Integrated Flood Control Measures in Tokyo and GIS-based inundation prediction model

Tokyo Metropolitan University
首都大学東京

Hideo Amaguchi[a], Akira Kawamura[a],and Tadakatsu Takasaki[b]
Department of Civil & Environmental Engineering, Tokyo Metropolitan University[a]
and Institute of Civil engineering of the Tokyo Metropolitan Government[b] , Tokyo Japan

Abstract

■ To solve the problem of increasing ***flood damage due to urbanization***, many overflow detention facilities and artificial underground reservoirs have been constructed in Tokyo. Furthermore, the ***Comprehensive Flood Control Project*** intends to alleviate and prevent flood damages from both the viewpoints of rivers and their basins.

■ In order to evaluate these measures and predict the flooded area, we present the ***GiS-based inundation prediction model*** in urban catchment.

■ The model is a physically based distributed model which can be simulated by one dimensional hydrodynamic modelling incorporating the ***interaction between the sewage system, the river system, the streets, and the areas flooded*** with stagnant water.

■ Since the method ***accounts for spatially distributed hydrological and topographical characteristics of the catchment***, it has great potential for studying the influence of changes in land use, the buried pipe system and flood control facilities on the hydrological behaviour of a urban catchment.

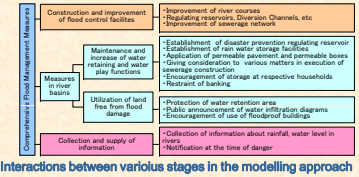
COMPREHENSIVE FLOOD CONTROL PROJECT IN TOKYO

■ Rainfall are absorbed not only by channels but the by entire basin, while the flooding can be cut by means of regulation reservoirs, pools, etc. And temporarily stored there to allow rainwater to permeate the soil and replenish underground water.

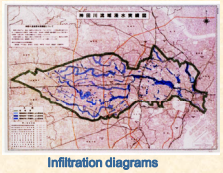
■ The Tokyo Metropolitan Government Bureau of Construction has been developing hydrological data acquisition system by telemetry rainfall information systems, for accurate and speedy collection of rainfall, water level and other hydrologic data through their own networks.

■ There are 138 rainfall gauges, 150 water level gauges, 31 sea level gauges and 21 reservoir gauges all over Tokyo.

■ The stations are mostly remote controlled and the information about the precipitation and flood can be collected and transferred automatically every 1minuits.

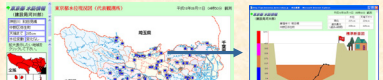


Interactions between variolus stages in the modelling approach



Infiltration diagrams

Under Ground Reservoir and River

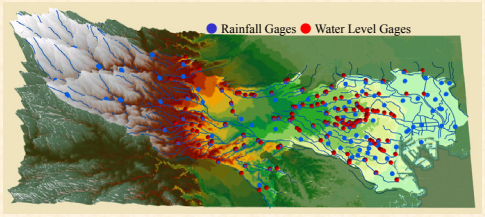


Information on water level in rivers

Water level Time Series

Flood Control Facilities

Water retaining and water play functions



Observation Network on Water Level Gages in rivers and Rianfall Gages

Introduction

■ Urbanization has been a universal phenomenon in the later half of the 20th Century, especially prominent in Tokyo.

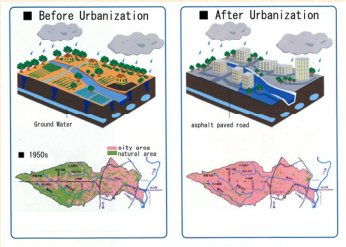
■ With the progress of urbanization in the form of high density housing land development, the water retention capacity of the land occupied by the urban areas has declined because of the increased amount of paved surface areas, the extension the sewage system in the urban to its surrounding areas.

■ In the end, the urban development of the surrounding areas increased the outflow into rivers, shortened the flood reach hours, and reduced the safety of rivers from flooding.

■ With increased property values of buildings and other structures, potential damage from prolonged flooding can easily extended in the millions of dollars.

■ To solve the problem of increasing flood damage due to urbanization, many overflow detention facilities and artificial underground reservoirs have been constructed in Tokyo.

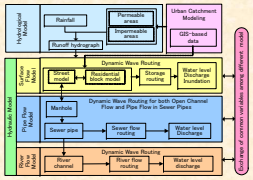
■ Furthermore, the Comprehensive Flood Control Project intends to alleviate and prevent flood damages from both the viewpoints of rivers and their basins.



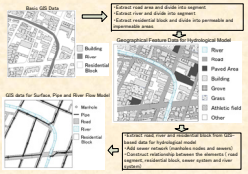
Urban Inundation Model With Geographical Feature Data

■ In order to evaluate these measures and predict the flooded area, we present the GIS-based inundation prediction model in urban catchment.

■ The model is a physically based distributed model which can be simulated by one dimensional hydrodynamic modelling incorporating the interaction between the sewage system, the river system, the streets, and the areas flooded with stagnant water.



Modelling Approach



Urban Catchment Modelling

3D View of Input Data

Modelling Approach

■ The inundation model used here is composed of an urban catchment modelling , and two analytical models are needed.

■ A hydrological model, which simulates surface runoff from rainfall and a hydraulic model describing flows in pipes, and streets and residential block and storage of water on the surface and river flows. In urbanized areas, the main contribution to the catchments response stems from water flows over impervious surface and in underground storm drains.

■ In this model, the urban drainage system consists of two flows, one representing the free surface flow in the streets, residential blocks and rivers and one for the pipe network.

■ In particular, the drainage system between the streets and the pipes is modelled as two dynamically interconnected networks, and manholes function as points of flow exchange between them. Water from the street system can enter the pipe system by flowing through manholes and vice versa.

■ The hydrodynamic model is based on a solution of the St Venant equation.

Urban Catchment Modelling with geographical feature data

■ Data needs for the simulation model of urban inundation are related to a distinct representation of the runoff areas, the surface characteristics and local constraints that possibly influence surface flow patterns, the underground sewer system, and the river systems.

■ Single runoff area within the catchment from the fundamental GIS geographical feature data which is formed with the building, the residential block and the rivers divides into 8 types, according as with distinct model parameters to qualify depression storage and infiltration such as river, road, paved area, building, grass and so on.

■ And the river and the road area divide into the segments, built up the geographical feature data for hydraulic model for surface flow model.

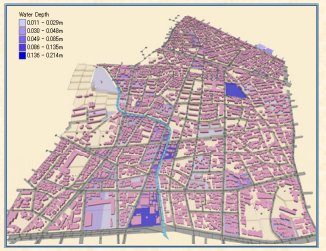
Model Application —Case Study—

■ One of the test areas to prove the concept of the GIS-based inundation model is a sub-catchment of Kanda River Basin with an area of 1.1 km² in the city of Tokyo. In this study, the 1999 Aug. 21st flood event was selected for simulation.

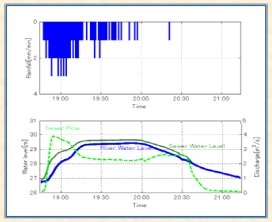
■ Although, there was no record of spatial distribution of actual flood inundation available, based on the meeting with local people, it was found that the simulated inundation pattern was closed to the actual situation.

■ Right graph shows the complexity of the flow conditions during the flood event as both the sewer flow and river flow.

■ When the downstream node floods due to arising river stream level, backwater effects retard to pipe flow because of a reduced head difference. From this moment, flow in pipe will reduce.



Simulated maximum flood inundation due to 1999 flood



Flow condition during the flood event

Conclusion

■ The inundation model due to heavy rainfall in urban area was developed and was applied to Kanda River, Tokyo.

■ The model developed here can express well the inundation process. This model can be applicable for predicting a flood hazard due to heavy rain in urban area and be a useful tool.