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Introduction of Hydraulic Field Investigation Method to Utilize on the Inhabitation Environment Definition at a River

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In recent years, attention on the inhabitation environments of animals and plants which coexist with humans is growing more and more, and relevant research is being activated. In habitats of rivers, a lot of factors are interacting, even among them, some elements especially such hydraulic factors as water velocity and water depth, and such geological shapes as gravels, sand and mud are being considered as primary elements. In this study, various field investigations are carried out to determine the relationship between the river habitats of fishes and hydraulic primary elements using high-tech equipments. Furthermore numerical experiments to classify such habitats according to topographical spaces are carried out. In detail, hydraulic field investigations performed in this study can be summarized as topographical survey, discharge measurement, water level fluctuation monitoring and so on. In numerical experiments, the RMA2 model of the commercial program, Surface-Water Modeling System (SMS), which is widely used in conducting a two-dimensional analysis of the flow behavior of a river is utilized. In conclusion, as a result of field investigation, the relationship between water velocity and water depth is obtained. And the relationship between water velocity and water temperature is identified, too. Finally, using above obtained results, the inhabitation environment was classified into Riffle, Glide, Run, Pool, and E.D.Z according to the relationship between water velocity and water depth.

Key words : Inhabitation, Water Velocity, field investigation, topographical survey, RMA2

INTRODUCTION

A number of large and small dams have been constructed in line with industrial development. And gradually this urbanization has exposed animals and plants are living in the downstream to a sudden change in their habitats. Even a few years ago, with the development of industries and urbanization, environmental destruction is recognized as to be inevitable, and campaigns for environmental conservation could not receive significant support. However, in presents, a situations are changed. That is, environmental conservation is perceived to be necessary not only for humans, but also for the protection of habitats of animals and plants which coexist with humans.

River habitats for animals and plants which are well adjusted to the environments can be

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categorized into various forms according to hydraulic characteristics such as current velocity and water depth, as well as to the kinds of riverbed materials such as gravels, sand and mud. In particular, freshwater fishes create many types of habitats according to the river's current velocity, water depth and riverbed materials.

These days, a range of researches are being conducted at the inside and outside of the country to study the habitats of fishes, and numerous techniques are used to effectively classify such habitats. In Korea, Woo *et al.* (1998) proposed a critical flow necessary for habitats of fishes in determining the river maintenance flow. Lee *et al.* (2006) proposed a technique of calculating the flow amount necessary for fish inhabitation. Lee (2007) conducted research into restoring river ecosystems and riverine aesthetics in urban stream. Also, abroad, Fonstad and Marcus (2005), Handcock *et al.* (2006), and Marcus *et al.* (2003) conducted research to identify the inhabitation environments of animals and plants using satellite images' RGB band and infrared band.

Of the Geum River basin, on the basis of on-site exploration, this study selected the 600 m longitudinal section from the floodgate of the regulating reservoir of Daecheong Dam considered to have the most artificial characteristics, as well as the 400 m longitudinal section located at Miho Stream 24 km from the merging point with Geum River deemed to have the most natural river characteristics. In other words, the hydraulic field investigation method introduced in this study is applied to various type of rivers. At a river flow velocity is rapid, the discharge measurement using Acoustic Doppler Current Profiler (ADCP) is introduced, and at a river flow velocity is slow, traditional discharge measurement method using a propeller type of current meter is utilized.

MATERIALS AND METHODS

1. Field investigation at representative artificial river

Geum River, one of the five large rivers in South Korea, flows from the middle inland region to the West Sea. It has a flow channel length of 401 km, and a catchment area of 9,886 km^2 or 10% of the country's total land area.

In 1981, 150 km upstream from the estuary of Geum River, Daecheong Multipurpose Dam was constructed at a point which is located 16 km northeast of Daejeon and 16 km south of Cheongju, and where Daejeon City meets the border of Chungcheongbuk-do. The major facilities of this dam include the main dam with a storage capacity of 1.49 billion m^3, and a regulating reservoir. This study, as area shown in Fig. 1, selected the 600 m downstream section from the floodgate of the regulating reservoir.

In this area, hydraulic features were surveyed using equipments as shown in Fig. 2. Survey items are including below items such as the sur-

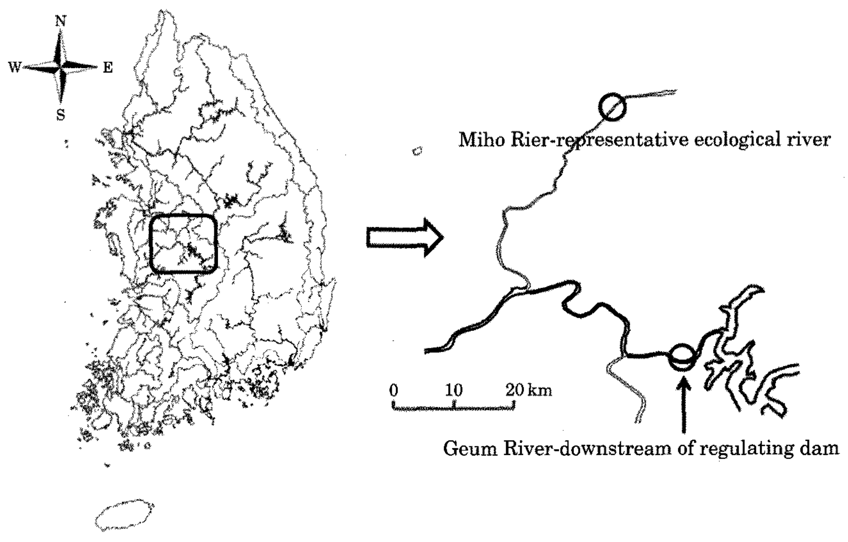


Fig. 1. Study area.

vey of the outflow discharge using the river flow measurement equipment (StreamPro ADCP (Teledyne RD Instruments)); the survey of the current velocity, current direction, and water level changes at one point using 3-dimensional current velocity measurement equipment (ADV 6600 (Acoustic Doppler Velocimeter)-Sontek/YSI, Inc.); the monitoring of water level changes on the right and left hand sides of the target area using a water level gauge (Orphimedes (OTT MESSTECHNIK GmbH & Co. KG)) and a wave gauge (Compact-WH (Alec Electronics Co., Ltd.)). As shown in Fig. 2, the outflow discharge was measured in four sections and water level was monitored in two sections.

2. Field investigation at representative ecological river

Also, as shown in Fig. 1, the 400 m longitudinal

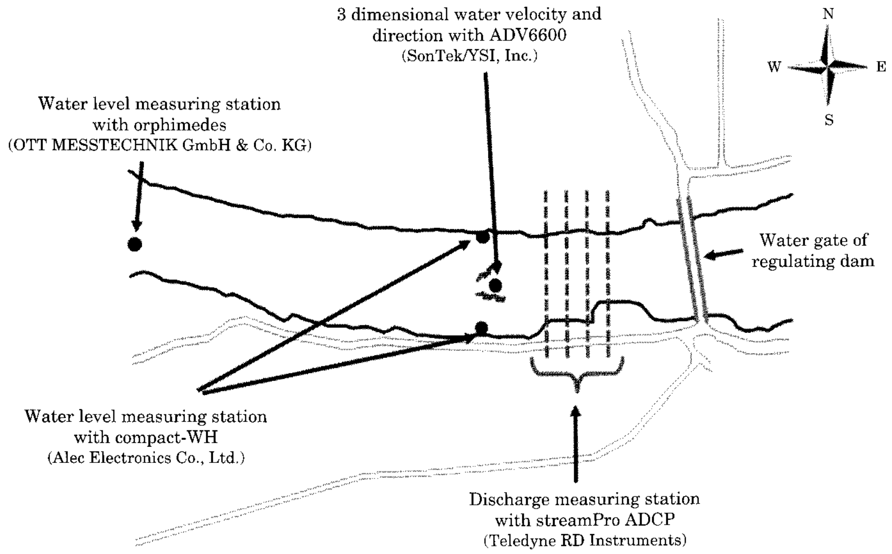


Fig. 2. Field investigation at representative artificial river.

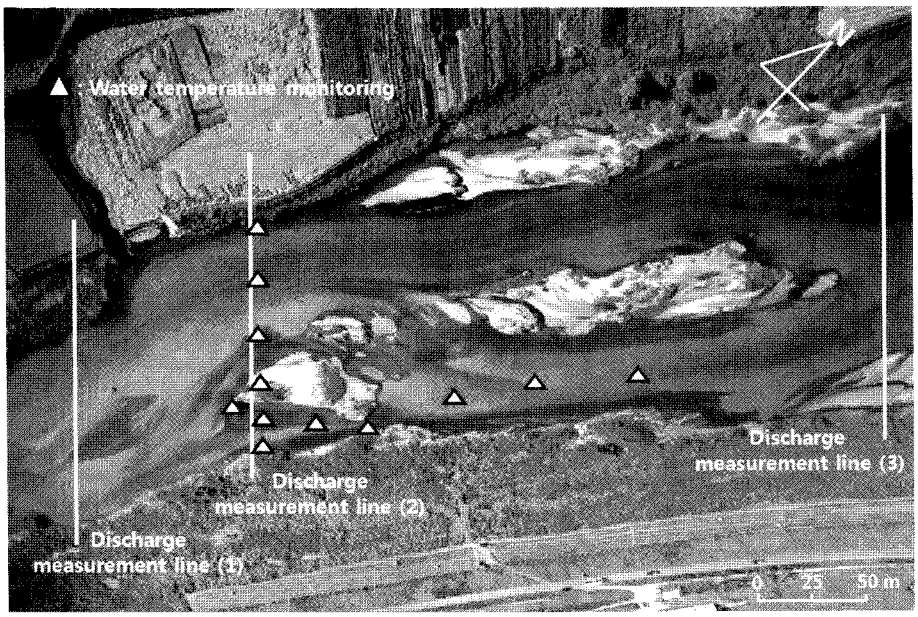


Fig. 3. Field investigation at representative ecological river.

section of the whole Miho Stream where the widest range of habitats were observed is selected as target area to investigate quantitative hydraulic characteristics in a natural river. To be more specific, located in Ochang-myeon, Chungcheongbuk-do is this area at 127° 23′(E) and 36° 40′(N), 24 km from the confluence of Miho Stream and Geum River. A water storage facility is located 2 km upstream from the survey section, and a sewage disposal plant is located 1 km downstream.

Water temperature monitoring was conducted in the longitudinal and latitudinal direction from the surveying control point using the water temperature gauge Water Temp Pro. (Onset Ltd.) for 2.5 days between 12:00, October 8 and October 10, 2007. At the same time, using the propeller current meter (Swoffer Model 3000), the current velocity was measured on October 10 at three points in the cross section of current measurement shown in Fig. 3, and other 12 points. During this period, the day's water temperature peaked at around 14:00, and since sunny days continued for about 3 days without significant weather changes, the flow amount was measured only for one day on assumption that there would be no big change in the flow amount. Also, for preliminary experiments, the water temperature by level from the water surface to the bottom was monitored, and for safe water temperature measurement, the water temperature gauges were installed at a depth of 10 cm from the water surface.

3. Topographical survey and numerical experiment

In an effort to define topographical characteristics of target two areas and acquire accurate topographical data in numerical experiments, this study used the Sokkia Powerset Totalstation equipment in conducting a precise topographical survey. The survey was conducted at the point density of 5 m intervals, and the measurement coverage was maintained at a length of 10 to 20 m. Fig. 4 shows topographical DEM with 1 m lattices made based on survey points using GIS spatial analysis.

Recently, the commercial program SMS RMA2 model is widely used in conducting a 2-dimensional analysis of the flow behavior in a river (Jennings, 2003; Nielsen and Apelt, 2003, Rathburn and Wohl, 2003; Rao, 2005). Discharge measurement result for target rivers was used as the upstream boundary conditions respectively, and water level measurement results were used as the downstream boundary conditions. Finite element meshes for hydraulic simulation were structured by using the actual measurement results for the target river sections, inputting the every 5 m-interpolated ASCII files, and undergoing an amendment procedure.

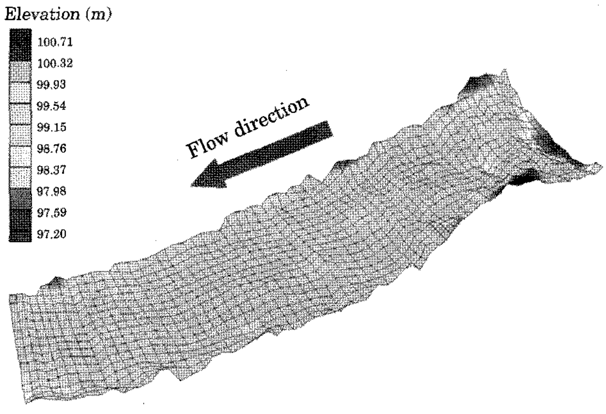


Fig. 4. Topographical survey.

RESULTS AND DISCUSSION

1. Hydraulic characteristics

The determination of current velocity distribution and the measurement of outflow discharge were conducted between December 5 and December 6, 2006. For reference, the Daecheong regulating reservoir defines its minimum release amount as $12.6\,m^3\,s^{-1}$ (KWATER, 2004).

Water levels were continuously monitored during the field survey period. Using bubble gauges, water level changes were monitored at an interval of 5 minutes, but it is difficult to define the characteristics of water level fluctuation from those data due to the accuracy is low. Therefore to overcome that problem, in this investigation, the wave gauge, Compact-WH, has a 0.1 mm accuracy, enabled the monitoring of water level changes at an interval of 1 seconds. In this investigation the water level of both embankments was monitored by the above mentioned wave gauge at an interval of 1 minutes. And at the center of the target area, water level, flow direction and 3-dimensional water velocity were moni-

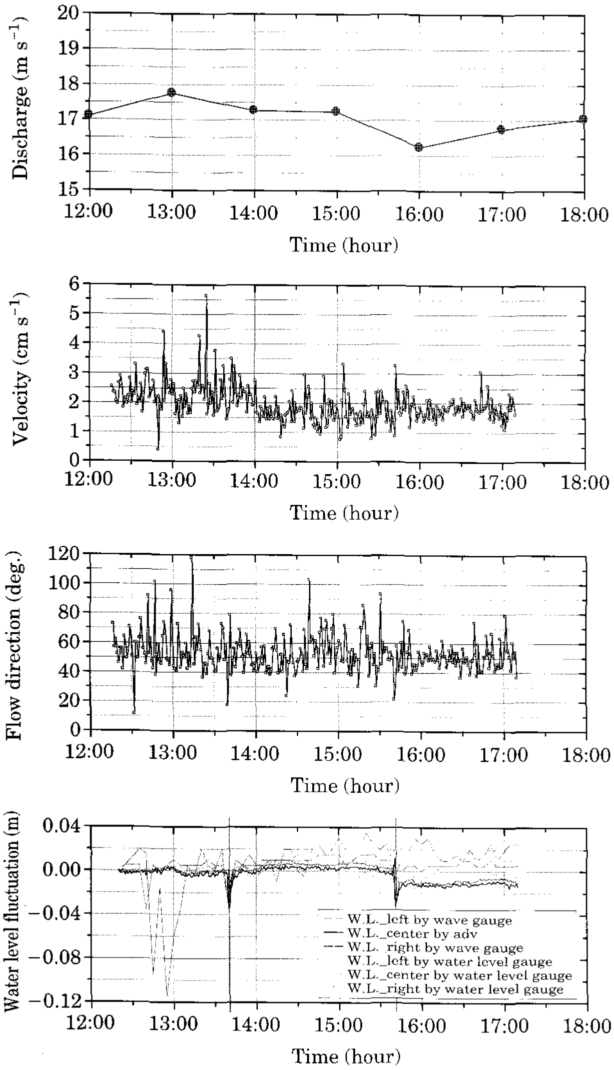


Fig. 5. Characteristics of hydraulic flow.

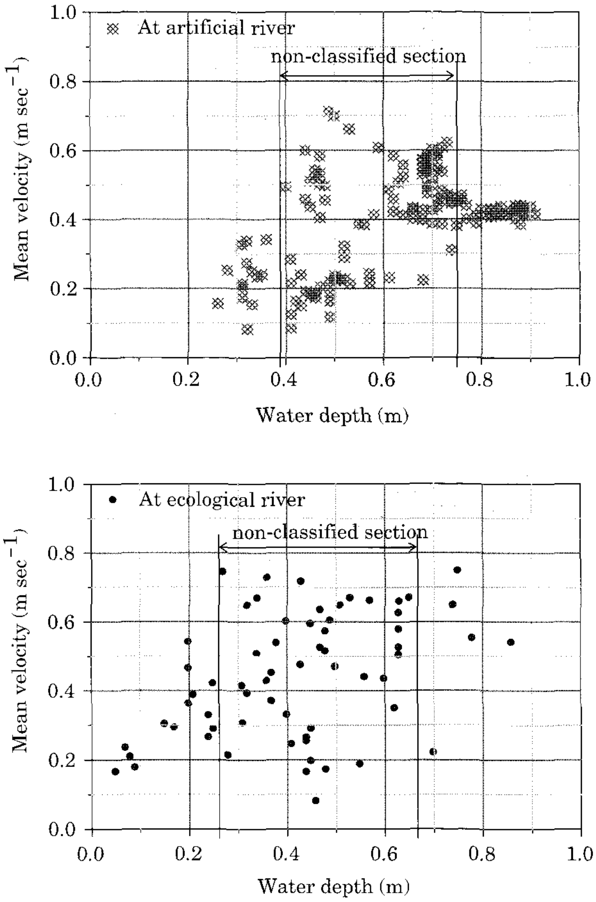


Fig. 6. Correlation between water velocity and water depth.

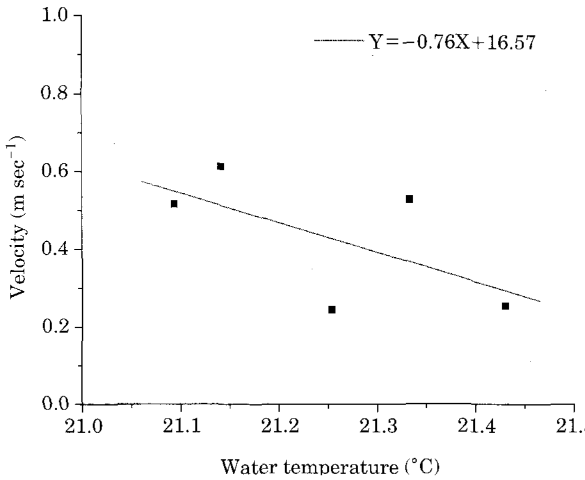


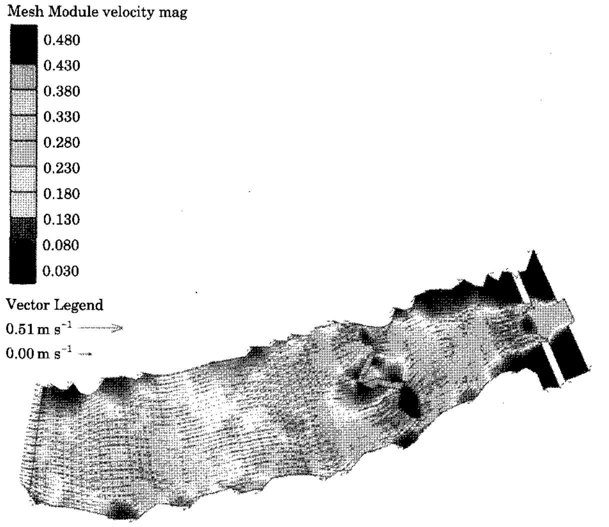
Fig. 7. Correlation between water velocity and water temperature.

tored by the ADV at an interval of 1 minutes, too.

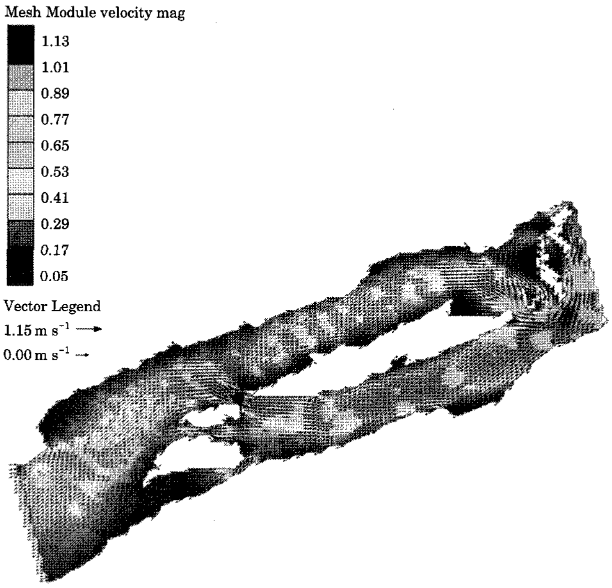
Fig. 5 shows the characteristics of hydraulic flow. In detail, those are discharge obtained by the StreamPro ADCP, water velocity and water direction monitored by the ADV and water level fluctuation obtained by water level gauge, wave gauge and ADV depending on time.

2. Analysis of hydraulic factors

Fig. 6 shows the relationship between water velocity and water depth at representative artificial river and at representative ecological river. But the correlation between water velocity and water depth is not clear in certain range between 0.3 m and 0.7 m as shown in figures. It is obvious that the inhabitation classification in this kind of section is very difficult. Therefore in this study,



(a) Hydraulic distribution at artificial river



(b) Hydraulic distribution at ecological river

Fig. 8. Results of numerical experiments.

the water temperature monitoring was carried out to solve this problem.

Water temperature monitoring results are shown in Fig. 7, which presents the correlation between water temperature and water velocity at the five investigation points. The red solid line shows a linear relationship between the two factors, and their relational expression is shown in Fig. 7. From the Equation (1), it can be calculated easily that the water temperature 21.0°C corres-

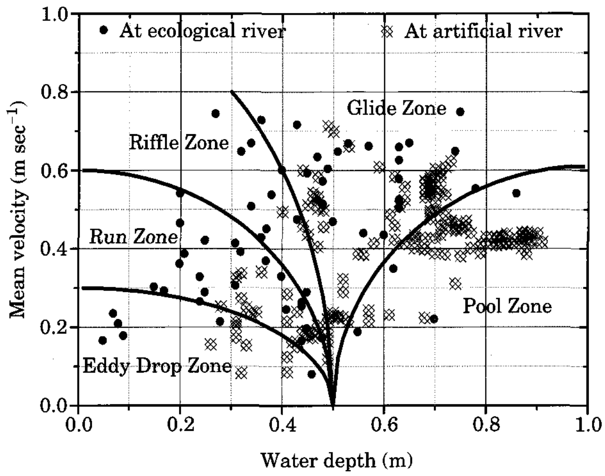


Fig. 9. Inhabitation classification on the water velocity and water depth.

ponds to the water velocity 0.61 m sec^{-1}.

$$\begin{aligned} &Watervelocity \\ &= -0.76\ Watertemperature + 16.57 \end{aligned} \quad (1)$$

This result is utilized as a basis for the inhabitation classification between Glide and Pool in the next chapter.

Fig. 8 shows the 2-dimensional distribution of hydraulic factors obtained by the numerical experiments. It shows the current characteristics effectively that inflow of discharge, approximately 20 $m^3 s^{-1}$, into the downstream is depending on the water depth of the left and right embankments. In the future, these numerical results can be utilized for the inhabitation classification at a big river.

3. Inhabitation classification

Inhabitation classification was carried out in this chapter. The classification bases are the water velocity 0.3 m s^{-1}, 0.6 m s^{-1}, 1 m s^{-1} and 0.61 m s^{-1} according to the water depth 0.5 m. All bases except 0.61 m s^{-1} were obtained from the field investigation. And the classification basis between Glide and Pool is obtained from the regression line between water velocity and water temperature. The result of inhabitation classification is shown in Fig. 9.

Techniques proposed herein are deemed to offer a very high application in large-scale rivers such as Korea's five large rivers.

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