B－12. 5 Study on Impact Assessment of Global Warming and Its Countermeasures on Infrastructure

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Total Budget for FY1990-1992 9,373,000 Yen

Abstract Global warming may reduce the margin of the safety factor in the infrastructure and disaster prevention system in urban areas through climate change so that the estimation method of the reduction in its margin is to be developed. The influence of the global warming on infrastructures and its countermeasures were discussed. The risk assessment of the infrastructure and the damage to human activities due to the global warming were investigated. In this study, as an example, the margin of discharge rate in a sewer system and how to control inundation in an urban area were also considered. An evaluating concept of risk and damage of inundation was presented.

Key Words Global Warming, Infrastructure, Sewer System, Inundation

1. Introduction

Most infrastructures are constructed in urban areas, so that it has been estimated that the impact of the global warming could lead to a significant damage for human activities. Because the infrastructures are durable for about 50 to 100 years, we should consider the global warming effect on their planning before getting too late.

2. Research Objective

The objectives of this research are to develop an assessment method of the impact of the global warming on infrastructures and to evaluate the safety factor of the current storm drainage system in urban areas as an infrastructure for preventing disasters due to global warming.

3. Results

(1) Research on Impact Assessment of Global Warming and Its Countermeasures on Infrastructure

The influence of the global warming on infrastructures and its countermeasures were discussed as shown in Fig. 1. The risk assessment of the infrastructure and the damage to human activities due to the global warming were also discussed.

(2) Research on Sewer Networks

① Objectives

Inundation in urban areas has been more serious due to the increase in developed urban area and pavement ratio. Global warming may cause the change of precipitation pattern as well so that reconsideration of the current sewer system is unavoidable. The conventional design method on the storm drainage system in urban areas, however, has many problems, such as calculation of diameter of main sewer pipes, the way of thinking of the rational method, itself, flow conditions assumed in the design method and the lack of consideration of a network. In order to solve these problems, it is of importance to understand the accurate drainage capacity in the current sewer network. In a sewer network, energy losses at junctions are one of the most important factors in design, they, however, have not been understood correctly

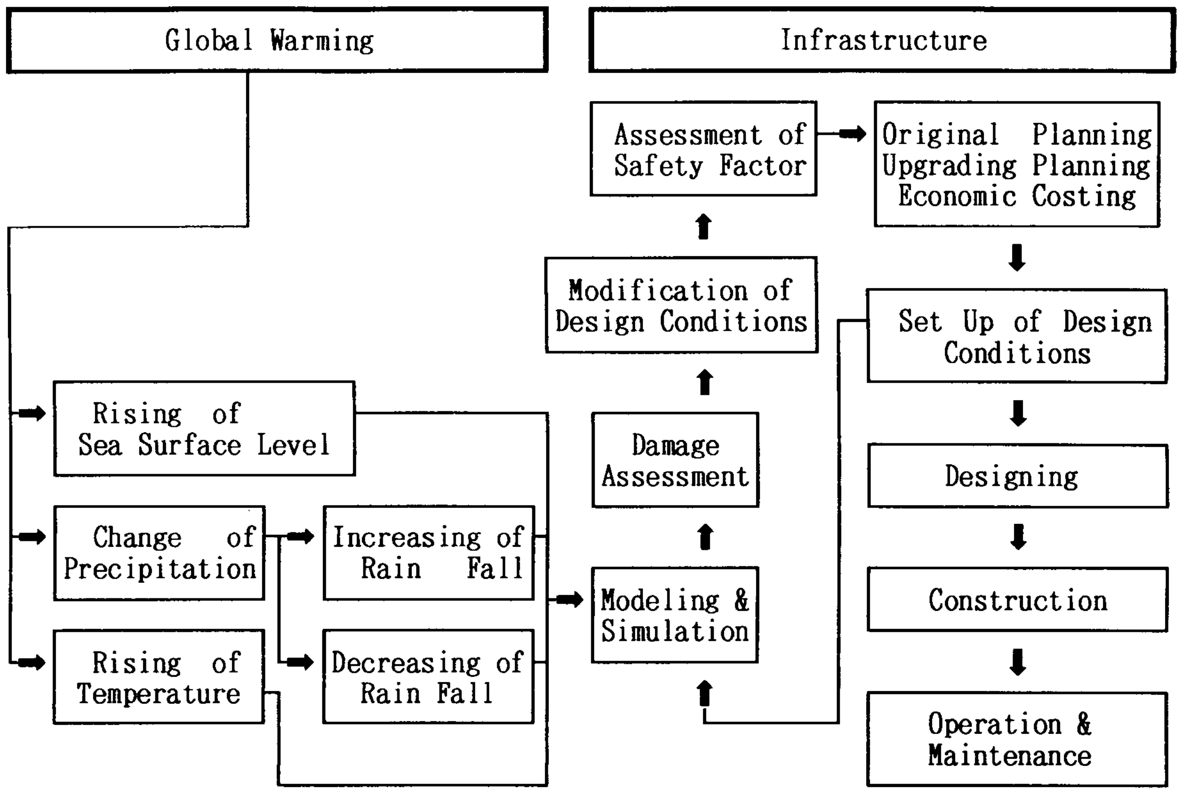

Fig.1 Concept of Impact Assessment of Global Warming and Its Countermeasures on Infrastructures

yet. It is also necessary to estimate the energy losses at junctions to simulate the storm drainage. This study focused on the energy losses at junctions.

② Experimental Apparatus
Two kinds of experiments were performed to obtain energy losses at junctions; straight-through flow and 90°-bending flow.

③ Experimental Procedure
The total energy head, E was calculated at each measuring point in terms of $E=he+hp+v^2/2g$, in which he: elevation, hp: pressure head, v: mean flow velocity, and g: gravitational acceleration. An energy grade line upstream or downstream from the junction was approximated by a straight line that fitted 3 data points. A total head loss at a junction, ΔE is defined as the difference between the two lines at the junction, that is, $\Delta E=Eu-Ed$, in which Eu and Ed are the total heads at the upstream and downstream ends at the junction,

Table 1 Experimental conditions

Run	angle	upstream pipe diameter D_u(cm)	manhole diameter D_m(cm)	downstream pipe diameter D_d(cm)	D_m/D_d	D_u/D_d
1	180°	5	7	5	1.4	1
2		5	9	5	1.8	1
3		5	12	5	2.4	1
4		5	9	6	1.8	1.2
5	90°	5	9	5	1.8	1
6		5	12	5	2.4	1

respectively, as shown in Fig.2. In the experiment, the flow rate, Q was ranged from 0.1 l/s to 2.9 l/s. The experimental conditions are indicated in Table 1. Runs 1 to 4 are for straight-through and Runs 5 and 6 are for 90°-bending pipe flow. In Runs 1, 2, 3, 5, and 6, the effect of junction size was examined. In Run 4, the effect of pipe diameter ratio was studied.

④ Experimental Results

A. Relationship between head loss ΔE and flow rate Q

The head loss, ΔE changes due to the flow rate, Q and water level at a junction as shown in Fig.3. The head loss, ΔE also changes due to the weir height at the downstream end of the pipe as shown in Fig.4. In gravity flow, ΔE decreases as Q increases. On the other hand, in surcharge flow, ΔE increases as Q increases.

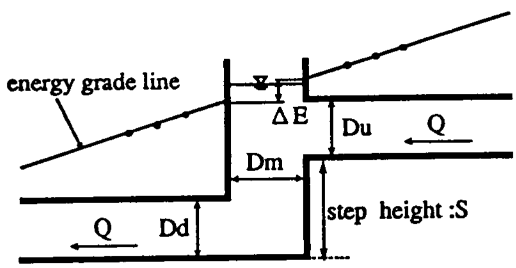

Fig.2 Definition of head loss

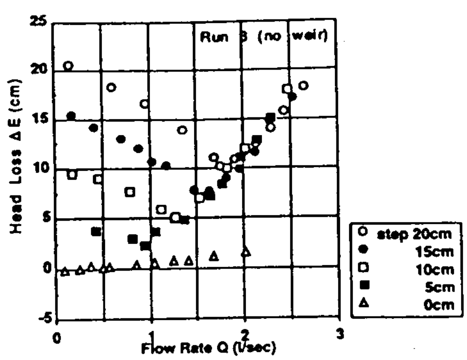

Fig.3 Head loss versus flow rate (No weir)

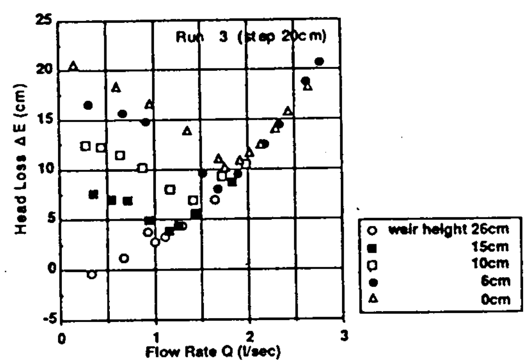

Fig.4 Head loss versus flow rate (20 cm of step)

B. The coefficient of the total head loss

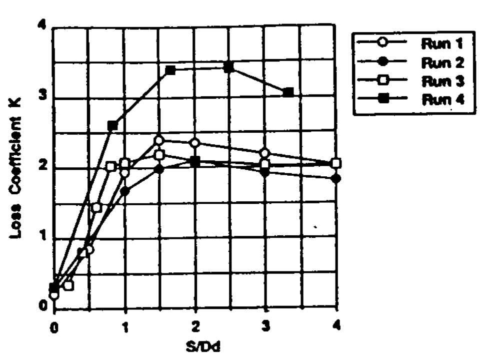

Fig.5 Head loss coefficients (Runs 1 to 4)

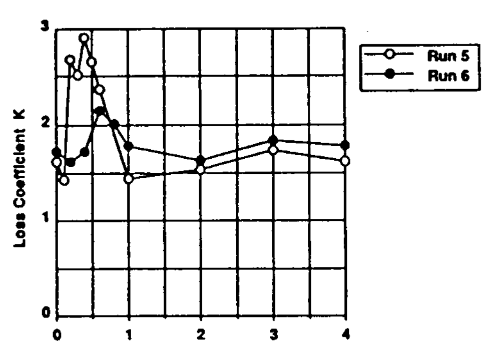

Fig.6 Head loss coefficients (Runs 5 and 6)

The head loss coefficient, K is given in Figs.5 and 6 as a function of S/Dd, in which S: the difference in water level between the upstream and downstream pipe ends and Dd: the downstream pipe diameter. Head loss at a junction occurs by the collision of inflow with the downstream wall of the junction, in which the inflow is oscillating, forming strong vortexes, and having been dispersing. It was obviously found that the occurrence of strong vortexes in a junction is related to Reynolds Number of flow and its shape. In Runs 1 to 3, the head loss coefficient, K approaches to 2.0 as S/Dd increases more than unity. In Run 4, it is larger than those in Runs 1 to 3 because the flow velocity in the downstream pipe is smaller than the others. In Run 5, it is as large as 2.9 in which S/Dd is around 0.4. In Run 6, it is smaller than that in Run 5 owing to the decrease of strong vortexes and oscillation in the water surface.

(3) Risk and Cost-Benefit Analysis of Inundation in Urban Areas

An evaluating concept of risk and damage of inundation is discussed subsequently.

The factors, which cause inundation, are divided into two major groups as follows:

Direct factors : water level and duration of inundation,

Indirect factors: precipitation and its pattern, runoff coefficient, and level of outlet of a storm sewer.

Also, there are direct and indirect factors of the disaster prevention as follows:

Direct factors : drainage capacity in sewer network,

Natural indirect factors : topographical drainage capacity,

Artificial indirect factors: information of weather forecast, action program of refuge, refuge drill, place of refuge.

The construction and maintenance costs of the sewer network are expended as "Prepaid-direct cost". The costs on the artificial indirect factors are also expended as "Prepaid-indirect cost". By summing them up, consequently, the costs of public investment,"C", for the disaster prevention system on inundation is obtained.

C = Prepaid-indirect cost + Prepaid-indirect cost

On the other hand, the total benefit is estimated by calculating the reduced damages on "direct damage" and "indirect damage". The terms of these damages are considered as follows:

Direct damage : loss of lives, injury, disease, damage of assets, expenses of cleaning and disinfection,

Indirect damage: traffic delay, delay of economic activity in inundation period.

It is generally accepted to invest to the disaster prevention system on inundation as far as the total benefit exceeds the costs of public investment ,C,.

4. Conclusion

The influence of the global warming on infrastructures and its countermeasures were presented in this study.

The experimental results on sewer networks indicated that the total energy loss at a circular junction is fairy influenced by the difference in water level between the upstream and downstream pipes. In case of surcharge flow in a straight-through pipe, the head loss coefficient, K changes from 0.2 to 3.4. In case of surcharge flow in a 90°-bending pipe, it changes from 1.4 to 2.9. In free surface flow, the head loss at junctions, ΔE is able to be calculated using the following equation.

$$\Delta E-(S-hd)=\alpha Q^{n}$$

where S; the difference in water level between the upstream and downstream pipe ends, hd: the downstream water depth, Q: the flow rate, and α (<0) and n (>0): constants. The value of n ranges from 1.70 to 2.20.

A concept on risk and cost-benefit analysis of inundation in urban areas was also presentet.