Flood Risk Assessment of Underground Space Inundation
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Abstract
The flood disaster of Fukuoka in 1999 exposed the vulnerability of underground spaces against inundation. In order to implement measures against this problem effectively, flood risks of underground spaces must be properly assessed. This paper describes the research plan of the Flood disaster prevention division, NILIM, concerning flood risk assessment of underground spaces. The present state of this issue and the outline of the research are presented.

1. INTRODUCTION
“Urban flood disasters”, or flood disasters that cause damage to facilities typically exist in urbanized areas are becoming prominent in recent years. It is because of the concentration of population and assets in flood prone areas, which makes flood risks of urban facilities very high. In particular, various underground spaces such as basements, subway stations and shopping malls that exist in flood prone areas are quite vulnerable to inundation.

In order to cope with such “urban flood disasters”, structural and non-structural measures are being strongly promoted. To make this effort efficient, appropriate flood risk assessment is indispensable.

This paper describes the present state and issues on inundation of underground spaces. It also outlines the research plan of the Flood disaster prevention division, NILIM, concerning flood risk assessment of underground spaces.

2. STATES OF UNDERGROUND SPACE INUNDATION
2.1 The flood disaster of Fukuoka in 1999 (Suetsugi 2000)
In June, 1999, Fukuoka city was hit by a torrential rain and the central part of the city was submerged under water. The cause of the inundation was both overflow from drainage channels and a middle-scale river channel, the Mikasa river. The maximum rainfall 77mm/hr was beyond the design intensity of the interior drainage system.

During this flood, subway stations, shopping malls and underground floors of private buildings were inundated. 71 buildings with underground floors, which are about 40% of all the buildings around Hakata station, were damaged. 10 underground spaces among them were completely submerged. It claimed the life of a person who stayed in a building basement. Hotels and shops with or inside underground facilities were forced to take a long-term suspension of business, because of various kinds of damage such as a breakdown of electric supply equipments which were settled in underground spaces.

Some administrators of underground spaces took measures to prevent inundation, using sandbags and temporary floodwalls by boards, etc. However most of the administrators did not implement any measure beforehand. It is because they were not aware of the danger of inundation in case of heavy rainfalls beyond the capacity of drainage facilities.

2.2 Measures taken after 1999 Fukuoka disaster
In August, 1999, after the disaster in Fukuoka, a joint statement “Urgent measures against inundation of underground spaces” was issued by 4 central government agencies. It pointed out necessity to:
A) Rouse awareness of danger of underground spaces.
B) Transmit accurate and prompt information to administrators of underground spaces during flood.
C) Prepare appropriate refuge plan.
D) Promote prevention and mitigation measures against inundation of underground facilities.

In July, 2001, the flood fighting law was amended. The severe damage of Tokai flood disaster in September, 2001 triggered this. For the purpose of promoting effective evacuation activities during flood, designation of “inundation expected areas”, which are hazardous areas derived from computer simulations, became obligatory to the river administrators. Responsible municipalities must take account of this information when making disaster prevention plans including measures for underground facilities.

3. ISSUES ON FLOOD RISK ASSESSMENT OF UNDERGROUND SPACES
3.1 Flood hazard assessment method
In order to implement measures which are proposed in the above-mentioned statement, some technical problems must be solved. When selecting an appropriate measure to protect an underground facility, it is indispensable to know quantitatively the flood risk of the exact place where it exists. Although preparation of flood hazard maps is strongly promoted in Japan, flood risk information is not available for any arbitrary places. 145 out of about 3,000
municipalities have prepared flood hazard maps so far (December, 2001).

In order to prepare credible hazard information, accurate prediction of the actual process of inundation is necessary. However, flood hazard information which has been prepared so far is insufficient, since inundation caused by landside water such as overflowed water from drainage channels has not been evaluated. This type of inundation is significant in Japan especially in urbanized areas. Because of the difference of design return period of facilities, inundation caused by landside water occur more frequently than that by riverine flood. Thus development of an appropriate simulation model which can consistently consider both landside water and riverine flood is needed.

3.2 Damage estimation method of underground spaces

In addition to the preparation of flood hazard information by government and so forth, feasible and effective way to prevent or reduce damage to underground facilities must be presented in order to prompt implementation of measures by the administrators or owners. For that purpose, way to accurately estimate damage based on understanding of the characteristics of underground spaces must be established.

4. RESEARCH PLAN FOR THE FLOOD RISK ASSESSMENT OF UNDERGROUND SPACES

The flood disaster prevention division of NILIM is conducting research on the development of flood risk assessment method for underground spaces. The result will be utilized for preparing and publishing a nationwide database of flood risk information. The flowchart of the study is shown in Figure 1. The major research topics are as follows:

- Development of flood hazard simulation method applicable to both riverine flood and landside water inundation.
- Development of damage estimation method for underground space inundation.
- Development of flood risk index for urbanized area and underground spaces.
- Standardization of flood risk analysis and mapping method.

5. REFERENCE