ADAPTATIONS AND COUNTERMEASURES FOR MITIGATING IMPACTS DUE TO GLOBAL WARMING IN GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING

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ABSTRACT: This paper describes what will be happened by torrential rainfall and temperature rising due to global warming. It also introduces some examples of researches and developments concerning the mentioned-above which are being conducted in Ibaraki University. Especially, this paper describes vulnerability of river levees and banks against torrential rainfall and degradation of water quality of closed water environment such as lake/marsh which will be caused by temperature rising due to global warming. Furthermore, this paper mentions significance of aftercare in damage site by introducing an exemplum of utilization of disaster waste in the 2004 year Niigata Chuetsu earthquake. Consequently, it describes the author's philosophy for adaptation and countermeasures against global warming.

Keywords: Adaptation and countermeasure, Torrential rainfall, Temperature rising, River levee and bank, closed water environment, Aftercare of Damaged Site, Geotechnical and Geoenvironmental Engineering

INTRODUCTION

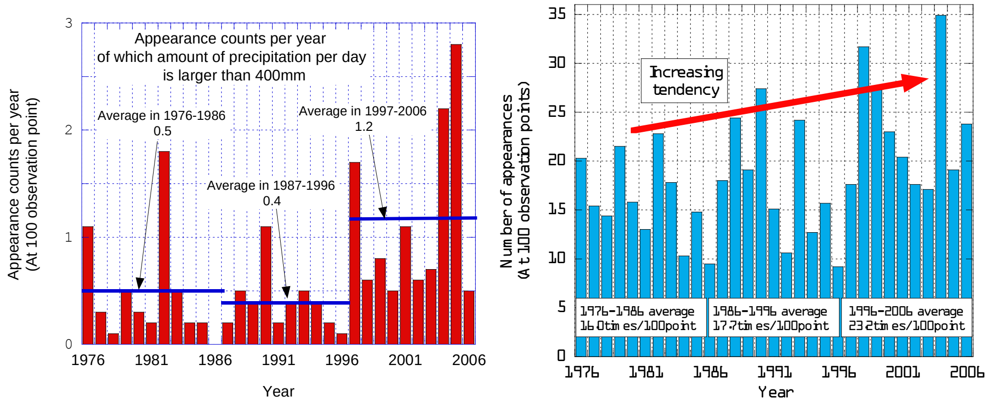
Recently, we have had so many disasters and accidents such as damages of levees at large rivers and large landslides near mountainous area, which are caused by torrential rainfall in Japan. It is thought that the global warming is one of the reasons inducing torrential rainfall. River levees and banks consist of soil materials. Mountains also consist of much kind of ground materials. The fundamental properties of soil and ground materials are strongly dependent on water amount contained in materials. Therefore, river levees and banks and mountainous area are vulnerable by much amount of water due to torrential rainfall. Moreover, it is well known that the damages of levees and land slopes become more serious by compounding torrential rainfalls with large earthquakes.

Whereas, IPCC prefigures that the temperature increased by global warming will be maximum 6.4 centigrade at 2099 year. It also prefigures the maximum amount of rising sea-level due to global warming will be 59 cm at the end of this century. It is anticipated that temperature rising will derive deterioration of water chemistries in closed water environments such as lakes/marshes. Sea-level rising will also derive expanding of brackish-region in rivers by running of seawater to the upside of rivers.

As the above mentioned, it is afraid that global warming will derive many problems on geotechnical and geoenvironmental engineering. Therefore, civil engineers in all of the world will have to solve those problems from the viewpoint of global perspective. Not only developed countries but also developing countries have to solve the same problems. The author believes that all of researchers and engineers in geotechnical and geoenvironmental engineering can contribute hugely to solve those problems. This paper introduces some examples of researches concerning adaptations and countermeasures for mitigating impacts due to global warming. Furthermore, it also describes a perspective of civil engineering for mitigating impacts due to global warming.

WHAT WILL BE HAPPENED BY MANY OCCURRENCES OF TOREENTIAL RAINFALL DUE TO GLOBAL WARMING

Figure 1 shows the recent situation of rainfall in Japan. The left figure shows the number of appearance per year of which amount of precipitation per day is larger than 400mm in Japan (Japan Meteorological Agency 2006, Uchida 2008). The right figure also shows the number of appearance of which amount of precipitation per hour is larger than 50mm from 1976 to 2006 year in Japan (Japan Meteorological Agency 2006, Munegumi et al. 2008).



Left figure: Appearance counts per year of which amount of precipitation per day is larger than 400mm in Japan (Japan Meteorological Agency 2006, Uchida 2008).

Right figure: Number of appearance of which amount of precipitation per hour is larger than 50mm in Japan (Japan Meteorological Agency 2006, Munegumi et al. 2008).

Figure 1 Recent situation of rainfall in Japan.

These figures indicate that the number of appearance of torrential rainfall is increasing year in. Especially, the number of torrential rainfall is found to be particularly increasing in recent several years.

In fact, there are some disasters caused by torrential rainfall in Japan. Figure 2 shows the disaster of levee crashing by the 2004 year Niigata torrential rainfall at Igarashi river, July 2004. A lot of amounts of water run out from the point of levee crashing at Igarashi river. Consequently, Sanjyo-city had large disasters by overflowing from the Igarashi river.

Figure 2 Levee crashing by 2004 Niigata torrential rainfall at Igarashi river, July 2004 (Photos is from the Hokuriku Regional Bureau, Ministry of Land, Infrastructure and Transport in Japan).

Table 1 shows the damage by the 2004 year Niigata torrential rainfall. It is found that the 2004 year Niigata torrential rainfall derived large accidents as shown in Table 1.

Table 1 Damage by the 2004 year Niigata torrential rainfall

Completely destroyed house	70 (68 household)
Half destroyed house	5354 (5437 household)
Partially destroyed house	94 (94 household)
House flooded above floor board	2178 (2222 household)
House flooded below floor board	6117 (6176 household)

Figure 3 is the situation of levee crashing by 2000 Tokai torrential rainfall at Shin river, September 2000. As in these figures, heavy torrential rainfalls on and after the 2000 year have attacked river levees and banks as infrastructure and crashed them.

Figure 3 Levee crashing by 2000 Tokai torrential rainfall at Shi n river, September 2000 (Photo is quoted from the website of Kokusai Kougyo Co. Ltd.).

It is conceivable that these accidents and disasters are caused by torrential rainfall due to global warming.

WHAT SHOULD WE DO AGAINST TORRENTIAL RAINFALL

Our Ibaraki University research group is now studying many engineering subjects against torrential rainfall (Munegumi et al. 2008, Uchida 2008, Uchida et al. 2007). Our group focuses the vulnerability evaluation of river levees and banks. The purpose of our studies is to investigate and evaluate the vulnerability of river levees and banks as infrastructure against torrential rainfall resulting from global warming and abnormal climate.

At the 2006 year, the following experimental work was carried out: 1) Estimation of vulnerability of river levees and banks against torrential raining by means of plasticity index, 2) Estimation of vulnerability of river levees and banks against torrential rainfall by means of water retention characteristics.

The conclusions obtained in the above study are follows.

1) Estimation of vulnerability of river levees and banks against torrential rainfall by means of plasticity index

We measured the values of plasticity index of soil materials which are used for river levees and banks in Japan by the test method for liquid limit and plastic limit of soil (JIS A 1205: 1999). From the experimental results, the plasticity index of Kanto-loam is relatively large, so the water retention property of the Kanto-loam is expected to be large and the vulnerability of river levees and banks made by the Kanto-loam is relatively low. This study measured the plasticity indexes of the other materials such as Akaboku-soil, Kuroboku-soil, Niigata river levees material, Tsuishikari river levee material, and Ebetsu-soil and estimated the vulnerability of river levees and banks made by the above materials.

2) Estimation of vulnerability of river levees and banks against torrential raining by means of water retention characteristics

This study also measured the water retentivity of nine kinds of soil materials selected as the representative materials for river levees and banks in Japan (Uchida et al. 2007). The above experiment was carried out by the test method for water retentivity of soils (JGS 0151-2000). Moreover, this study calculated the one-dimensional deformation of the above soil materials in drainage process (Uchida et al. 2007) and evaluated the water retention properties by using the results obtained by the above experiments. From the viewpoint of one-dimensional deformation and the water retentivity of soils, this study evaluated the vulnerability of river levees and banks against torrential raining. Figure 4 shows the vulnerability of river levees and banks against torrential rainfall and suitable countermeasures.

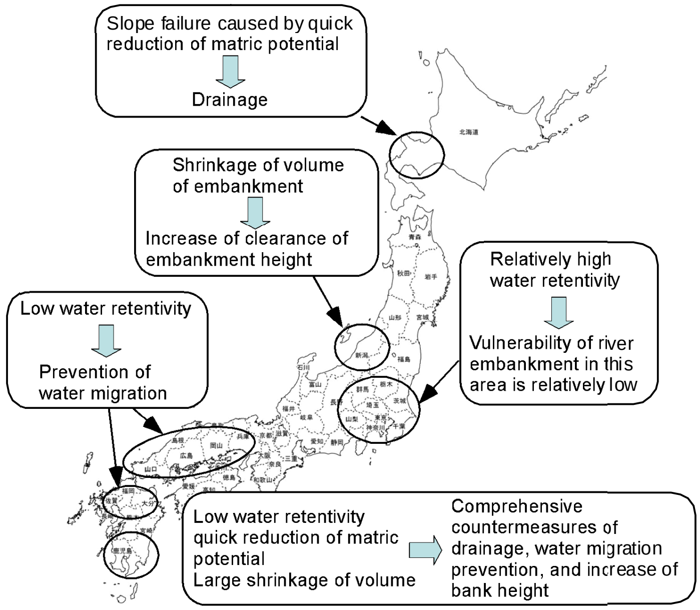


Figure 4 Vulnerability of river levees and banks against torrential rainfall and suitable countermeasures.

At the 2007 year, the following experimental work was carried out: 1) Estimation of vulnerability of river levees and banks against torrential rains using the water retention characteristics at the prescribed vertical stress and the volume change characteristics of levee and bank soil under unsaturated triaxial compression conditions, 2) Trial estimation of vulnerability of actual river levees by the above water retention characteristics and the above volume change characteristics.

The conclusions obtained in this study are follows:

a) The settlements of river levees and banks materials under water seepage conditions are lager than that under water drainage conditions.

b) This study predicted the maximum settlement of the actual river levee named the Kimotsuki river by the water retention characteristics and the volume change characteristics. From the calculated results, the predicted maximum settlement of concentrated heavy rains may become 2.48cm in Kimotsuki river.

c) This study proposed the vulnerability evaluation of river levees and banks using freeboard of embankment. The proposed evaluation can compare the effect of water level rise with the settlements and the standard values of freeboard.

d) From the above considerations, it was found that the estuary region such as 1 km from downriver is affected strongly and that settlement of the secondary shirasu is affected strongly by torrential raining.

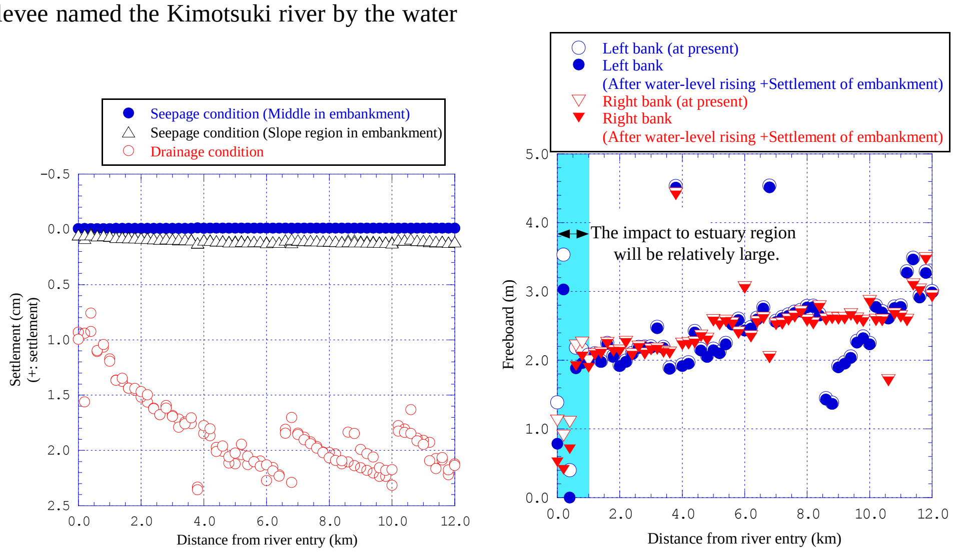


Figure 5 The predicted settlement (left) and the predicted freeboard (right) of embankment by raining in the Kimotsuki-river.

WHAT WILL BE HAPPENED BY TEMPERATURE RISING DUE TO GLOBAL WARMING

It is anticipated that temperature rising due to global warming will derive deterioration of water chemistries in closed water environments such as lakes/marshes. Figure 6 shows the actual situation of closed water environment named as Akabane-Ryokuchi park at Ibaraki. As in Fig. 6, the marsh is eutrophied and a lot of water-bloom is growing so the quality of water is so bad. If the temperature of marsh water will be increasing by global warming, it is thinkable that the quality of water will be worse than now. In Vietnam, there is the same situation (see Fig. 7) as the above so Vietnam has also the same problem due to global warming. Therefore, our group are now developing the new technology using combustion waste such as coal fly ash and/or melted slag for mitigating water pollution in closed water environments. The detail of the above new technology is referred by Kigata et al. (2008).

(a) Cover shot : The marsh is eutrophied and a lot of water-bloom is growing

(b) Side of the marsh : Eutrophicating marsh is marked and methane gas from marsh deposit can be observed.

Figure 6 Actual situation of closed water environment named as Akabane -Ryokuchi park in Ibaraki

Figure 7 Actual situation of closed water environment in the park in Hanoi, Vietnam.

Whereas, sea-level rising will also derive expanding of brackish-region in rivers by running of seawater to the upside of rivers (see Fig. 8). The phenomena will also derive the worse quality of water in lower area of river. Komine (2007a and 2007b) obtained the map on damage pattern of river levees and banks showin in Fig. 9 from a lot of experimental results. Furthermore, the author proposed the countermeasures in Table 2 for each region in Japan against expanding of brackish-region in rivers

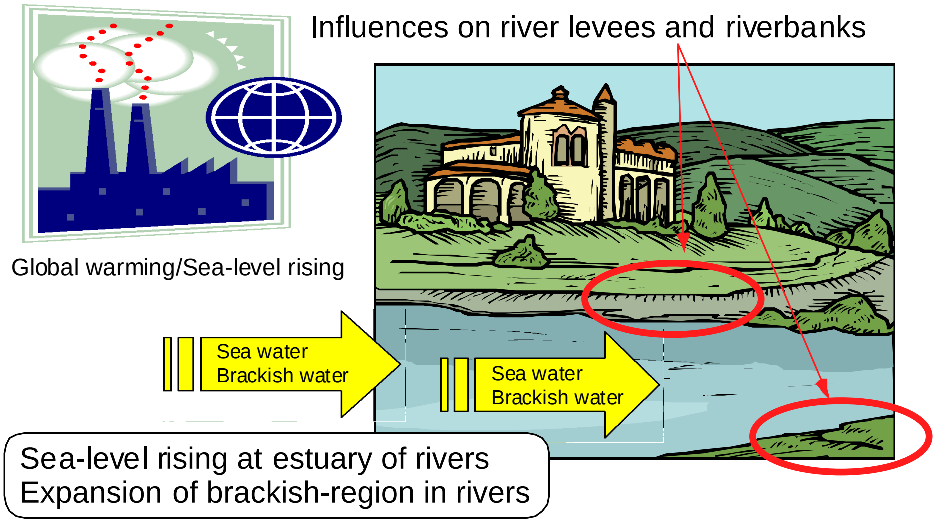


Figure 8 Possibility of damage patterns of river levees and banks by expanding of brackish-region in rivers

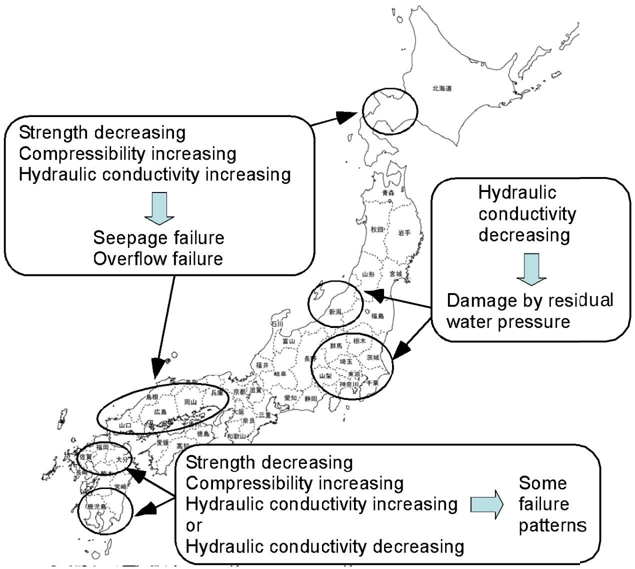


Figure 9 Possibility of damage patterns of river levees and banks by expanding of brackish-region in rivers

Table 2 Countermeasures for each region in Japan expanding of brackish-region in rivers

Region	Influence	Damage pattern	Countermeasure
Hokkaido	Strength decreasing Compressibility increasing Hydraulic conductivity increasing	Seepage Overflow	Water proof
Kanto (Ibaraki)	Hydraulic conductivity decreasing	Damage by residual water pressure	Water drainage
Shinetsu (Niigata)	Hydraulic conductivity decreasing	Damage by residual water pressure	Water drainage
Chugoku (Yamaguchi)	Strength decreasing Compressibility increasing Hydraulic conductivity increasing	Seepage Overflow	Water proof
Kyushu (Ohita, Kagoshima)	Strength decreasing Compressibility increasing Hydraulic conductivity increasing	Seepage Overflow	Water proof

AFTERCARE OF DAMAGED SITE - E.G. CARE AFTER LARGE EARTHQUAKES

In the preceding section, the author has introduced some examples of beforehand countermeasures on the basis of the prediction of damage. The beforehand countermeasures are expected to be act effectively against natural disasters. However, the author thinks that only beforehand countermeasures are not enough. Because we never fail to have some damages caused by natural disasters although we make a lot of beforehand countermeasures. Therefore, the author believes that aftercare of damage site is also one of adaptations and countermeasures.

Figure 10 shows the landscape photos at the site damaged by 2004 year Niigata Chuetsu earthquake.

Figure 10 Houses damaged by 2004 year Niigata Chuetsu earthquake. A lot of damaged houses remain after 3 years of earthquake, yet. (The above pictures were photo by Dr. Murakami, Ms. Suzuki, Mr. Nunokawa at Octorber 20th, 2007)

This earthquake happened at October 23rd, 2004 after a couple weeks of the 2004 year Niigata torrential rainfall described in the preceding section. The magnitude of this earthquake is 6.8 and the maximum vertical acceleration is 1750.2 Gal.As shown in Fig. 10, there are a lot of damaged houses after 3 years and this site have not been reconstructed, yet.

Large natural disasters such as the 2004 year Niigata Chuetsu earthquake mentioned above always generate a lot of disaster waste. The damage by the 2004 year Niigata Chuetsu earthquake shown in Table 3 always generates a lot of waste.

Table 3 Damage by the 2004 year Niigata Chuetsu earthquake

Body count	65
Injured person	4795
Completely destroyed house	3175
Partially destroyed house	2165
Damaged infrastructure	40343

Figure 11 shows an example of utilization of disaster wastes. The structure shown in Fig. 11 is the debris barriers made by disaster wastes which were generated by the 2004 year Niigata Chuetsu earthquake. The author believes that the example in Fig. 11 is one of exemplary aftercare as adaptations and countermeasures.

Figure 11 Debris barriers made by disaster wastes which were generated by 2004 year Niigata Chuetsu earthquake.

(The above pictures were photo by Dr. Murakami, Ms. Suzuki, Mr. Nunokawa at Octorber 20th, 2007.)

CONCLUSION: PERSPECTIVE OF ADAPTATIONS AGAINST GLOBAL WARMING

This paper described and introduced the researches and development for adaptations and countermeasures against global warming. The author believes that adaptations and countermeasures have to be able to apply in developing and developed countries. Therefore, it is necessary and significant for us to make philosophy of suitable adaptations and countermeasures. The exemplum of utilization of disaster waste shown in Fig. 11 is expected to become the adaptations and countermeasures for damage site. We, civil engineers have to progress our researches and development by using not only high-technology but also traditional technology.

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