Investigation into situation of practical use of distributed models and technical manual for models and development of future analytical technique in Japan

Exemples d'utilisations pratiques de modèles distribués et de manuels techniques pour les mesures et la modélisation pour résoudre les problèmes du futur au Japon

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RÉSUMÉ

Au Japon, en raison de l'urbanisation rapide, les rejets issus de précipitations torrentielles dépassent souvent les capacités de drainage des réseaux de collecte des eaux de ruissellement. Aussi, JIWET a décidé d'appliquer des modèles afin d'améliorer l'efficacité les plans de drainage des rejets urbains de temps de pluie. Pour ce faire, des organismes publics locaux ont examiné comment les modèles et les manuels étaient mis en œuvre et ont analysé des exemples types. Cet effort a donné lieu à la révision du « Manuel Technique pour l'Utilisation Pratique des Modèles Hydrauliques Distribués » (édition 1999 et 2003) afin de répondre aux attentes supplémentaires des travailleurs actuels et de la publication de la version révisée du Manuel Technique (édition 2006).

L'article détaille la façon dont les modèles et le Manuel récemment révisé ont été mis en œuvre ainsi que les résultats issus des nouvelles modalités d'application.

ABSTRACT

In Japan, stormwater outflows exceeding the drainage ability of sewer systems has often occurred due to rapid urbanization and torrential rainfall in urban areas in recent years. So, JIWET aimed to apply the models to efficient and effective planning of stormwater drainage enhancement plan, local public bodies surveyed how the models and the manual were used and collected examples, and revised "Technical Manual for Practical Use of Distributed Hydraulic Models (1999,2003 edition)" to meet the additional requests from actual workers, and published revised manual, "Technical Manual for Practical Use of Distributed Hydraulic Models (2006 edition)".

In this report, the details of how the models and the newly revised manual were used and results derived from additional needs are mentioned.

KEYWORDS

CSOs ; distributed models ; integrated analysis ; inundation prevention ; manual.

INTRODUCTION

In Japan, stormwater outflows exceeding the drainage ability of sewer systems has often occurred due to rapid urbanization and torrential rainfall in urban areas in recent years.

Inland-floods accounted for about 46% of flood damage in the past ten years from 1993. And that percentage increased to 80% in urban area (**see figure 1.**).

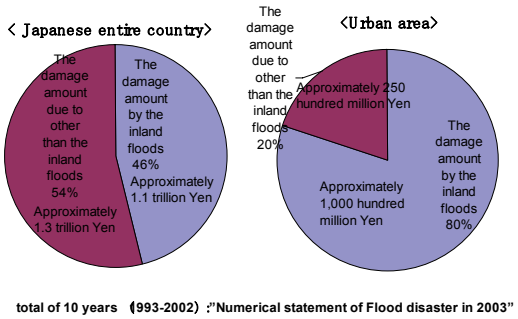

Figure 1. Assortment of submersion damages

In urban areas, damages from inland-floods accounted for larger parts of the graph, where combined sewer systems which collect wastewater and stormwater with a same pipe had been widely adopted.

Among 206 cities (10.2%) where combined sewer systems were adopted and 2,024 bodies which already started installing sewerage systems, the areas where stormwater drainage enhancement project including both separated and combined sewer systems were planned became 1,243,543 ha. It means that 67 % of total areas of both separated and combined sewer systems, 1,863,674 ha, had stormwater drainage enhancement plan. It accounts for 30 % of sewered population, so that stormwater drainage enhancement plan has great roll in controlling quality of public waters and floods. **Table 1. Table 2.**

Category	separate sewer system	Combined sewer	Total
	Number of Local Authority		
Local government sewerage system	1673	183	1856
Basin-wide sewerage system **	112	21	133
Association and other body	33	2	35
Total	1818	206	2024

Table 1. Urban sewer systems (source: Numerical statement of sewer system in Japan 2004)

Unit:Hectare

Category	City number which adopted separate sewer system			City number which adopted Combined sewer system **			Total		
	Sanitary sewage	Storm-water	Combined system	Sanitary sewage	Storm-water	Combined system	Sanitary sewage	Storm-water	Combined system
Local government and Basin-wide sewerage system	988,231	510,154	-	617,500	493,791	227,278	1,605,731	1,003,945	227,278
Association and other body	28,431	38,096	-	1,788	1,730	446	30,219	11,874	446
Total	1,016,662	548,250	-	619,288	495,521	227,724	1,635,950	1,015,819	227,724
							1,863,674		1,243,543

Table 2. Scheduled area for stormwater collection

But combined sewerage system discharges wastewater to public waters through stormwater outlet and stormwater pomp stations. Because sewerage service had been extended in recent years, people tended to gather around the watersides. In those circumstances, after the happening of environmental problems such as drifted white colored solids (congealed ball of oil), the Ministry of Land, Infrastructure and Transport (MLIT) took those events as a turning point and established “CSO control measure investigation committee” in June 2001. The MLIT measured CSOs, reviewed control measures of CSO and published the report of the investigation results.

Considering this report, the enforcement ordinance of Sewerage Law was revised in September 2002, and in those regulations, implementation of CSO control measures within ten years became legal duty.

They have brought about a lot of problems such as inundation, CSOs, defuse pollution and so on. As part of making countermeasures against those problems, JIWET published “Technical Manual for Practical Use of Distributed Hydraulic Models” in 1999, aiming at utilizing distributed models for planning efficient and effective measures for inundation and aiming at inspecting the efficiency of stormwater drainage plans. In addition, the MLIT launched a policy for CSO problems in 2002, and JIWET revised the manual in June 2003, following the national policy when making plans of CSO abatement by means of the manual and models.
Thereafter, total amount of runoff and peak flow rate had increased by increasing impervious area (increased runoff coefficient) caused by progress of urbanization, and isolated showers of torrential rain probably caused by heat island phenomenon, so-called “urban flood” started to occur very frequently. To develop countermeasures to those incidents, the low for “specified urban river inundation prevention measure” was legislated in 2004. And the MLIT established “inundation prevention subcommittee”, and urban inundations prevention methods had been discussed. Under those circumstances, application boundary of distributed hydraulic models were being expanded, so that the survey that questioned about experienced inundation situations, the use of the earlier volumes of the model manual and knowledge acquired by application of the model was carried out to the actual worker of local public bodies to plan more efficient and effective stormwater drainage measures and to revise “Technical Manual for Practical Use of Distributed Hydraulic Models (2003 edition)”

This paper describes the analysis of the questionnaire, investigation and a possibility to make wider application of distributed models in order to cope with issues and demands provided as a result of the investigation mentioned above. The paper also addresses integrated analysis of inland-flood□and modeling of runoff infiltration facilities, analytical techniques and measures for the purpose of polishing up the manual.

1 FACT-FINDING

1.1 Investigation contents

JIWET aimed to understand the problem and demands of published manual from local public bodies which investigated utilizing distributed models, investigated the actual situation of control measures of CSO of local public bodies that adopted combined sewerage and examination for inundatins measures, and accumulating and arranging an arrangement and the analytical case with Distributed Hydraulic Models application situation. Moreover JIWET carried out investigation into analysis knowledge for stormwater engineers putting distributed models to practical use.

1.1.1 Investigation object

JIWET carried out the questionnaire for the subject of sewage works administrator of the whole country 713 local public bodies. And questionnaire collection rate was 42% (303 local public bodies /713 local public bodies)

1.1.2 Investigation item

- About essential information

This item investigated he realities of the approach on the situation of the flood damage of object of local public bodies, the flood measures, and control measures of CSO of local public bodies.

- Opinion and demand for “Technical Manual for Practical Use of Distributed Hydraulic Models (1999, 2003 edition)”.

This item understood of the problem the present situation and present like the use etc. of the manual beside the collections of opinion and the demand,etc.for “Technical Manual for Practical Use of Distributed Hydraulic Models (1999, 2003 edition)”.

- Work achievements of distributed hydraulic models

This item investigated the use situation of Distributed Hydraulic Models like the method of operating the Distributed Hydraulic Models including the method of multiplying the handling of purpose, the calibration ,and the simulation work achievements which Hydraulic Models was used and the expenditure for agential taskss etc.

1.2 Result of the survey

The questionnaire survey result and the analysis result are shown as follows.

1.2.1 Flood damage

80 % of local publish boodies which responded the survey suffered flood damage in the past five years (**see figure 3.**)

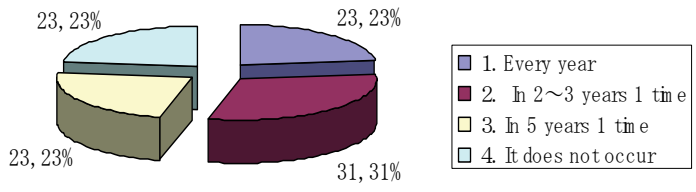

Figure 3. Frequency of suffering by submersion

The largest number of answers that showed “shortage of capacity of drainage facilities” such as sewer and channel was a cause of flood (**see figure 4.**). “Poor drainage flow rate to discharging area” was followed. And the other answers indicated excessive rainfall.

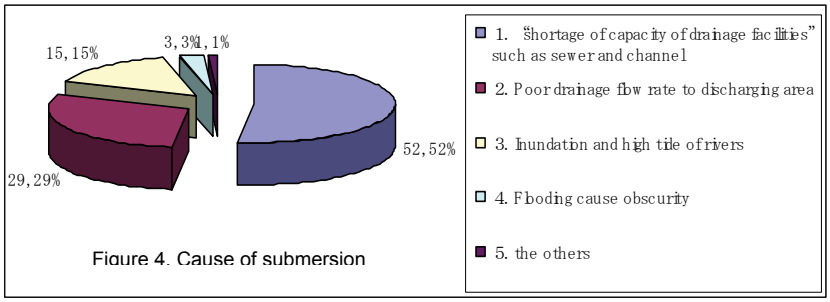

Figure 4. Cause of submersion

1.2.2 Using distributed models or the manual

On the subjects such as Flood preventions and improvement of combined sewer system, experience of using Distributed model like InfoWorks CS, MOUSE, XP-SWMM and "distributed model application manual" published by JWET were surveyed

About 40% of responded municipalities didn't have used distributed models or the manual. This indicated that there might be many occasions to use the model to efficient planning of flood prevention in the future. Furthermore, after the publication of the revised manual, there were many requests that demanded further revision. The number of the model application works showed an increasing tendency and were expanding to integrated analysis with river, and to inner water flood analysis. And responses showed another need that the model should applicable to area where infiltration facilities were adopted (**see figure 5.**).

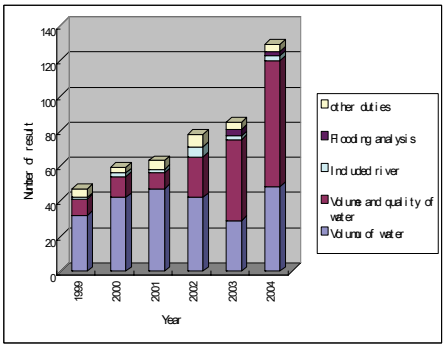

Figure 5. Transition of analysis contents of the duties utilizing the models by year

1.2.3 Investigation methods of the modeling

The present situation of the modeling was such that the data which was needed to the modeling of the targeted area was collected from related bureaus, onsite surveys and measurements. The data from related bureaus included computer input data such as sewerage ledgers and rainfall data. Onsite water quality surveys were carried out for several years to obtain adequate data for improvement of model accuracy.

2 NEW ANALYTICAL TECHNIQUE

This study examined about "Application to the inland-flood analysis " that had been given as needs as a result of the profit use situation investigation. The technique of the examination of the analysis and the model are shown by using the application experrience to a real valley as follows.

2.1 Application to inland-flood analysis

As hydraulic analysis model which is utilized in japan is developed to analyze the effluent phenomena in urban area and hydraulic phenomena considering sewer

pipes, structures, operating etc., it is capable to express the hydraulic phenomena in sewer pipes and spouting phenomena from manholes exactly, but as a feature of phenomenon of inland-flood of urban area limits in Japan can not show the phenomena of inundation flow and diffused flow on surface.

For this reason, proposed modeling method is to set up as "**dual drainage**" as an actual sewer pipe underground and a virtual open channel on surface (as an actual road) in order to analyze the phenomena of inland-flood inundation which inundation flow from sewer pipes in urban area. **Figure 6.**

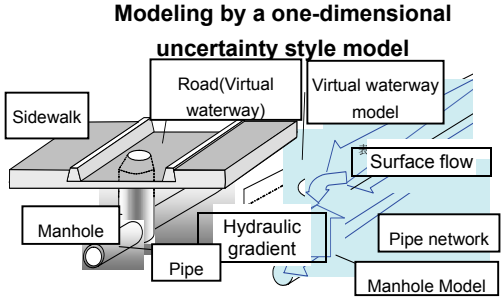

Figure 6. Image of dual drainage

3.1.1 Modelling the sewer facilities and finding out spouting points

To find out the spouting points from only sewer facilities model with no open channel on surface. **Figure 7.**

3.1.2 Modeling virtual open channels and run of the flood analysis programme

- To build simple virtual open channels at required points, after estimating the flood runoff directions on surface with considering spouting points, land slopes, previous flood areas.
- Any virtual open channels on surface can be located at any places even if there is no sewer facilities is laid beneath the channel for the model.
- To identify the reappearance of finding out spouting points with the dual drainage model structure of sewer facilities and virtual open channels.

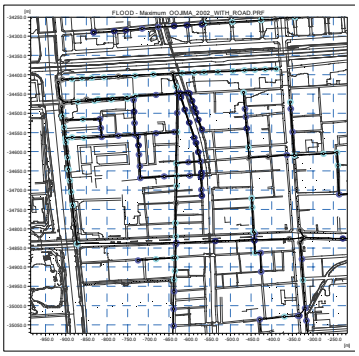

Figure 7. Identification of overflow points

3.1.3 Reproducing inundation phenomena at limited area

In the case of supposition that a road is converted to a virtual open channel in the process of flood analysis, the shape and measurements of the cross section should be defined by geographical information based on the basic investigation, because the shape of cross section and width of the channel are important factors to appear the inundation phenomena.

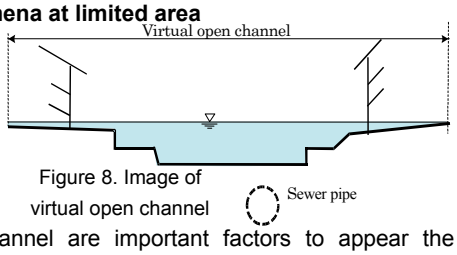

Figure 8. Image of virtual open channel

And for better modeling, some approaches to approximate the actual phenomena and analytical results, for examples setting up the width of a channel with considering building area which is not regarded as flood area, setting total roughness factors of channels; **Figure 8.**

3.1.4 Reappearance case of the inundation flow on surface

The model application was verified to depict a map of flood expected area.

● The general outline of the target area

Upstream basin of an urban watercourse that had an area of 730 ha was selected.

The area had combined sewer system.

The area had 36 storm overflow chambar.

The ground elevation was ranged from T.P.40 m to 56 m and maximum difference of elevation was 16 m.

● The target items of the model

All drainage pipes include branches, open channels and diversion weirs were modeled (**see figure 9.**).

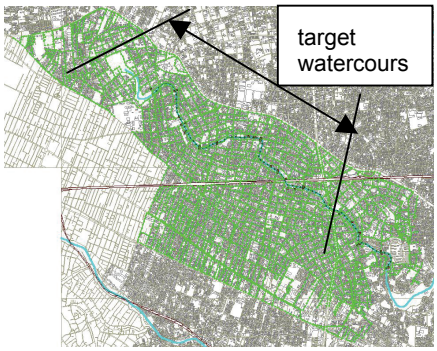

Figure 9. Target pipeline network and watercourse

The roads that have drainage pipe in the ground were included in the model as hypothetical open channel. And storm water flowed along road surface to lower place.

● Calibration : The result of calibration using tree rainfall conditions was consistent.

● Result of examination : By setting up roads (open channels) and taking account of surface current, some extent of water movement on the ground could be expressed, and it was concluded that the model would be applicable to draw a map of flood expected area **(see figure 10.)**.

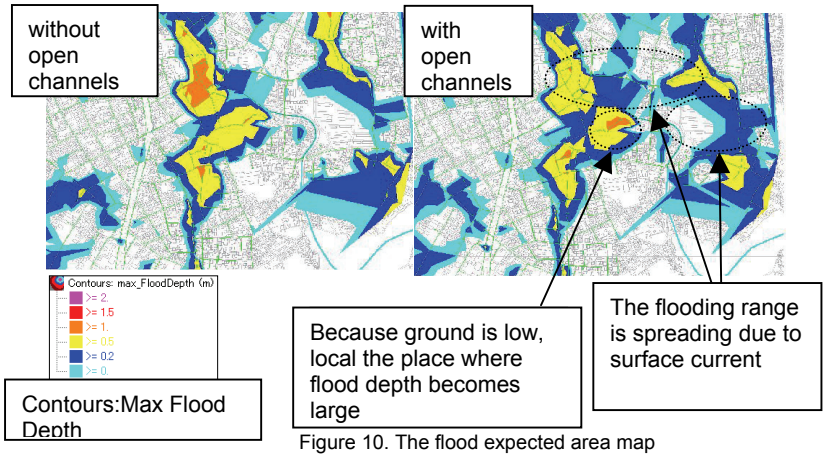

Figure 10. The flood expected area map

(Comparison of with/without taking account of open channels)

CONCLUSION

As a result of this study, when the similar modeling was applied, it was confirmed that both the flood models gave nearly the same numbers of time-series of overflow rate, maximum overflow rate and total overflow rate. And the coherence of model application to the simulation of submergence was also confirmed.
From those results, the flood models were applicable for flood analysis only if accurate modeling was achieved and calibration with measured data was practiced.

But present analysis using the flood models have following problems. Those problems should be resolved in the future.

- Some flow conditions such as water revel and current speed have been observed and data have been accumulated, but inland flood phenomena such as submergence caused by overflow from manhole, and shifting of submerged area have not been adequately comprehended. So that a clarification of flood related phenomena is needed. In Japan, by simulating overflow from manhole using pilot plant, and by getting a clear picture of the flood phenomena, improvement of the flood model is under investigation.
- Abnormal weather is observed worldwide in recent years. Local torrential rain occurs frequently in Japan these days, and very local torrential rain are confirmed. When seizing these extreme phenomena and applying the flood model to the extreme phenomena, problem will be in-put of the rainfall distribution. In application of the model when rainfall data exists on multiple locations, there is example in Japan that rainfall data are inputted by " Thiessen polygon division ".
- There is not enough water quality analytic data in Japan, so that data should be accumulated by on-site survey.

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