COMPREHENSIVE FLOOD DISASTER PREVENTION MEASURES IN JAPAN

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ABSTRACT

In the course of the rapid economic growth since the 1960's, the concentration of population and properties in urban areas, especially in three major cities has been remarkable. Subsequent land development in and around these areas, its influences on the hydrological cycle and measures against flood disaster are described in this paper.

INTRODUCTION

Structural measures applied to rivers areas can't alone solve urban flood problems. Thus, the Comprehensive Flood Disaster Prevention Measures formulated in 1979 are a combination of river improvement works, flood control measures in the basin, and non-structural measures for flood damage mitigation.

CHANGES IN THE TSURUMI RIVER AND ITS INFLUENCE

Outline of the Tsurumi river

The Tsurumi river basin, which is a typical urbanized basin, is introduced as an example of the Comprehensive Flood Prevention Project to give a better understanding of the Japanese experience in handling the urban flood problems. The Tsurumi basin (235 km²) is located in the western part of the Tokyo megalopolis. Characteristics of the basin are shown in Table 1. 70% of the basin area is covered by plateaus and hills with gentle slope, and the rest is alluvial plains. The downstream area is well known for its industrial activities (the Keihin industrial district).
Table 1. Outline of the Tsurumi River Basin

<table>
<thead>
<tr>
<th>Characteristics of Basin</th>
<th>Specification of Basin</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage Area by Pump</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alluvial Plain</td>
<td>225km²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>About 50km²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>68km²</td>
<td></td>
</tr>
<tr>
<td>Urban Development Area</td>
<td>101km²</td>
<td>77% of Basin Area</td>
</tr>
<tr>
<td>Geography</td>
<td>Hill, Plateau and Lowland</td>
<td>97.3km including Tributaries</td>
</tr>
<tr>
<td>Length of Main Stream</td>
<td>42.5km</td>
<td></td>
</tr>
<tr>
<td>Slope of River</td>
<td>1/1/600 ~ 1/1,500</td>
<td>Upstream from Ochiai Bridge</td>
</tr>
<tr>
<td></td>
<td>1/1/1,500 ~ 1/2,000</td>
<td>Middle and Downstream</td>
</tr>
<tr>
<td>Flood Prone Area</td>
<td>Population</td>
<td>272 thousand (1970)</td>
</tr>
<tr>
<td></td>
<td>Assets</td>
<td>570 billion yen (1970)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>342 thousand (1975)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>985 billion yen (1975)</td>
</tr>
</tbody>
</table>

Changes in the basin and its influences

With easy access from the major cities and favorable topographical conditions, the basin has been rapidly developed. The urbanized area was only 10% of the basin in 1958. Urbanized area covered 60% of the basin in 1975, and is supposed to cover 80% of the basin in the near future.

These changes brought out serious flood damages through the change in run-off processes, Fig. 1 shows the shortening of the flood concentration time observed at the Sueyoshi Bridge. Fig. 2 indicates the transformation of the flood hydrograph caused by the progress of land development.

Figure 1. Shortening of flood concentration time due to urbanization.
Comprehensive flood disaster prevention measures

These two factors, the shortening of the flood concentration time and the change in shape of the hydrograph, as well as the increase in population and number of properties in the flood-prone area, reduced the safety margin in the river basin against flood hazard.

COMPREHENSIVE FLOOD DISASTER PREVENTION MEASURES

In 1981, the Tsurumi River Basin Conservation Plan was determined after extensive discussions of the Tsurumi River Basin Council (composed of the representatives of the Ministry of Construction, and local governments in charge of river administration, drainage, city planning and so on). The contents of the plan are as follows:

Target rainfall and discharge distribution

Basically, the maximum rainfall in the post-war era (Sept., 1958, 353 mm/2 days) which corresponds to a 10-year return period, was selected as the target (design) rainfall, whereas 50 mm/hr rainfall was adopted to determine the scale of the river improvement works in the upper reaches.

The basin was classified into three categories: retaining area, retarding area, and lowland area, based on hydrological characteristics and land use. Flood discharge (which varies by progress of land development) was distributed to these three areas and to river area (Fig. 3).
The target rainfall causes a flood of peak discharge 1,570 m$^3$/s at the first stage, when 60% of the basin is developed. This peak discharge is supposed to be raised to 1,820 m$^3$/s at the end of the 10 year project period (75% development). Comparing the figures of the two stages, the distribution of discharge to the river area is more than doubled by the river improvement works and construction of the retarding basin in the middle reach of the river. The discharge distributed to the retaining area is increased from 50 m$^3$/s to 170 m$^3$/s, which is to be alleviated by constructing a large number of detention facilities. As a result, the share of the lowland area is decreased from 400 m$^3$/s to 130 m$^3$/s, which means that the inundation volume becomes one third after the completion of the project. The project period is about 10 years.

**Measures in the basin and river area**

In order to maintain the retarding function of the basin, a total storage capacity of 2.2 million m$^3$ is allocated to the retaining area. Municipal governments have a statute which orders developers to provide a certain amount of detention capacity according to the scale of development.

In 1981, the historical inundation map was published to guide land use in the right direction and to aid flood fighting and evacuation. This was favorably accepted by the citizens in the basin in general.
Comprehensive flood disaster prevention measures

Execution of the project and its effect

In 1985, the developed area reached 73% of the basin. However, the share of small scale development is more than expected. So far, detention capacity of 1.3 m\(^3\) (59% of the target) was secured by over 500 on-site and off-site facilities. In view of the discharge capacity of the river, about 70% of the target was completed.

The effect of the project is shown in Table 2. The rain storm in September 1976 caused inundation over an area of 22 km\(^2\). On the other hand, a larger rain storm in August 1983 caused little inundation thanks to the progress of the project.

Table 2. Effect of damage reduction by flood disaster prevention measures

<table>
<thead>
<tr>
<th>Date of Flood Occurrence</th>
<th>Precipitation</th>
<th>Submerged Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Below Floor</td>
</tr>
<tr>
<td></td>
<td>Maximum Hourly Rainfall for 2-days</td>
<td>Inundation Area</td>
</tr>
<tr>
<td>Sep., 1976</td>
<td>22.1 mm/hr</td>
<td>166.4 mm</td>
</tr>
<tr>
<td>Oct., 1981</td>
<td>28.7</td>
<td>188.1</td>
</tr>
<tr>
<td>Aug., 1983</td>
<td>33.9</td>
<td>231.9</td>
</tr>
</tbody>
</table>

SUBJECT OF FLOOD DISASTER PREVENTION MEASURES IN FUTURE

Storage and infiltration are set up as comprehensive flood disaster prevention measures. However, since the effect of these facilities for run-off control has an element of uncertainty, and rapid counter-measures in times of extraordinary flooding are not considered, there are many subjects which must be solved in future. These subject are discussed in this chapter.

The effect of storage and infiltration facilities for runoff control

The effect of each facility in restricting runoff is confirmed through experiment and survey on site. But the influence that these facilities have on the hydrological process is not yet sure. This is because 1) the effect of runoff control depends on the district, and in particular infiltration capacity depends on geology, 2) it's difficult within the current run-off model to estimate the effect of local runoff control on flooding at the target place set for disaster prevention. A new method that models the movement of surface flow in a river basin, divided in a 10 m x 10 m mesh, is now being investigated by another researcher. From now on, it will be necessary to grasp the effect of runoff control by reform of the runoff model and investigation of the influential zone of runoff control (if the influence of each facility is little, you'd better combine them).
Countermeasures in flood time

Flood fighting, refuge and relief activity are carried out as countermeasures when flooding occurs.

- **flood fighting**
  - sand bag stacking (against overtopping) (Fig. 4)
  - bough or bamboo drifting (against scouring) (Fig. 5)
  - hooping (against leak) (Fig. 6)

- **refuge**
  - announcement of refuge order
  - protect road to refuge
  - conduct to refuge place

- **relief**
  - relief of old people and children
  - rescue by the Self defense Force and so on

Of these, flood fighting and refuge activity are started at the standard warning water-level in the river (excess probability $Pr=1/2$ to $1/3$). However, 1) since the warning water-level occurs frequently and since its value is determined for flood fighting, even when the water-level is higher than the warning one, refuge activity often can't be executed immediately, 2) water-level rises rapidly in an urban river, so it's difficult to start activity at the standard warning water-level. That is, flood damage often occurs while the start of activity is being decided and information is being transmitted to related organizations.

Countermeasures are listed as follows:

1) Rapid collection and transmission of flood (damage) information
   - introduction of submergence-level gauge, wireless radio (digital type) and radio broadcasting facility in house.

2) Investigation on the standard of refuge activity
   - Concerning refuge, it's better to decide the standard of refuge activity from total rainfall amount as well as warning water-level (especially in flat area).

3) Compilation and publication of flood hazard map
   - It's necessary to predict the extent of inundation area after a dyke breaks or flood overtops. So, if a flood hazard map showing the movement of inundated area is compiled, it's very effective not only for the authorities but also for residents. Various informations on flood fighting and refuge must be mentioned in it.
Comprehensive flood disaster prevention measures

Figure 4. Sand bag stacking.

Figure 5. Bough drifting.

Figure 6. Hooping.