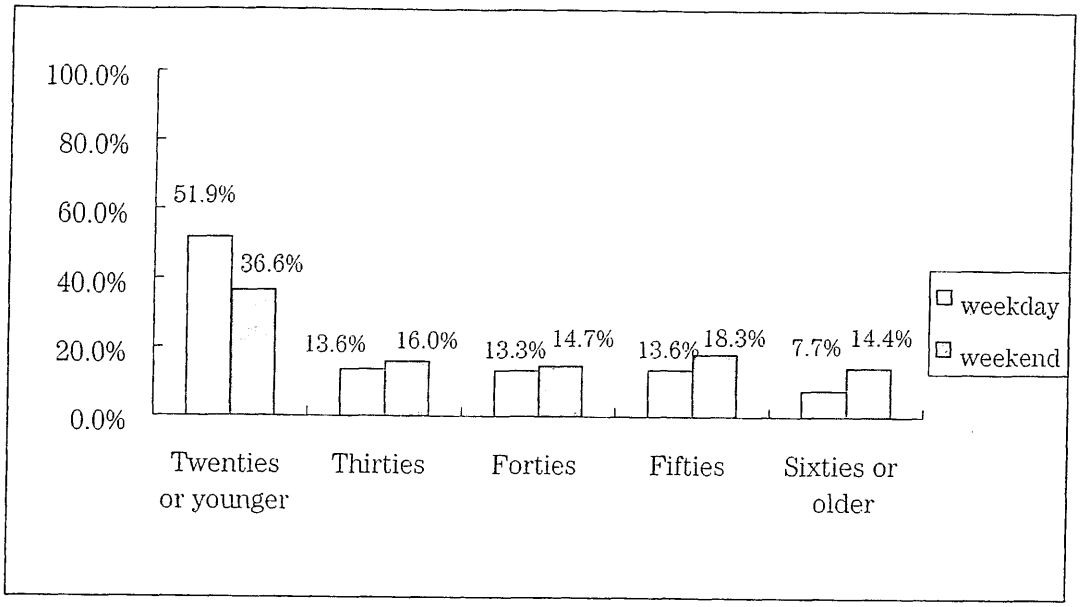
First, we will summarize the main characteristics of the survey samples.

There were 339 weekday samples and 306 weekend samples. The sex ratio for both days was 36.9% male to 63.1% female.

Next, we consider age distribution. In the weekday survey subjects in their twenties or younger accounted for 50.9%. In the weekend survey the percentage of people in their sixties or older increased. Thus, we were able to gather responses from all generations. The reason for this age group difference is presumably that younger people use the underground space on their way to school or work on weekdays, while older people and middle-aged groups use the underground space for the purpose of family recreation etc. at the weekend (Fig.3-2).

Table 3-2 (F2) age

Answers	weekday	percentage	weekend	percentage
Twenties or younger	176	51.9%	112	36.6%
Thirties	46	13.6%	49	16.0%
Forti es	45	13.3%	45	14.7%
Fifties	46	13.6%	56	18.3%
Sixties or older	26	7.7%	44	14.4%



The proportion of households with members particularly susceptible to disasters was slightly higher at the weekend (9.5%) than on a weekday (2.9%).

Table3-2 (F3)Households with or without members particularly susceptible to disasters

Answer	weekday	percentage	weekend	percentage
With	10	2.9%	29	9.5%
Without	329	97.1%	277	90.5%

<I : Use of the underground space>

As to area of residence, those who live in Fukuoka City amounted to more than 60% of the users on a weekday, while at the weekend those who live in the city and those who live outside were about equal. The number of users from outside the city was slightly greater at the weekend than on a weekday.

Table 3-3 (question1) Area of residence

Answer	weekday	percentage	weekend	percentage
In Fukuoka City	209	61.7%	154	50.3%
Outside Fukuoka City	130	38.3%	152	49.7%

This difference is also reflected in the frequency of use (Question 2). Frequent users who use the underground facility 4 to 5 times a week amounted to more than 25% on a weekday, as opposed to a little more than 10% at the weekend. As seen on the table below, weekend users visit the underground mall less frequently than weekday users. More than 70% of weekend users answered that they use the facility several times a month or less. (The total for the three categories of "several times a month", "several times a year", and "seldom use" was 72.2%.)

Table 3-4 (Question 2) Frequency of underground space use

Answer	weekday	percentage	weekend	percentage
4 to 5 times a week	85	25.1%	32	10.5%
several times a week	74	21.8%	53	17.3%
several times a month	79	23.3%	102	33.3%
several times a year	39	11.5%	45	14.7%
seldom use	62	18.3%	74	24.2%

As to what time of day they use the facility, users between the hours of 1 p.m. and 6 p.m. amounted to a little less than 60% both on a weekday and at the weekend. There was a slight difference in that there were more users from 12 p.m. to 1 p.m. on a weekday than at the weekend, while users after 6 p.m. were more numerous at the weekend than on a weekday. Since it is located at the center of a business district, Hakata Station is used by many businessmen during their lunch breaks, while at the weekend many people stop by to have dinner after an excursion or pass through on their way home at rather late hours.

Table 3-5 (SQ Qustion2) Time of day of use

Answer	weekday	percentage	weekend	percentage
Before 9:00	8	2.4%	7	2.3%
9:00 - 12:00	32	9.4%	38	12.4%
12:00 - 13:00	77	22.7%	44	14.4%
13:00 - 18:00	197	58.1%	173	56.5%
After 18:00	25	7.4%	44	14.4%

When asked about the purpose of their use, more than 60% of the subjects, in both the weekday survey and the weekend survey, answered that they had come in order to shop, while 40% said they had come to eat. A little less than 20% gave the purpose of their visit as simply to get on the subway or just pass through en route to elsewhere. Obviously, people coming to work or do business, or to commute to office or school were more numerous on a weekday, and those traveling and sightseeing were higher at the weekend.

Table3-6 (Question 3) Purpose of visit

Answer	weekday	percentage	weekend	percentage
Shopping	2.9	61.7%	205	67.0%
Eating o ut	143	42.2%	121	39.5%
Riding the subway	59	17.4%	56	18.3%
Work or business	45	13.3%	23	7.5%
Commute to office or school	32	9.4%	11	3.6%
Passing through	58	17.1%	40	13.1%
Traveling and sightseeing	16	4.7%	22	7.2%
Avoiding bad weather	10	2.9%	2	0.7%
Others	23	6.8%	13	4.2%

We found less variation in the degree of familiarity with the physical layout of the exits and passages of the underground mall than expected given the varied characteristics of the users.

When asked in question 4 "How well are you acquainted with the location of exits and passages of this underground mall?", 40% answered "know mostly", and 30% answered "know only partly", both on a weekday and at the weekend. However, there was a difference in the number of people who answered "know almost all" between a weekday (16.5%) and the weekend (10.8%). Correspondingly, the number of people who answered "know not at all" is a little higher at the weekend.

Table 3-7 (question4) Familiarity with the location of exits and passages

Answer	wee kday	percentage	weekend	percentage
Know almost all	56	16.5%	33	10.5%
Know mostly	142	41.9%	129	42.2%
Know only partly	102	30.1%	100	32.7%
Know not at all	39	11.5%	44	14.4%

There are comparatively more users with good geographical knowledge on a weekday, while the number of those without any geographical knowledge is slightly higher at the weekend. Apart from these extreme strata, there is not much difference between a weekday and the weekend as regards the remaining 70%, 40% of whom "know mostly" and 30% "know only partly".

< Ⅱ : Risk perception of flood disaster in underground spaces>

Below is the result of question (5), in which subjects were asked to identify from the list given (earthquakes, fires, gas explosions, and floods) all the types of disaster damage likely to occur in underground spaces.

Table 3-8 (question 5) kind of disaster which may take place in underground spaces

Answer	weekday	percentage	weekend	percentage
Earthquake	110	32.4%	79	25.8%
Fire	201	59.3%	156	51.0%
Gas explosion	88	26.0%	76	24.8%
Flood	219	64.6%	174	56.9%

Overall, more than 50% of the people surveyed identified fire and flood damage as likely forms of disaster in underground spaces. This suggests that these two types of disaster are more easily associated with underground spaces than the other two. The percentages are lower for each kind of disaster at the weekend than on a weekday, although the distribution pattern is almost the same. In particular, the percentages of those who mentioned flood disaster and fire are 8% higher on a weekday, which suggests that these users are more sensitive to such matters than weekend users. This difference presumably derives from the fact that the proportion of users who reside in the city and use the facility frequently is higher on a weekday than at the weekend. Such people are more likely to have clear memories of past disasters, such as the Fukuoka Flood.

In addition, in sub question 5, when interviewees were asked to identify the "the reason why you think flood disaster may occur", those selecting the answer "because I know about flood disaster in underground spaces" amounted to 60% both in the weekday survey and in the weekend survey. From this we can confirm that experience of the Fukuoka flood disaster

has had the effect of raising consciousness about flood disaster prevention

Table 3-9 (sub question5) People's reasons for thinking that flood disaster may occur

Answer	weekday	percentage	weekend	percentage
Experienced flood disaster before	51	23.3%	35	20.1%
Know about flood disaster in underground spaces	130	59.4%	103	59.2%
The Mikasa River is nearby	51	23.3%	36	20.7%
Do not know why	51	23.3%	28	16.1%
Others	3	1.4%	1	0.6%

Next, question 6 concerns the extent to which people would experience anxiety if any of the listed types of disasters were to occur while they were using the underground space.

The results are shown below in table 3-10 ①~④. Around 60% of the people answered that they would feel "very uneasy", while 10-15% said they would "not feel so uneasy" or "not feel uneasy at all" with respect to each type of disaster. Although we may regard the former group as being highly sensitive to disasters, we should not over-generalize the second group as "insensitive". This is because there may be two kinds of people together in this class: those who do not feel uneasy because they have good geographical knowledge and can evacuate themselves calmly, and those who do not feel uneasy because they have no image of disaster occurrence at all. Whatever the type of disaster, those who feel very uneasy when disasters occur amount to 60%, a fact which has to be born in mind by the authorities responsible for their evacuation.

Table 3-10 (question6) ① earthquake

Answer	weekday	percentage	weekend	percentage
very uneasy	192	56.6%	180	58.8%
uneasy	105	31.0%	81	26.5%
not so uneasy	38	11.2%	41	13.4%
not uneasy at all	4	1.2%	4	1.3%

Table 3-10 (question6) ② fire

Answer	weekday	percentage	weekend	percentage
very uneasy	189	55.8%	178	58.2%
uneasy	114	33.6%	95	31.0%
not so uneasy	33	9.7%	31	10.1%
not uneasy at all	3	0.9%	2	0.7%

Table 3-10 (question6) ③ gas explosion

Answer	weekday	percentage	weekend	percentage
very uneasy	206	60.8%	191	62.4%
uneasy	89	26.3%	79	25.8%
not so uneasy	40	11.8%	31	10.1%
not uneasy at all	4	1.2%	5	1.6%

Table 3-10 (question6) ④ flood disaster

Answer	weekday	percentage	weekend	percentage
very uneasy	193	56.9%	184	60.1%
uneasy	103	30.4%	77	25.2%
not so uneasy	37	10.9%	38	12.4%
not uneasy at all	6	1.8%	7	2.3%

Question 7 is about "the risk of the Mikasa River bursting its banks due to heavy rain". 61.6% on a weekday, and 62.1% at the weekend answered that the degree of risk was "very high" or "high".

The following question 8 concerns "the risk of inundation of the underground mall due to overflow of the Mikasa River". The proportion of those responding that this risk is "very high" or "high" was 68.(1)% on a weekday and 69% at the weekend.

As seen above, there is no gap between weekday visitors and holiday visitors on risk perception about water overflow from a nearby river or inundation of the underground mall. 60% to70 % of the people perceive a risk, while 30% to 40% take a more optimistic view. Incidentally, the risk of inundation of the underground mall is perceived to be slightly higher than the risk of the Mikasa River overflowing.

Table 3-11 (question 7) The risk of the Mikasa River bursting its banks due to heavy

Answer	weekday	percentage	weekend	percentage
Very high	56	16.5%	62	20.3%
High	153	45.1%	128	41.8%
Low	118	34.8%	107	35.0%
No risk at all	12	3.5%	9	2.9%

Table 3-12 (question 8) The risk of inundation of the underground mall due to overflow of the Mikasa River

Answer	weekday	percentage	weekend	percentage
Very high	96	28.3%	81	26.5%
High	135	39.8%	130	42.5%
Low	100	29.5%	88	28.8%
No risk at all	8	2.4%	6	2.0%
Donít know	0	0.0%	1	0.3%

Further, we will examine how this disaster risk perception is related to the degree of geographical knowledge about the layout of the underground mall.

Those who answered "know almost all" or "know mostly" in question 4 are here referred to as the "geographically knowledgeable stratum". Those who answered "know only partly" or " do not know at all" are referred to as the "geographically disoriented stratum". Analyzing data from the weekday survey and weekend survey in total, we obtain the following results (Table 3-13, Table 3-14).

Table 3-13 Relation between geographical knowledge of the underground mall and risk perception of the Mikasa River bursting its banks.

Answer	geographically knowledgeable stratum		geographically disoriented stratum	
	Actual number	percentage	Actual number	percentage
Very high	78	21.7%	40	14.0%
High	171	47.5%	110	38.6%
Low	105	29.2%	120	42.1%
Not at all	6	1.7%	15	5.3%

Geographically knowledgeable stratum :N=3 60 Geographically disoriented stratum :N=285

Geographically knowledgeable stratum :N=360 Geographically disoriented stratum :N=285

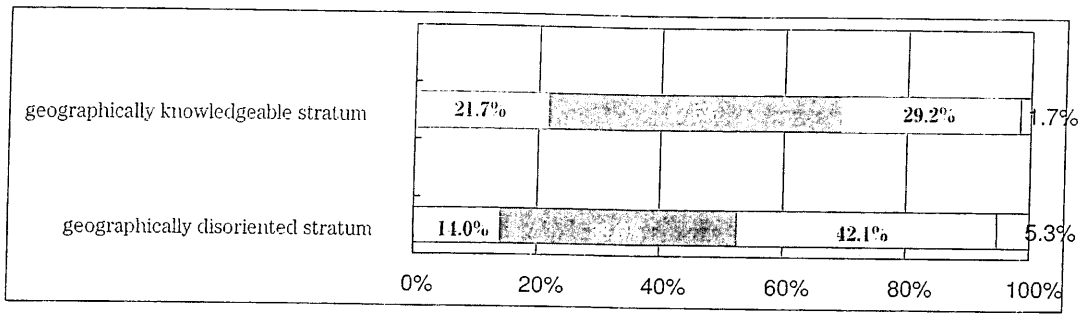


Figure 3-2 Relation between geographical knowledge of the underground mall and risk perception of the Mikasa River bursting its banks.

As seen in figure 3-2, those users who are well acquainted with exits and other aspects of the layout of the underground mall have a fairly severe risk perception about the Mikasa River bursting its banks. Among these people there is a high percentage who reside within Fukuoka City (65.8%), and many of them are also high frequency users of the underground mall (29.2% of them use 4 to 5 times a week). It is assumed that these are the people who actually experienced this flood disaster.

The situation with regard to question 8 is similar. Those who are better acquainted geographically with the underground mall tend to perceive a higher risk of inundation than those with less knowledge. Precisely because they frequent the underground space around Hakata Station and are familiar with its layout, their disaster prevention awareness was raised to a realistic level as a result of their experience of the Fukuoka Flood Disaster.

Table 3-14 Relation between degree of geographical knowledge and inundation risk perception.

Answer	geographically knowledgeable stratum		geographically disoriented stratum	
	Actual number	percentage	Actual number	percentage
Very high	110	30.6%	67	23.5%
High	148	41.1%	117	41.1%
Low	96	26.0%	92	32.3%
Not at all	6	1.7%	8	2.8%

Geographically knowledgeable stratum :N=360 Geographically disoriented stratum :N=285

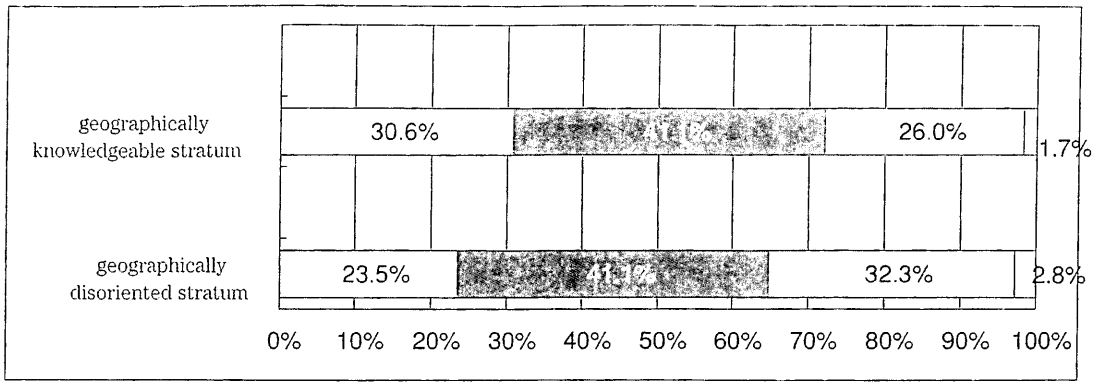


Figure 3-3 Relation between degree of geographical knowledge and inundation risk perception

In questions 9 to 11, interviewees were presented with concrete disaster scenarios (such as "if rain water comes up as high as your ankle when you are in the underground mall" or "if elevators or escalators are out of service as a result of flooding") in order to investigate there actual behavioral responses to disasters.

In question 9, we asked people how uneasy they would feel if floodwater reached as high as their ankles. Most (81.5 % on a weekday and 83.1 % at the weekend) responded that they would feel either "very uneasy" or "uneasy". When exposed to a visible concrete menace such as submergence, most people feel uneasy.

Table 3-15 (Question 9)The degree of uneasiness felt when rain water inundation reaches as high as the ankles while in the underground mall

Answers	weekday	percentage	weekend	percentage
Very uneasy	127	37.5%	140	45.8%
Uneasy	149	44.0%	114	37.3%
Not very uneasy	52	15.3%	49	16.0%
Not uneasy at all	11	3.2%	3	1.0%

In the following question 10, we asked about people's behavioral responses to such scenarios. 79.4% on a weekday and 76.5% at the weekend answered that they would "go up to the ground floor through a nearby exit", from which we assume that their primarily desire

would be to simply escape from the underground space as soon as possible. On the other hand, those who answered "follow an announcement from the communication system or instructions by those concerned" were 16.8 % on a weekday and 20.6 % at the weekend. The number of people who would follow the instructions of a facility manager was slightly higher at the weekend.

Table 3-16 (question 10) Behavioral responses to disasters

Answers	weekday	percentage	weekend	percentage
Follow an announcement from the communication system or instructions by the facility manager	57	16.8%	63	20.6%
Go up to the ground floor through a nearby exit	269	79.4%	234	76.5%
Continue walking through the underground space	12	3.5%	5	1.6%
Other	1	0.3%	3	1.0%
Do not know	0	0.0%	1	0.3%

In question 11 "How uneasy would you feel if water prevents you from using the elevator or escalator?". Those who answered "very uneasy" amounted to 46.6% on a weekday and 52.3% at the weekend. The degree of uneasiness in this scenario is greater than in the case of inundation as deep as the ankle in question 9. Furthermore, the aggregate percentage of those who answered either "very uneasy" or "uneasy" remained at 74.9% on a weekday, but rose to 84.3% at the weekend, with a gap of nearly 10 percentage points.

Table 3-17 (Question 11)Degree of uneasiness when elevators and other facilities are out of service due to flooding

Answ ers	weekday	percentage	weekend	percentage
Very uneasy	158	46.6%	160	52.3%
Uneasy	96	28.3%	98	32.0%
Not very uneasy	77	22.7%	39	12.7%
Not uneasy at all	8	2.4%	9	2.9%

The high degree of uneasiness registered in question 11 has no relation to the frequency of use (question 2) or degree of geographical knowledge. It just seems to be a characteristic of weekend users.

Then, why do weekend users show a higher degree of uneasiness than weekday users in question 11, even though they show the same degree in question 9? Because we did not have enough samples we cannot prove causal relations for sure, but we suspect this is related to the proportion of those particularly susceptible to disasters (F4).

Table 3-18 Relation between presence or absence of household members particularly susceptible to disasters and the degree of uneasiness when elevators and other facilities are out of service

Answers	With members particularly susceptible		With out members particularly susceptible	
	Actual number	Percentage	Actual number	percentage
Feel very uneasy	23	59.0%	295	48.7%
Feel uneasy	10	25.6%	184	30.4%
Not very uneasy	6	15.4%	110	18.2%
Not uneasy at all	0	0.0%	17	2.8%

With members particularly susceptible :N=39 Without members particularly susceptible :N=606

Among people from households with members particularly susceptible to disasters, the proportion of those who answered "very uneasy" was about 10 percentage points higher.

The scenario presented in question 11 ("if elevators or escalators are out of service due to flooding") seems to raise a strong uneasiness among those with household members who have difficulty in moving by themselves. Therefore, it is assumed that at the weekend, when the proportion of those with household members particularly susceptible to disasters was higher, the number of those with higher degrees of uneasiness was consequently greater.

Another factor to be noted is the presence of large numbers of office workers and students who come to the underground mall unaccompanied, whereas at the weekend many people come with their families and the various generations would have to evacuate together.

Even if underground facilities are affected by submergence, weekday users can evacuate themselves by simply running up a staircase to the ground level, but weeked users have to move carefully making sure of companions' safety and of not losing sight of them. The latter type of users are thus presumably more uneasy about elevators or escalators

being out of service, which can move large numbers of people at one time.

If this assumption is true, it can also be surmised that weekend users would have stronger uneasiness than weekday users in cases of "power cuts due to flooding", "confusion about exits" or "information confusion" in underground spaces.

<Ⅲ : Information needs during evacuation>

In questions 12 to 15, we ascertained people needs with respect to information provided by facility managers and evacuation guidance.

First, in question 12, we asked people how they would respond behaviorally when an announcement calling for evacuation was broadcast in the underground mall. Both on a weekday and at the weekend, about 74% of respondents said they would "evacuate". Following this, those who answered that they would "investigate the situation" were 20.1% on a weekday and 14.7% at the weekend. Only a few respondents said they would "behave the same as the others around".

Table 3-19 (question 12) Behavioral responses to a call for evacuation.

Answers	weekday	percentage	weekend	percentage
Evacuate	251	74.0%	226	73.9%
Investigate the situation	68	20.1%	45	14.7%
Behave the same as the others around	20	5.9%	35	11.4%

We asked in question 13 how important announcements calling for evacuation are for individuals' evacuation behavior. The answer "very important" amounted to 70.4% of the weekday users and 82.4% of the weekend users. This makes it clear that users' decisions to evacuate are dependent upon calls by facility managers. On the contrary, those who answered "not very important" and "not important" were only 3.6% on a weekday and 1.0% at the weekend.

The reason for this result is presumably that it is hard for users of an underground space to know the circumstances outside, thus making it difficult for them to assess the risk independently according to their own perceptions.

Table 3-20 (question 13)The importance of announcements calling for evacuation users' evacuation during flood disaster

Answers	weekday	percentage	weekend	Percentage
Very important	264	77.9%	264	82.4%
Important	63	18.6%	39	15.0%
Not very important	9	2.7%	3	2.3%
Not important	3	0.9%	0	0.3%

We asked how important evacuation guidance is in question 14. 70.4% of the weekday users and 82.4% of the holiday users answered "very important". "Not very important" and "not important" in total amounted only to less than 5 %.

Table 3-21 (question 14) Importance of evacuation guidance while evacuating during a flood disaster

Answers	weekday	percentage	weekend	percentage
Very important	251	74.0%	252	82.4%
Important	72	21.2%	46	15.0%
Not very important	13	3.8%	7	2.3%
Not important	3	0.9%	1	0.3%

In question 15, we asked people to identify their information needs when evacuating from the underground space, allowing for multiple answers. The answer "where to escape from" was given by nearly 80% of respondents both on a weekday and at the weekend. "Where rain water is pouring in" and "which passages are blocked off" were both cited by 54.0% on a weekday and 50.7 % at the weekend.

These results are further evidence that most people try to move towards exits to the ground level during evacuation. And in order to select routs, they want to get information about the exits where water is pouring in and passages that are blocked off. The answers "when inundation of the underground mall is expected", "the rainfall situation outside" or "the condition of railway and other services" remained in the 20 to 30% bracket, demonstrating that these are of secondary importance as information needs.

Table 3-22 (question 15)Information users think they need during evacuation from the underground space

Answers	weekday	percentage	weekend	percentage
how hard it is raining outside	96	28.3%	83	27.1%
risk of river overflow or flooding	88	26.0%	58	19.0%
when inundation of the underground space is expected	130	38.3%	128	41.8%
where rainwater is pouring in from	183	54.0%	155	50.7%
which passages are blocked off	183	54.0%	155	50.7%
where to escape from	266	78.5%	246	80.4%
railway and other traffic services	80	23.6%	74	24.2%
other	1	0.3%	1	0.3%
do not know / no information needs	2	0.6%	0	0.0%

The answer "risk of river overflow or flooding" amounted to 26.0% on a weekday, but was slightly lower at the weekend at 19.0%. The gap is assumed to result from the fact that there is a higher percentage of residents from outside Fukuoka City among weekend users. For investigative purposes, we compared the information needs by residential area, and the results are shown in the following table 3-23.

Table 3-23 The relation between residential area and kind of information needs

Answers	weekday	percentage	weekend	percentage
Rain fall circumstances	93	26.7%	86	30.5%
Risk of river overflow or flooding	97	26.7%	49	17.4%
expected time of inundation of underground space	136	37.5%	122	43.3%
exits where there is severe water inflow	190	52.3%	148	52.5%
passages cut off by rainwater	200	55.1%	138	48.9%
where to escape from	285	78.5%	227	80.5%
railway and other traffic services	77	21.2%	77	27.3%
others	1	0.3%	1	0.4%
do not know/no information needs	1	0.3%	1	0.4%

There was a gap of more than 9 percentage points between inhabitants of Fukuoka City and those from outside in the numbers of people who gave the answer "risk of river overflow or flooding". (Such a remarkable gap is not seen in any of the other items.)

It is assumed that inhabitants of Fukuoka City are more interested in the overflow risk of the nearby river because they would be trying to return to their homes on foot.

In situations where it is dangerous for people to walk back home on foot overland (as was the case, for example, when the Mikasa River overflowed), it is necessary to evacuate them to a nearby refuge site in the underground space. Even if flooding is on a small scale, there is a danger of loss of life due to people falling into ditches, channels or manholes while wading through muddy water.The danger of injury or loss of life while trying to return home cannot be excluded even after people have successfully evacuated from the underground space.

Therefore, facility managers are responsible not only for the evacuation of users to the ground level, but also for preventing subsequent loss of life, by broadcasting or otherwise providing information regarding whether local residents should return home immediately or proceed to a refuge site near the station along with people from outside the city. It is necessary for municipalities to understand adequately this role of facility managers, and disseminate proper information to them immediately.

3.4 Survey Results 2

A comparison of weekday and weekend results from the Tokyo survey

The underground space at Asakusa in Tokyo consists of the underground floors of Matsuya department store, the underground shopping area inside the Asakusa Station of the Eidan subway line, and the underground passageway connecting this station with the Asakusa Station of the Toei subway line. Although no serious disasters have occurred here in the past, it is said to have a high risk of flooding. We chose to conduct a survey at this location in order to provide a comparison with the survey conducted at Hakata Station, where disaster has actually occurred.

The data was collected on the following dates:

Weekday: Monday, 13th of March, 2000

Weekend: Sunday, 12th of March, 2000

As with the Fukuoka survey, face to face interviews were conducted continuously for about seven hours from 11 in the morning to 6 in the evening on both days.

<Face sheet>

First, we will summarize the main characteristics of the survey samples.

There were 315 weekday samples and 318 weekend samples. The sex ratio of the weekday samples was 48.5% male to 51.7% female. The sex ratio of the weekend samples was 45.0% male to 55.0% female

As regards the age distribution of the survey respondents, people in their twenties or younger were somewhat over-represented both on a weekday and at the weekend, but responses from the other age groups were obtained fairly evenly.

Table 3-24 (F2) Age

Answers	weekday	percentage	weekend	percentage
Twenties or younger	95	30.2%	94	29.6%
Thirties	49	15.6%	60	18.9%
Forties	49	15.6%	48	15.1%
Fifties	54	17.1%	68	21.4%
Sixties or older	68	21.6%	48	15.1%

The percentage of households with members particularly susceptible to disasters did not vary much, with 13.0% on a weekday and 10.(1)% at the weekend.

< Ⅰ : Characteristics of underground space usage>

54.3% of the weekday respondents lived within the 23-ward area of Tokyo proper, a little more than half, while at the weekend respondents from outside the 23 wards were slightly more numerous at 52.5%. However, since this is only a minor difference, we can say that the percentage of people from inside the city and those from outside was roughly half and half both on a weekday and at the weekend.

As to the frequency of the respondents' use (question 2), frequent users who visit 4 to 5 times a week amounted to 22.5% of the weekday users, but only 17.9% of the weekend users. As to the other frequency strata, there were no major differences.

Table 3-25 (question 2) Frequency of visits to the underground space

Answer	weekday	percentage	weekend	percentage
4 to 5 times a week	71	22.5%	57	17.9%
several times a week	58	18.4%	43	13.5%
several times a month	65	20.6%	78	24.5%
several times a year	41	13.0%	56	17.6%
seldom use	80	25.4%	84	26.4%

As to the time of day when respondents used the facility, "13:00 - 18:00" amounted to more than 50% of the users both on a weekday and at the weekend. The distribution of respondents in the other time zones was fairly even, both on a week day and at the weekend.

Table 3-26 (sub question 2) Time of day of use

Answer	weekday	percentage	weekend	percentage
Before 9:00	22	7.0%	35	11.0%
9:00 - 12:00	44	14.0%	55	17.3%
12:00 - 13:00	51	16.2%	39	12.3%
13:00 - 18:00	169	53.7%	159	50.0%
After 18:00	29	9.2%	30	9.4%

The purposes of use cited most often by weekday users were "riding the subway", "work or business", and "shopping". For weekend users they were "shopping", "riding the subway", and "travel and sightseeing". This shows that Asakusa is a business town on weekdays, but a sightseeing spot on weekends (famous for sites like Kaminarimon).

Table 3-27 (question 3) Purpose of use

Answer	weekday	percentage	weekend	percentage
Shopping	74	23.5%	96	30.2%
Eating out	31	9.8%	43	13.5%
Riding the subway	105	33.3%	93	29.2%
Work or business	89	28.3%	29	9.1%
Commute to office or school	49	15.6%	40	12.6%
Passing through	49	15.6%	53	16.7%
Traveling and sightseeing	68	21.6%	84	26.4%
Avoiding bad weather	1	0.3%	1	0.3%
Others	26	8.3%	15	4.7%

We asked in question 4 "how well do you know the exits and passageways of this underground space?". The total percentage of the answers "know mostly" and "know in general" was 51.(1)% on a weekday, and 46.0 % at the weekend. Weekday users have a little more geographical knowledge of the place.

Table 3-28 (question 4) knowledge of exits and passages

Answer	weekday	percentage	weekend	percentage
Know almost all	56	17.8%	52	16.4%
Know mostly	105	33.3%	94	29.6%
Know only partly	101	32.1%	98	30.8%
Know not at all	53	16.8%	74	23.3%

<Ⅱ : Degree of uneasiness about flood disaster in underground space>

When respondents were asked to identify all the types of disaster they thought could occur in the underground space from the list provided (earthquake, fire, gas explosion, flood disaster), the results were as follows: (question 5)

Table 3-29 (question 5) disasters likely to occur in the underground space

Answer	weekday	percentage	weekend	percentage
Earthquake	183	58.1%	190	59.7%
Fire	172	54.6%	135	42.5%
Gas explosion	78	24.8%	71	22.3%
Flood	86	27.3%	85	26.7%

About 60% of the people gave the answer "earthquake", followed by 54.6% of the weekday users and 42.5 % of the weekend users who cited "fire". Less than 30% of weekday or weekend users at Asakusa gave the answer "flood disaster". This figure is more than that of "gas explosion", but it clearly shows that they are not very concerned about flood risk in underground spaces.

Furthermore, we asked "the reason why you think flood disaster may occur" in sub question 5. The answer most often given by weekday and weekend users was "because the Arakawa River is nearby", followed by "because I know about underground flood disaster" More weekday users pointed out the proximity of the Arakawa River, and more weekend

users pointed out the precedence of flood disaster cases. The extent of this difference was about 10 percentage points.

This difference presumably derives from the fact that weekday users are more likely to be regular users on business and are better acquainted with the geography of the place, while weekend users tend to be temporary visitors come for sightseeing or shopping.

Table 3-30 (sub question 5) The reason why you think disaster may occur

Answer	weekday	percentage	weekend	percentage
Experienced flood disaster before	3	3.5%	3	3.5%
Know about flood disaster in underground spaces	23	26.7%	30	35.3%
The Ara kawa River is nearby	49	57.0%	40	47.1%
Do not know why	10	11.6%	15	17.6%
Others	13	15.1%	6	7.1%

Next, question 6 concerns the extent to which people would experience anxiety if any of the listed types of disasters were to occur while they were using the underground space.

The result is as below. There was no difference between a weekday and the weekend. However, there are differences depending on the kind of disaster. The percentage of those replying that they would be "very uneasy" amounted to around 65% for gas explosion, just under 60% for fire, just under 60% for earthquake, but under 50% for flood disaster. The proportion who answered that they would "not feel uneasy very much" or "not feel uneasy at all" exceeded 20% only in the case of flood disaster.

Table 3-31 (question 6) Degree of uneasiness in time of disaster

① Earthquake

Answer	weekday	percentage	weekend	percentage
very uneasy	167	53.0%	189	59.4%
uneasy	94	29.8%	95	29.9%
not so uneasy	51	16.2%	29	9.1%
not uneasy at all	3	1.0%	5	1.6%

② Fire

Answer	weekday	percentage	weekend	percentage
very uneasy	170	54.0%	190	59.7%
uneasy	109	34.6%	96	30.2%
not so uneasy	34	10.8%	30	9.4%
not uneasy at all	2	0.6%	2	0.6%

③ gas explosion

Answer	weekday	percentage	weekend	percentage
very uneasy	205	65.1%	206	64.8%
Uneasy	69	21.9%	75	23.6%
not so uneasy	37	11.7%	31	9.7%
not uneasy at all	4	1.3%	6	1.9%

④ flood disaster

Answer	weekday	percentage	weekend	percentage
very uneasy	142	45.1%	153	48.1%
uneasy	92	29.2%	96	30.2%
not so uneasy	76	24.1%	58	18.2%
not uneasy at all	5	1.6%	11	3.5%

The absence of risk perception against flood disaster is also demonstrated in the answers to questions 7 and 8.

In answer to question 7 about "the risk of the Arakawa River bursting its banks", more than half the respondents replied either that there was "low risk" or "no risk at all" (52.6% on a weekday and 50.9% at the weekend).

Table 3-32 (question 7)The risk of the Arakawa River bursting its banks due to heavy rainfall

Answer	weekday	percentage	weekend	percentage
Very high	13	4.1%	31	9.7%
High	96	30.5%	102	32.1%
Low	178	56.5%	162	50.9%
No risk at all	28	8.9%	23	7.2%

Table 3-33 (question 8) The risk of inundation of the underground space due to overflow of the Arakawa River

Answer	weekday	percentage	weekend	percentage
Very high	28	8.9%	33	10.4%
High	121	38.4%	123	38.7%
Low	146	46.3%	139	43.7%
No risk at all	20	6.3%	23	7.2%

The results above show that more than half of the users of the underground space at Asakusa had a high degree of confidence in flood control management of the Arakawa River, and do not have a realistic risk perception as regards flood damage in the underground space.

We examined the relation between this disaster risk perception and the degree of knowledge about the underground space (question2). However, we detected no significant difference like that observed in the Fukuoka case. Both those with good geographical knowledge and those without such knowledge, answered similarly to the question about the degree of flood risk. Regardless of the extent of their geographical knowledge, the answer given by the most people was "not very high", followed in second place by "high".

In questions 9 to 11, interviewees were presented with concrete disaster scenarios (such as "if rain water comes up as high as your ankle when you are in the underground mall" or "if elevators or escalators are out of service as a result of flooding") in order to investigate their actual behavioral responses to disasters.

In question 9, we asked people how uneasy they would feel if floodwater reached as high as their ankles. The majority of respondents answered that they would feel either "very uneasy" or "uneasy", the aggregate percentages for these two responses being 83.2% on a weekday and 82.1% at the weekend. Although their perception of the risk of flood disaster was low, even at Asakusa most people felt uneasy as they did in Fukuoka when presented with a concrete visible threat, such as inundation.

Table 3-34 (question 9) The degree of uneasiness when rain water inundation reaches as high as the ankles while in the underground mall

Answers	weekday	percentage	weekend	percentage
Very uneasy	116	36.8%	146	45.9%
Uneasy	143	45.4%	115	36.2%
Not very uneasy	51	16.2%	50	15.7%
Not uneasy at all	5	1.6%	7	2.2%

In the following question 10, we asked about people's behavioral responses to such conditions. 70.8% of weekday users and 67.9% of weekend users said that they would "go up to the ground floor through a nearby exit", from which we assume that their primarily desire would be to simply escape from the underground space as soon as possible. On the other hand, those who answered "follow an announcement from the communication system or instructions by those concerned" were 26.7% of weekday users and 29.9% of weekend users. Weekend users appear to be somewhat more likely to follow the direction of the facility managers.

Table 3-35 (question 10) Behavioral responses to disasters

Answers	weekday	percentage	weekend	percentage
Follow an announcement from the communication system or instructions by the facility manager	84	26.7%	95	29.9%
Go up to the ground floor through a nearby exit	223	70.8%	216	67.9%
Continue walking through the underground space	5	1.6%	5	1.6%
Other	3	1.0%	2	0.6%

In question 11 "How uneasy would you feel if water prevents you from using the elevator or escalator?". Those who answered "very uneasy" amounted to 38.7% on a weekday and 45.6% at the weekend, which is similar to the results obtained for "inundation as high as the ankle" in question 9. The sum of "very uneasy" and "uneasy" is 71.(1)% on a weekday and 76.4% at the weekend, which again is not much different from the those figures in question 9.

Table 3-36 (Question 11) The degree of uneasiness when elevators and other facilities are out of service due to flooding

Answers	weekday	percentage	weekend	percentage
Very uneasy	122	38.7%	145	45.6%
Uneasy	102	32.4%	98	30.8%
Not very uneasy	73	23.2%	64	20.1%
Not uneasy at all	18	5.7%	11	3.5%

The following table shows the relation between presence or absence of household members particularly susceptible to disasters and the degree of uneasiness when elevators and other facilities are out of service

Table 3-37 Relation between presence or absence of household members particularly susceptible to disasters and the degree of uneasiness when elevators and other facilities are out of service

Answers	With members particularly susceptible		Without members particularly susceptible	
	Actual number	percentage	Actual number	percentage
Feel very uneasy	38	52.8%	229	40.8%
Feel uneasy	22	30.6%	178	31.7%
Not very uneasy	9	12.5%	128	22.8%
Not uneasy at all	3	4.2%	26	4.6%

It is clear that those who have people particularly susceptible to disasters in the family feel greater unease.

This is different from the answers given to question 9 on the supposition of "rainwater as high as the ankles".

Table 3-38 Presence or absence of household members particularly susceptible to disasters and the degree of uneasiness when rain water inundation reaches as high as your ankles

Answers	With members particularly susceptible		Without mem bers particularly susceptible	
	Actual number	percentage	Actual number	percentage
Feel very uneasy	30	41.7%	232	41.4%
Feel uneasy	31	43.1%	227	40.5%
Not very uneasy	10	13.9%	91	16.2%
Not uneasy at all	1	1.4%	11	2.0%

In this case, the distribution of degrees of uneasiness is the same regardless of whether or not there are household members particularly susceptible to disasters.

This shows that the assumption in question 11 "if water prevents you from using elevator or escalator" arouses strong uneasiness among those with household members particularly susceptible to disasters who have difficulty moving by themselves, as seen in the Fukuoka case.

< Ⅲ : Information needs during evacuation >

In questions 12 to 15, we ascertained people's needs with respect to information provided by facility managers and evacuation guidance.

First, in question 12, we asked people how they would respond behaviorally when an announcement calling for evacuation was broadcast in the underground mall. 76.8% of the people on a weekday answered that they would "evacuate", while the figure for the weekend was 73.9%. The next most often given answer was "wait and see", which was less than 20%, and those who answered "behave in the same way as others" were few.

Table 3-39 (question 12) Behavioral responses to a call for evacuation.

Answers	weekday	percentage	weekend	percentage
Evacuate	242	76.8%	235	73.9%
Investigate the situation	53	16.8%	60	18.9%
Behave the same as the others around	19	6.0%	23	7.2%
Cannot happen suddenly	1	0.3%	0	0.0%

We asked in question 13 how important announcements calling for evacuation are for individuals' evacuation behavior. Over 75% of both weekday and weekend users answered "very important". This clearly shows that users' decision making as regards evacuation behavior depends on facility managers' instructions.
On the contrary, those who answered "not very important" or "not important" were only 2.5% on a weekday and 1.6% at the weekend.

Table 3-40 (question 13) The importance of announcements calling for evacuation to users' evacuation during flood disaster

Answers	weekday	percentage	weekend	percentage
Very important	238	75.6%	240	75.5%
Important	69	21.9%	73	23.0%
Not very important	8	2.5%	5	1.6%
Not important	0	0.0%	0	0.0%

We asked about the degree of importance of evacuation guidance in question 14. 72.1% of weekday users and 73.0% of weekend users answered "very important". Those who answered "not very important" or "not important" were only few in number.

Table 3-41 (question 14) importance of evacuation guidance while evacuating during a flood disaster

Answers	weekday	percentage	weekend	percentage
Very important	227	72.1%	232	73.0%
Important	72	22.9%	79	24.8%
Not very important	15	4.8%	6	1.9%
Not important	1	0.3%	1	0.3%

We collected plural answers on information needs when evacuating from an underground space. 81.0% of the people on a weekday, and 75.2% at the weekend chose information about "where to escape from". This was the answer selected by the highest number of people. The next most often cited answer was "where rain water is flow in", chosen by 41.0% of the weekday users and 46.5% of the weekend users.

Information on "which passages are blocked off" was chosen by 37.5% on a weekday and

43.1% at the weekend. "When inundation is expected in the underground space" was selected by 35.9% on a weekday and 38.7% at the weekend.

Table 3-42 Information you think you need during evacuation from the underground space

Answers	weekday	percentage	weekend	percent age
how hard it is raining outside	96	30.5%	91	28.6%
risk of river overflow or flooding	94	29.8%	97	30.5%
When inundation of the underground space is expected	113	35.9%	123	38.7%
where rainwater is pouring in from	129	41.0%	148	46.5%
which passages are blocked off	118	37.5%	137	43.0%
where to escape from	155	81.0%	239	75.2%
railway and other traffic services	103	32.7%	98	30.8%
other	14	4.4%	2	0.6%
do not know / no information needs	2	0.6%	0	0.0%

As to information needs, there was not much difference in answer distribution between weekday users and holiday users. Nor was there any notable difference in information needs between inhabitants of the 23 Tokyo wards and those from outside.

3.5 Research Results 3: A comparison of the underground space in the vicinity of Fukuoka Station and the underground space at Asakusa

Finally, we will compare the results of the surveys conducted at the two locations in Fukuoka (Hakata) and Tokyo (Asakusa).

<Face sheet>

First, we look at the characteristics of the research samples. 645 samples were gathered in Hakata and 633 samples in Asakusa. The sex ratio of the two sets of samples differ somewhat. In Hakata it was 36.9% male to 63.(1)% female, while in Asakusa it was 46.6% male to 53.4% female. (The proportion of women was higher in Hakata).

Next, as regards the age distribution of the samples, people in their twenties or younger accounted for 44.7%, nearly half, in Hakata, while in Asakusa they were around 30%. The distribution of the other age groups was fairly even.

Table 3-43 (F2) age

Answers	Hakata	percentage	Asakusa	percentage
Twenties or younger	228	44.7%	189	29.9%
Thirties	95	14.7%	109	17.2%
Forties	90	14.0%	97	15.3%
Fifties	102	15.8%	122	19.3 %
Sixties or older	70	10.9%	116	18.3%

The percentage of people with household members particularly susceptible to disasters was 6.0% in Hakata, and 11.5% on Asakusa.

< I : Underground space use>

As to residential area, those who live "inside Fukuoka City" and those "outside Fukuoka City" in Hakata were nearly half and half, and those who live "inside the 23 wards" and those "outside the 23 wards" in Asakusa were again half and half. There was no remarkable difference in residential distribution between the two cities.

As to frequency of use (question 2), there was no difference in the distribution between the two locations of the survey either.

As to time of day of use, those who use each area from 13:00 to 18:00 hold more than 50% in both areas. There was a slightly higher percentage of early morning users in Asakusa, while in Hakata there was a slightly higher percentage of people who use during lunch time.

Table 3-44 (Sub Question 2) time of day of use

Answer	Hakata	percentage	weekend	percentage
Be fore 9:00	15	2.3%	57	9.0%
9:00 - 12:00	70	10.9%	99	15.6%
12:00 - 13:00	121	18.8%	90	14.2%
13:00 - 18:00	370	57.4%	328	51.8%
After 18:00	69	10.7%	59	9.3%

The distinctive features of each underground space were strongly reflected in the survey results on purpose of use.

In Fukuoka, an overwhelmingly high percentage of people visit for shopping (64.2%) and eating (40.9%), while in Asakusa many people come to use the subway (31.3 %), for shopping (26.9%), and for traveling and sightseeing (24.0%).

This difference derives from the fact that the underground market around Fukuoka Station (Deitos) is a place where office workers and residents come to buy daily goods or to enjoy eating out, while the Asakusa underground space is a passageway for subway users or for sightseeing customers. This difference in purpose of use is reflected in the age distribution of the respondents. In Fukuoka they are comparatively young, whereas in Asakusa people in their fifties sixties, and older were also well represented.

Table 3-45 (question3) Purpose of use

Answer	Hakata	percentage	Asakusa	percentage
Shopping	414	64.2%	170	26.9%
Eating out	264	40.9%	74	11.7%
Riding the subway	116	17.8%	198	31.3%
Work or business	68	10.5%	118	18.6%
Commute to office or school	43	6.7%	89	14.1%
Passing through	98	15.2%	102	16.1%
Traveling and sightseeing	38	5.9%	152	24.0%
Avoiding bad weather	12	1.9%	2	0.3%
Others	36	5.6%	41	6.5%

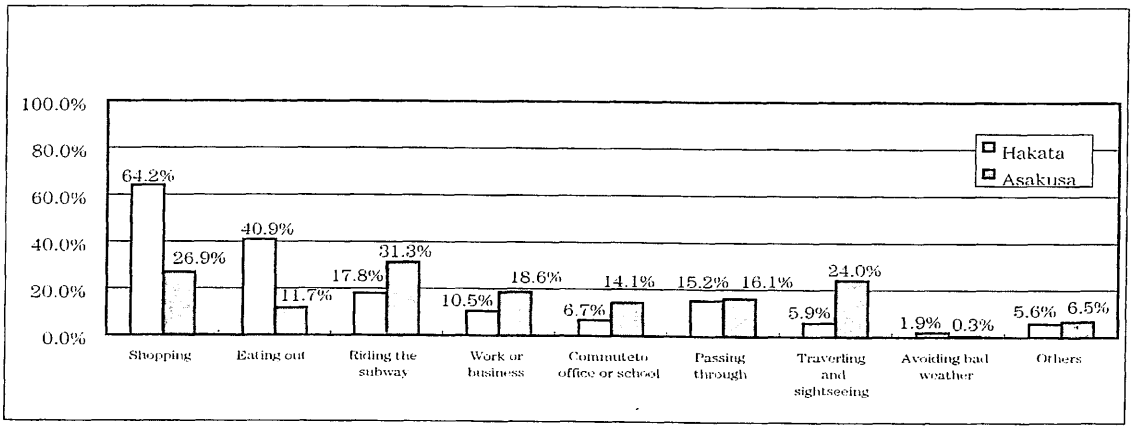


Figure 3-4 Purpose of use in the underground spaces at Hakata and Asakusa

As to question 4 "how well are you acquainted with the exits and passageways in this underground space?", the sum of the percentages of those who "know almost all" and "know mostly" was 55.8% in Fukuoka and 48.5% in Asakusa, which shows that users in Fukuoka are a little better acquainted with local geography. This also derives from the fact that the Fukuoka Station area is used mostly by local residents and office workers, whereas the Asakusa underground space has more tourists and transient visitors.

Table 3-46 (question4) Knowledge of exits and passageways

Answer	Hakata	percentage	Asakusa	percentage
Know almost all	89	13.8%	108	17.1%
Know mostly	271	42.0%	199	31.4%
Know only partly	202	31.3%	199	31.4%
Know not at all	83	12.9%	127	20.1%

< II degree of uneasiness about flood disaster in underground space>

Below is the result of question (5), in which subjects were asked to identify from the list given (earthquakes, fires, gas explosions, and floods) all the types of disaster damage likely to occur in underground spaces.

Table 3-47 (question 5)kind of disaster which may take place in underground spaces

Answer	Hakata	percentage	Asakusa	percentage
Earthquake	189	29.3%	373	58.9%
Fire	357	55.3%	307	48.5%
Gas explosion	164	25.4%	149	23.5%
Flood	393	60.9%	171	27.0%

60.9% of respondents cited "flood disaster" in Hakata, while in Asakusa only 27% did so. On the contrary, earthquake, which was selected by nearly 60% of the people in Asakusa, was identified by only less than 30% in Fukuoka. This is presumably a difference of awareness due to the experience of the Fukuoka Flood Disaster. Users' awareness of disaster prevention has been eroded in Asakusa. This has resulted in a highly vulnerable situation, considering the risk of flooding in the underground space there. As to fire and gas explosion, similar percentages were obtained for these answers in both areas.

When we asked "the reason why you think flood disaster may occur" in sub question 5, the answer "because I know a flood disaster in underground space" amounted to as high as 36.1% in Hakata, while in Asakusa no reason was chosen by any particularly high percentage of the respondents. This confirms that the experience of the Fukuoka Flood Disaster has raised the level of consciousness about disaster prevention among the users of the underground space in Hakata.

Table 3-48 (sub-question 5) The reason why you think disaster may occur

Answer	Hakata	percentage	Asakusa	percentage
Experienced flood disaster before	86	13.3%	6	0.9%
Know about flood disaster in underground spaces	233	36.1%	53	8.4%
The Arakawa or Mikasa River is nearby	87	13.5%	89	14.1%
Do not know why	79	12.2%	25	3.9%
Others	4	0.6%	19	3.0%

In the following question 6, subjects were asked how uneasy they would feel if each of the listed disasters (earthquakes, fire, gas explosion, flood disaster) were to occur while they were in the underground space. The results are as below. There is no difference of consciousness for disasters ① to ③between Fukuoka and Asakusa. However, only as regards flood disaster was a difference found. The percentage of people responding that they would feel "very uneasy" if a flood disaster occurred was 58.4% in Fukuoka and 46.6% in Asakusa. Those saying that they would "not feel uneasy very much" was 11.6% in Fukuoka and 21.2% in Asakusa.

Table 3-49 (question 6) Flood disaster

Answer	Hakata	percentage	Asakusa	percentage
very uneasy	377	58.4%	295	46.6%
uneasy	180	27.9%	188	29.7%
not so uneasy	75	11.6%	134	21.2%
not uneasy at all	13	2.0%	16	2.5%

This difference of risk consciousness against flood disaster is also seen in the answers to questions 7 and 8.

Those who answered in question 7 that the risk of the local river (Mikasa or Arakawa) bursting its banks is "not very high" or "almost nothing" were 38.2% in Fukuoka, but as much as 61.8% in Asakusa.

Similarly, in reply to question 8, those who said that the risk of inundation in underground space due to an overflow of the local river is "not very high" or "almost nothing" was 31.3% in Fukuoka, and 51.8% in Asakusa.

Table 3-50 (question 7) Risk of the Mikasa River or the Arakawa River bursting its banks due to heavy rain

Answer	Hakata	percentage	Asakusa	percentage
Very high	118	27.4%	61	9.6%
High	281	43.6%	198	31.3%
Low	225	34.9%	340	53.7%
No risk at all	21	3.3%	51	8.1%

Table 3-51 (question8) Risk of inundation of the underground space due to an overflow of the Mikasa River or the Arakawa River.

Answer	Hakata	percentage	Asakusa	percentage
Very high	177	27.4%	61	9.6%
High	265	41.1%	244	38.5%
Low	188	29.1%	285	45.0%
No risk at all	14	2.2%	43	6.8%
Don't know	1	20.0%	0	0.0%

From the results above, it is found that 60 to 70% of the users of the underground mall around Fukuoka Station where flood disaster has been experienced recognize the risk of inundation, while users of the Asakusa underground space take a more optimistic view and are unable to recognize the risk of flood disaster in underground space as something which could affect themselves.

In questions 9 to 11, interviewees were presented with concrete disaster scenarios (such as "if rain water comes up as high as your ankle when you are in the underground mall" or

"if elevators or escalators are out of service as a result of flooding") in order to investigate there actual behavioral responses to disasters.

We measured, in question 9, uneasiness when flood water reaches as high as the ankles. The percentage of those answering either "very uneasy" or "uneasy" was 82.2 % in both Fukuoka and Asakusa. The users of the underground space at Asakusa began to assess the risk realistically and showed the same degree of uneasiness as the users of Fukuoka only when a concrete image of flooding was presented to them.

Table 3-52 (question 9) Uneasiness when rain water reaches as high as the ankles in the underground space

Answer	Hakata	percentage	Asakusa	percentage
Very high	267	41.4%	262	41.4%
High	263	40.8%	258	40.8%
Low	101	15.7%	101	16.0%
No risk at all	14	2.2%	12	1.9%

In the following question 10, we asked about people's behavioral responses to such conditions. The answer "get out to ground level from a nearby exit" was 78.0% in Fukuoka, and 69.4% in Asakusa. The percentage was a little higher in the former.

On the contrary, those who answered "follow announcements from the communication system or instructions by those concerned" were 18.6% in Fukuoka and 28.3% in Asakusa. It was found that in the latter case, where the proportion of temporary visitors, tourists and elderly people is high, there was heavier dependence on the facility managers than in the other case.

Table 3-53 (question 10) Behavioral responses in times of disaster

Answers	Hakata	percentage	Asakusa	percentage
Follow an announcement from the communication system or instructions by the facility manager	120	18.6%	179	28.3%
Go up to the ground floor through a nearby exit	503	78.0%	439	69.4%
Continue walking through the underground space	17	2.6%	10	1.6%
Other	4	0.6%	5	0.8%
Don't know	1	0.2%	----	----

In response to question 11, "how uneasy would you feel if water prevents you from using elevators or escalators?", the percentage of those who answered either "very uneasy" or "uneasy" is 79.4% in Fukuoka and 73.8% in Asakusa,. There is not any considerable difference between the two areas in this respect.

Table 3-54 (question 11) Degree of uneasiness when elevators and other facilities are out of service due to flooding

Answers	Hakata	percentage	Asakusa	percentage
Very uneasy	318	49.3%	267	42.2%
Uneasy	194	30.1%	200	31.6%
Not very uneasy	116	18.0%	137	21.6%
Not uneasy at all	17	2.6%	29	4.6%

<Ⅲ : Information needs during evacuation>

In questions 12 to 15, we ascertained peoples needs with respect to information provided by facility managers and evacuation guidance

First, in question 12, we asked people how they would respond behaviorally when an announcement calling for evacuation was broadcast in the underground mall. Those who answered "evacuate" accounted for the highest percentages, both in Fukuoka (78.0%), and in Asakusa (75.4%). The second most cited answer, "wait and see", had 18%. Only a few said they would "follow the other people nearby". The answer distributions were similar in the two areas.

Table 3-55 (question 12) Behavioral responses to a call for evacuation

Answers	Hakata	percentage	Asakusa	percentage
Evacuate	477	74.0%	477	75.4%
Investigate the situation	113	17.5%	113	17.9%
Behave the same as the others around	55	8.5%	42	6.6%
Cannot happen suddenly	----	----	1	0.2%

When asked about the importance of a call for evacuation through the communication system to their evacuation behavior, those who answered "very important" were 81.9% in Hakata and 75.5% in Asakusa. The former was slightly higher. This difference also derives from the fact that the users in Fukuoka had seen the motion pictures or news on the Fukuoka Flood Disaster more frequently and were able to answer with a more realistic image of evacuation from the underground space to ground level. However, this difference was offset by the higher percentage of people who gave the reply "important" in Asakusa. Those who answered "not very important" or "not important" were less than 3% in both areas.

Table 3-56 (question 13) The importance of announcements calling for evacuation to users' evacuation during flood disaster

Answers	Hakata	percentage	Asakusa	percentage
Very im portant	528	81.9%	478	75.5%
Important	102	15.8%	142	22.4%
Not very important	12	1.9%	13	2.1%
Not important	3	0.5%	0	0.0%

Question 14 asked about the degree of importance of evacuation guidance. The answer "very important" was 78.0% in Fukuoka, and 72.5% in Asakusa, while "not very important" or "not important" accounted for only a very small percentage.

Table 3-57 (question 14) Importance of evacuation guidance while evacuating during a flood disaster

Answers	Hakata	percentage	Asakusa	percentage
Very important	503	78.0%	459	72.5%
Important	118	18.3%	151	23.9%
Not very important	20	3.1%	21	3.3%
Not important	4	0.6%	2	0.3%

In question 15, we asked people to identify their information needs when evacuating from the underground space, allowing for multiple answers.

Table3-58 (question 15)Information you think you need in time of evacuation from underground space

Answers	Hakata	percentage	Asakusa	percentage
how hard it is raining outside	179	27.8%	187	29.5%
risk of river overflow or flooding	146	22.6%	191	30.2%
when inundation of the underground space is expected	258	40.0%	236	37.3%
where rainwater is pouring in from	338	52.4%	277	43.8%
which passages are blocked off	338	52.4%	255	40.3%
where to escape from	512	79.4%	494	78.0%
railway and o ther traffic services	154	23.9%	201	31.8%
other	2	0.3%	16	2.5%
do not know / no information needs	2	0.3%	----	----

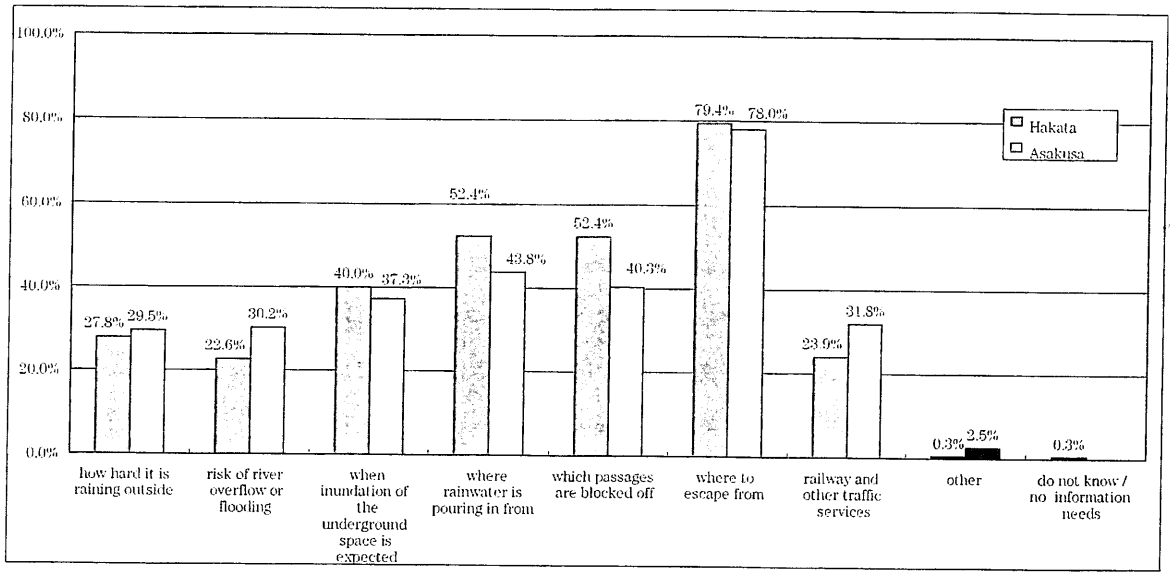


fig.3-5 Information needs in time of evacuation from underground space(in Hakata and Asakusa)

Information on "where to evacuate from" was chosen by the largest number of respondents, both in Hakata (79.4%) and in Asakusa(78.0%). Information needs cited more often by people in Hakata are "where rain water pours in" and "the passages which are blocked off", which were chosen by a majority of respondents in Hakata. Although the desire for information of all kinds was generally lower in Asakusa, "the overflow or flood risk of the river" and "the state of the railway and other traffic services" was chosen by a higher percentage of the people in Asakusa than in Hakata (8 percentage points more).

This difference is thought to be derived from the fact that users in Hakata answered the questionnaire assuming an actual flood disaster and imagined themselves searching for an evacuation route up to the ground level, whereas users in Asakusa approached the scenario presented in the questionnaire as an extension of their normal circumstances, such as doing business, sightseeing, or riding the subway.

3.6 Conclusions

The following is a summary of the survey results presented in sections 3.3 to 3.5 above.

(1) The underground shopping area around Hakata Station

As regards the characteristics of the users, people in their twenties or younger are numerous, and the purpose of their visits are shopping or eating out. The degree of the geographical acquaintance with the exits or passages of the underground space is a little better among weekday users.

The degree of uneasiness about flood disasters in the underground space is high, and the experience of the Fukuoka flood disaster has raised the level of consciousness about disaster prevention. In the comparison between weekday users and holiday users, weekday users have higher risk consciousness towards flood disaster.

However, it should be born in mind by those who carry out evacuation guidance that about 60% of the people answered that they feel very uneasy towards all the types of disaster, when asked about their degree of uneasiness about the occurrence of an earthquake, fire, gas explosion and flood disaster.

As to the overflow risk of the Mikasa River and inundation risk of the underground space, 60 to 70% of the respondents think these risks are high. In this paper we analyzed the relation between the degree of geographical acquaintance with the underground space and risk consciousness against flood disaster. The result is that those who are well acquainted with the exits and layout of the underground space evaluate both of the risks highly. The demographic features of the respondents is such that the percentage of people resident inside Fukuoka city is high and their frequency of use of the underground mall is high. As a result, we can assume that this case is an example demonstrating that the experience of the

Fukuoka flood disaster contributed to a raising of disaster risk consciousness among those who use the underground mall around Hakata Station daily.

As to behavioral responses to flood disasters, it is found out that most people would try to escape from the underground space immediately. Weekend users feel more uneasy than weekday users when elevators or escalators are out of service.
The reason for this difference is the variation in the proportion of people with household members particularly susceptible to disasters. Weekday users come mostly by themselves and tend to be young, so they think they can easily evacuate up to the ground level by themselves, while weekend users have to move in such a way as maintain the safety of their fellow travelers (including infants and elderly people), and make sure they do not get left behind. Although we did not ask about it in this questionnaire, one can also assume that such weekend users would also feel very uneasy about electrical power cuts, crowding, and information confusion during flooding. Facility managers should undertake appropriate evacuation guidance in consideration of the above circumstances.

It is found that most people would follow instructions to evacuate from facility managers, and they regard evacuation announcements and guidance as important. This is presumably because it is difficult for the users in an underground space to perceive the risk according to their own senses without knowing what is happening outside.

The information needs most often cited were where to evacuate from, where water is pouring in, and which exits and passageways are blocked off, information useful in the selection of evacuation routes. As to the risk of river overflow and flooding, weekday users perceived a higher level of risk than weekend users. This is derived from the fact that there is a higher percentage of residents from inside Fukuoka City among the former. Those who live inside the city are likely to attempt to walk back home over ground after they have evacuated, and are therefore exposed to a considerably high risk on their way. If the probability of an overflow of the Mikasa River is fairly high, information must be provided to facility managers in advance. The local government must also make provision for people remaining in the facility who are deemed to be in difficulty of returning home, and transmit instructions to facility managers so that these people can be evacuated to nearby places of refuge.

(2) Asakusa underground space

As to the characteristics of the users, although there are a little more people in their twenties or younger, the age distribution is more even here compared to Hakata. Asakusa is a business town on weekdays, and a sightseeing spot at the weekend, and the underground space functions as a passageway for people bound for these destinations.

Risk awareness towards flood disaster in underground space is low, but that towards earthquakes or fire is higher. The degree of uneasiness felt in response to the occurrence of flood disaster is far lower than that for any other type of disaster.

The majority of the respondents answered that the overflow risk of the Arakawa River and the risk of inundation in the underground space were not very high or none at all. These users of the Asakusa underground space have low risk consciousness towards flood disaster, leaving themselves in a defenseless state, considering the actual inundation risk. People need to be enlightened immediately about this risk of flood disaster so that they can become better prepared for it.

The degree of uneasiness towards water inundation and the behavioral responses to disaster are almost the same as those in Hakata. During evacuation most people would follow the evacuation instructions from facility managers, and rely on the evacuation announcements and evacuation guidance.

(3) A comparison of the Hakata case and the Asakusa case

The risk perception of flood disaster among the users in the two underground spaces are widely different. It is clearly shown that users in Fukuoka have a realistic perception of the risk of flooding as a result of their actual experience of it, while the risk perception of users in Asakusa has become seriously eroded.

The most remarkable difference was shown in their responses to the questions about the overflow risk of the Mikasa and Arakawa Rivers, and risk of a resultant inundation of the underground space. In Hakata, 60 to 70% of the people perceive a risk, while in Asakusa the majority of the people answered that the risks are not high or not at all, indicating they have no conception that flood disaster in an underground space could happen to themselves.

However, once presented with a concrete image, such as inundation to a specified depth, they responded with the same degree of uneasiness as those in Hakata. So it is assumed that disaster prevention would be most effective if information is given to the users in Asakusa underground space in a form that allows them to imagine themselves in a real situation of flood disaster.

There was no great difference between the two areas in the extent of uneasiness when flooding occurs, or in the behavioral responses to disaster. On the other hand, as regards information needs during evacuation, users in Hakata answered on the assumption of their behavior at the time of a real occurrence of inundation, while users in Asakusa tended to answer on the basis of the image of their normal life.

It is difficult to raise risk awareness in an underground space where no disaster has been experienced. Nevertheless, through the results of our research it was found that telling people what situation they would be in if a disaster occurred, and making them realistically aware of the risks would be a first step towards the raising of people's level of concern. However, if such efforts at raising awareness are merely one-off, people's consciousness will return to normal, and their disaster prevention awareness will simply erode away. The same applies to the users in the underground space around Hakata Station who have high consciousness of disaster prevention at the current time due to the recent experience of the Fukuoka Flood Disaster. In order to maintain consciousness of disaster prevention among users of an underground space at a high level, the facility managers and the local government authorities should provide information continuously on the risks in the underground space and maintain preparedness against the occurrence of disasters at all times.

紀要

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