camera co-located with the laser. Ranging data are then transferred via radio modem to a repeater location on Haenke Island where they are combined with meteorological measurements acquired every 15 minutes. The combined data set are transmitted hourly via the Geostationary Operational Environmental Satellite (GOES) to a Corps of Engineers Oracle-based time series relational database. Data are then reviewed for quality, rate of change errors, and missing data before further analysis and public dissemination. Information is available to the public and the scientific community via the Web at www.GlacierResearch.org, Finnegan, et al (2007). This readily available, near real-time data has proved to be useful to the local community as well as users and visitors of the surrounding marine environments, including cruise ships.

Over 4 years of data collected by the monitoring system so far show that the glacier exhibits an annual cycle of advancement and retreat. Advancement of Hubbard Glacier toward Gilbert Point has initiated between January and March and has persisted until between May and July. The remainder of the year, the glacier tends to retreat from Gilbert Point. Based upon this data, it appears the most likely time that a blockage of Russell Fiord could occur is in the late spring to early summer, just before the glacier tends to begin its annual retreat. The following table shows the minimum annual distance between Hubbard Glacier and Gilbert Point and dates of occurrence.

	Minimum
Date	Distance, m
June 14, 2007	120
June 27, 2008	169
June 16, 2009	107
May 13, 2010	367

Table 1. Annual Minimum Distance, Hubbard Glacier to Gilbert Point 2007 - 2010

FUTURE WORK

Changes in cost sharing requirements implemented in 2008 initiated a reduction in the scope of the USACE-AK effort in response to Hubbard Glacier. Continued operation and maintenance of the glacier terminus monitoring system is uncertain. Future efforts are likely to be concentrated in further advancing the economic diversity analysis effort.

CONCLUSION

The continued advancement of Hubbard Glacier poses an unusual flood and economic threat to the remote Alaskan community of Yakutat. USACE-AK has led an ongoing, collaborative study effort to respond to the hazards posed. Recognizing the numerous sources of uncertainty inherent to the situation, an adaptive planning approach has been pursued. Through such an approach, responses that would prove to be adaptable and, in particular, those that would provide a benefit to the community regardless of whether the overflow flood occurred or not, have been prioritized.

REFEERNCES

- Finnegan, D.C., Lawson, D.E., Hanlon, G., and Kalli, G. (2007). Near Realtime Monitoring of Tidewater Glacier Advance and Retreat: Hubbard Glacier, Southeast Alaska, American Geophysical Union Poster # C41A-0058.
- Mayo, Lawrence R. (1986). *Hubbard Glacier Near Yakutat, Alaska The Ice Damming* and Breakout of Russell Fiord/Lake 1986, National Water Summary 1986 – Ground-Water Quality: Hydrologic Conditions and Events.
- Post, Austin and Mayo, Lawrence R. (1971). Glacier Dammed Lakes and Outburst Floods in Alaska, Department of the Interior, United States Geological Survey Hydrologic Investigation Atlas HA-455.

ISSUES OF THE MEASURE OF EVACUATION AGAINST A STORM SURGE BY HITTING A HUGE TYPHOON IN JAPAN

Makoto KODAMA¹, Toshitaka KATADA²

- Department of Civil and Environmental Engineering, Gunma University, 1-5-1, Tenjin-cho Kiryu., Gunma, 376-8515, Japan, kodama@ce.gunma-u.ac.jp
- Department of Civil and Environmental Engineering, Gunma University, 1-5-1, Tenjin-cho Kiryu., Gunma, 376-8515, Japan, katada@gunma-u.ac.jp

Abstract: Because of global warming, the risk of a storm surge will increase more and more in the future. It is important to make residents appropriately evacuate so that they are not sacrificed to the storm surge disaster. In this paper, issues of the system of evacuation against the storm surge disaster in Japan and the ideal way of the system are examined referring to the United States. Moreover, the actual situation of resident's intention to evacuate at a storm surge disaster and relationship between the intention and its formation factors are clarified based on the result of the questionnaire survey. And appropriate way of education about disaster prevention for residents is considered.

INTRODUCTION

Because of global warming, the risk of a storm surge will increase more and more in the future. The Intergovernmental Panel on Climate Change (IPCC) published its 4th report in 2007. The report describes that ranges of sea level rise at the end of the 21st century (2090-2099) relative to 1980-1999 are 0.18 to 0.38m under a scenario with the lowest global greenhouse gas emissions and 0.26 to 0.59m under a scenario with the highest global greenhouse gas emissions. Moreover, it is likely that future tropical cyclones will become more intense (Oouchi, et al. 2006). As the intensity of typhoons increase, sea level is likely to rise due to their low atmospheric pressures, and the winds will cause strong drifts and high waves. Thus, intensified typhoons besides sea level rise are likely to increase damage caused by storm surges. Recently, serious damages by storm surges occurred in the world such as Hurricane Katrina at 2005 and Hurricane Gustav at 2008 in the United States. Maybe such the disaster of storm surges by huge typhoons will occur in Japan in the near future.

In Japan, below-sea-level areas along the three major bays are over populated and have accumulation of property. Thus, when a storm surge by a huge typhoon occurs in Japan, a large area suffers serious damage and a lot of residents should evacuate to the safety place. However, the system of the operation of evacuation against a heavy storm surge disaster is not enough, because Japan has not suffered from the disaster of the storm surge by the huge typhoon for half a century. Moreover, because a lot of residents have not been experience a storm surge disaster for many years, residents who appropriately understand the hazard of a storm surge and the way of evacuation at the disaster are few.

In this study, issues of the system of the operation of residents' evacuation against a storm surge disaster in Japan and the ideal way of the system are examined referring to the United States. Moreover, the actual situation of resident's intention to evacuate at a storm surge disaster and relationship between the intention and its formation factors are clarified based on the result of the questionnaire survey. And appropriate way of education about disaster prevention for residents is considered.

ISSUES OF OPERATION OF EVACUATION AGAINST A STORM SURGE BY AUTHORITIES AND MUNICIPALITIES IN JAPAN

It is expected that climate change due to global warming causes increasing intensity of tropical cyclones and a rise of 0.26 to 0.59m in sea level. In Japan, below-sea-level areas along the three major bays which are called "Tokyo bay", "Ise bay" and "Osaka bay" are over populated and have accumulation of property. So, when a storm surge by hitting a huge typhoon occurs there, the lives and property of many people will be affected. Therefore, it is important that people living in such areas evacuate so that they are not suffered by the disaster. When a storm surge occurs, it is assumed that the damage area extends over many municipalities. However, the system of residents' evacuation against such a widespread disaster is not complete in Japan. In the law about the disaster which is called "The Fundamental Disaster Relief Act", it provides that municipalities lead residents' evacuation. However, the law is not regulated the evacuation that exceeds many municipalities. Moreover, cooperation between municipalities about the evacuation is not enough, and the government authority doesn't lead residents' evacuation.

One reason why such the system has not been completely built up in Japan is as follows. A typhoon is brewing and developed in the low latitude, but it weakens near Japan gradually because the temperature of seawater falls in the high latitude. So, Japan has not suffered heavy damage from the storm surge caused by a huge typhoon for about 50 years, and did not have the situation that operated the wide area evacuation.

On the other hand, in the United States, when forecast that the hurricane hits the land of America, FEMA commands evacuation for concerned municipalities, and they announce the evacuation order. Moreover, FEMA offers regions necessary support of evacuation quickly such as to secure transport, shelters, and so on. For example, when the hurricane "Gustav" had hit in 2008, it succeeded that 1.9 million people have evacuated from a dangerous areas before the disaster occurred the State of Louisiana (The State of Louisiana, 2008).

A huge typhoon may hit Japan in the near future because of climate change. It is necessary that authorities and municipalities discuss each other about the acceptance systems of the residents' evacuation before the disaster occurring.

ISSUES OF RESIDENTS' INTENTION TO EVACUATE AGAINST THE STORM SURGE DISASTER

Even if the government has organized the evacuation guidance system, it can't reduce the number of victims of storm surge disasters unless the residents are amenable to it. In the areas which are often hit by deadly hurricanes like the United States., a lot of residents seem to understand the way to avoid the disaster. However, Japan has not been hit by a huge typhoon or suffered a heavy storm surge disaster for about 50 years, so we are finding that Japanese people don't fully understand the way to evacuate at the disaster.

Then, we consider the way of providing disaster prevention education to improve the residents' understanding of the way to evacuate at a storm surge disaster in addition to finding out the problems in the evacuation at a storm surge disaster from the viewpoint of residents' awareness based on the results of the questionnaire survey carried out among residents in the area which has been seriously affected by the storm surge disaster.

Region for research

The questionnaire survey was carried out in Nagashima-island in Kuwana City, Mie Pref., Japan. Booklets of the questionnaire were distributed to 4,618 residents, and 1,462 responded. The response rate was 31.7%.

Nagashima-island had suffered heavy damage from the storm surge caused by the huge typhoon that is called "Isewan Typhoon" in 1959. According to Fig.1, the area had inundated for 30-120 days.

Nagashima-island is the below-sea-level area. So, when the storm surge by "Super Isewan Typhoon" that is assumed by the regional crisis management committee about disaster prevention against storm surges and floods (consists of the authorities, municipalities, corporations of transportation and lifeline around Ise-bay area, and researchers) occurs, residents have to evacuate to safety shelters outside the island because the whole of the area will inundated above 3m depth. Moreover, the wind speed in Nagashima-island reaches 15m/s before 8 hours when the typhoon hits the main island of Japan, "Honshu", and reaches 20m/s before 6 hours. So, residents should begin to evacuate before such the situation.

The actual situation of residents' intention to evacuate against the storm surge disaster In the questionnaire survey, the scenario of the "Super Isewan Typhoon" hitting



Fig.1. The situation of the inundation of the storm surge by Isewan Typhoon in 1959



This is the same as the typhoon (Muroto Typhoon, 1934) of the atmospheric pressure that is the lowest observed till now in Japan.

The typhoon goes along the route causing most serious damage to lse bay area.

Fig.2. The scenario of Super Isewan Typhoon hitting Honshu and situations in the questionnaire

Honshu is shown Fig.2. Then, respondents answered their intention to evacuate in the scenario.

From the result of the questionnaire survey, the actual states of residents' evacuation intention clarified are as follows.

Intention to evacuate against the storm surge

Fig.3 shows the actual situation of the intention to evacuate in the scenario of Fig.2. According to the Fig.3, 24% residents answered that they will not evacuate although they live in the whole of the area that will inundated above 3m depth.

Then, formation factors of the intention to evacuate are analyzed. In Fig.4, the relation between the intention and factors that caused the especially large impact was shown. According to Fig.4, it is clear that the intention to evacuate is influenced by the estimation of the damage of their home by the inundation or storm. Then, based on the analysis of the relation between the estimation of the damage of the house and its formation factors, the estimation of damage of the home is formed by the knowledge of inundation depth of the past storm surge disaster at the position of their home and the damage experience by the storm are clarified. Such the relation between the past knowledge of the disaster experience and the estimation of the damage can be seen even due to the river flood (Oikawa, et al., 1999).

Moreover, according to Fig.4, residents who are physically disabled will not evacuate compared with others. So, it is important to organize the system of the support to evacuate for such people.



Fig.5 shows resident's intention of the evacuation beginning



Fig.3. Resident's Intention to evacuate against the storm surge

0%	20%	40%	60%	80%	100%
The awareness of the inundation level at the home when the storm surge of	occurs				(N)
My home won't inundate	52	.6		47.4	(137)
My home will inundate below the floor level		71.8		28	.2 (174)
My home will inundate above the floor level, but I think I can stay there		70.8		29.	2 (391
My home will inundate above the floor level, and I think I can't stay there		85.8			14.2 (681
The awareness of the time that the hor when the storm surge occurs	ne is i	nundat	ed		
My home inundated for 2-3 hours		64.1		35.9	(39)
For 6 hours	52	.8		47.2	(36)
For half a day		72.7		27	.3 (99)
For a day		82.1		1	7.9 (140)
For 2-3 days		79.1		2	0.9 (211)
For 4-6 days		75.8		24	1.2 (91)
For 1-2 weeks		78.5		2	1.5 (219)
For 3-4 weeks		83.2		1	6.8 (197
For a month or more		81.2		1	8.8 (255
The awareness of the damage of the h when the storm surge occurs	ome b	y storn	ny win	ds	
My home won't be broken by the stormy wind		67.2		32.8	3 (64)
My home will be broken, but I think I can stay there		71.1		28.	9 (818)
My home will be destroyed, and I think I can't stay there		86.3			13.7 (504)
The awareness of the condition of the	health				
It's hard to evacuate to outside Nagasima-island because of the physically disabled		69.0		31.	0 (242)
The other		80.0		2	0.0 (720)
Intention to e	evacua	te agair	nst the I won'	storm t evacu	surge] ate

Fig.4. Relationship between the intention to evacuate and formation factors of it

timing in the scenario shown in Fig.2. According to Fig.5, only 24% residents will begin to evacuate before the situation No.4 that they can barely evacuate walking.

Then, the formation factor of the intention of evacuation beginning timing is analyzed. At the result, according to Fig.6, the intention is influenced by the estimation of the damage of their house by the flood or storm. Moreover, it is especially clear that the intention of the evacuation beginning timing is Fig.5. Resident's intention of beginning timing to influenced by the awareness of the timing that residents can't walk or drive because of the stormy wind. Therefore, it is important to educate for residents that it is necessary for them to begin to evacuate before they are not able to move by the stormy wind of a typhoon at a storm surge disaster.

Place for evacuation

When a storm surge disaster occurs in Nagashima-island, the entire area becomes deeply flooded, it is therefore necessary to evacuate to a safe place outside the island in order not to produce victims. Therefore, the intention about place for evacuation is clarified.

According to Fig.7, 58% of those who responded indicated the intention to stay shelters in Nagashima-island.

Focusing on the factors affecting the intentions about place for evacuation, which were analyzed in Fig.8, firstly indicates that it is more perception about stormy



evacuate

()%	20	%	40	%	60%	8	J%	100%
The awareness of the inundation lever at the home when the storm surger	vel je od	cų	Irs						
My home won't inundate	19	7		4	2.3		29	.6	(71)
My home will inundate below the floor level		18.0	0	3	5.2		26.	2	(1 2 2)
My home will inundate above the floor level, but I think I can stay there		21.	9	_	38.5		23	8.0	270)
My home will inundate above the floor level, and I think I can't stay there		2	5.0		;	32.6	23	3.	(565)
The awareness of the damage of th when the storm surge occurs	e ho	me	e by	/ st	orm	y w	inds		
My home won't be broken by the stormy wind		25.0	6		34.9		23.	3 1	6 (43)
My home will be broken, but I think I can stay there		21.0	0		37.1		23	.8	(571)
and I think I can't stay there		2	5.2	T.	32	.2	2	5.0	(416)
The awareness of the timing that re- because of the stormy wind	side	nts	са	nno	ot w	alk			
It is not likely to be able to walk at the situation No.1-3 shown in Fig.1	2	3.5	1	1.8	17.6	2	5.5	11.8	(51)
At the situation No.4		-	40.	3		3	9.0	9	(77)
At the situation No.5			26.7		3	7.6		20.8	221)
At the situation No.6	1	9.9		3	8.1		29	.1	(402)
At the situation No.7-8	16.	5	3	2.0		29	.4	17.0	(194)
The awareness of the timing that re-	side	nts	ca	nno	ot di	rive	the		
It is not likely to be able to walk at the situation No.1-3 shown in Fig.1	10	10.	7	28.6	6	25	.0	14.3	(28)
At the situation No.4	9.1	Ļ	31.	8		34.	1	15.9	(44)
At the situation No.5		2	7.9			37.4		17.9	(179)
At the situation No.6		22.3	3		41.1			24.6	G 41)
At the situation No.7-8	1	9.1		30.	9		33.6	10) <mark>18</mark> (262)
The intention of beginning timing to e □Situation No.1 □No.2 ⊡No.3 □No	evacu	iate IN c	e in o.5	the ∎N	e sce Io.6	enar	io lik I o.7	e Fi ∎N	g.2] o.8

Fig.6. Relationship between the intention of beginning timing to evacuate and formation factors of it

wind damages than inundation damage that was affecting. Residents who are physically disabled or who don't have means of transportation also have a strong intention to stay shelters in Nagashima-island, it is therefore necessary to explore an evacuation support system for such residents.

Furthermore. although it is peculiar to the Japanese, they feel reluctant to evacuate to a new place where they are not used to living, feel reluctant to evacuate leaving the house and household furniture behind, or feel anxietv about being separated from the people currently living together, and such thoughts are a factor to have them stay inside the area. It is also necessary to discuss the evacuation system which takes such sense of indigenousness and the local community into consideration.

Conducting educational activities to raise residents' awareness in order for encouraging evacuation at a storm surge disasters and their effects

As described above, it is obvious that in Japan there remain a lot of problems in the residents' awareness about storm surge disasters which may occur in future, even at places where a serious damage was caused by a storm surge disaster before. When raising the residents' awareness about storm surge Q. Where will you evacuate if you can't stay your home?

Fig.7. Place for evacuation which residents think







disasters, it is important to show the residents what huge typhoon and storm surge disasters are like, as well as encouraging them to have appropriate understanding of evacuation at such times.

With that awareness of the issues, the authors have visited the area repeatedly, conducting the activities to raise the residents' awareness by providing disaster prevention lectures.

Points of lectures are as follows.

1) If a huge typhoon hit like "Super Isewan Typhoon" shown Fig.2, the wind speed in Nagashima-island reaches 15m/s before 8 hours when the typhoon hits Honshu, and reaches 20m/s before 6 hours. So, residents should begin to evacuate before such situations.

2) Moreover, Nagashima-island will inundate above 3m depth for a month or more, so residents can't stay here and are necessary to evacuate to a safe place outside the island.

3) Residents have to support to evacuate for those who are physically disabled in order not to produce victims at the disaster.

4) Because the forecast technology of the typhoon advanced, the course is almost understood 36 hours before the typhoon hitting. Therefore, municipalities can announce the evacuation advice for residents at that timing.

At the disaster prevention lectures, the results of simulating a storm surge flooding and typhoon were presented by using motion pictures and animation, as well as showing the actual situations of the typhoon and storm surge disaster which had occurred in this area in the past, so that they would have understanding of storm surge disasters. In addition, a comprehensive simulation system was developed that expressed hazardous phenomena such as storm surge flooding and stormy winds accompanied by typhoon, situation of communication to residents such as warnings and evacuation information, their evacuation situation and conditions of casualties



Fig.9. Snapshot of the animation of the comprehensive disaster scenario simulator