The Development of the Automatic Discharge Acquisition & Management System (ADAMS) using Ubiquitous Technique

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Abstract

Accurate river discharge is the most important factor in managing river basins and for successfully maintaining total maximum daily loads in Korea. It is not easy to measure the discharge directly in large rivers owing to physical and environmental constraints, even after investing much time and money. Recently, to overcome these historical drawbacks in river discharge measurement, we have developed the Automatic Discharge Acquisition & Management System (ADAMS) that scans the river cross-section and measures each cell (1m×1m) velocity using HADCP. The hardware system is composed of an HADCP sensor and winch, as well as a PC and software system for the discharge calculation module and hardware control module. It is controlled remotely via the internet and uses the velocity-depth integration method and the velocity-contour method for calculating river discharges. The characteristics of ADAMS are a ubiquitously accessible system, featuring real time automatic discharge measurement, remote control via the internet. The results using ADAMS at the Jindong stage site show less than 5% uncertainty and are 4 times more efficient than the ADCP & Q-boat system. This system can be used to measure any large river, river mouth or tributary river affected by backwater, all of which have a very difficult measuring real time discharge. The next generation of ADAMS will feature an upgrade to increase portability and GPS integration.

Key Words: Discharge Measurements, Remote Control, Ubiquitous Technique

1. Introduction

Water is the most important resource for human survival. Reliable river discharge information is the inevitable requisite for a good watershed plan & management as well as for total demand maximum loads (TMDL). Sometimes the correct river discharge issues arise regarding water rights and with competition between power, irrigation, municipal, industrial, and environmental water, in addition to recreation, aesthetic, and fish and wildlife uses. The best wayto know the amount of daily river discharge is to directly measure the river flow. But this was too ineffective and expensive to allow continuous measurement. So, traditionally daily river discharges have been made using the indirect measurement method for measuring

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stages and the translating method, which is used for stage-discharge relationships(Park, 2005).

These traditional processes have some problems. One of which is the daily discharge can be applied one year later, when the rating curve is completed. Another drawback is that it requires substantial field and engineering work.

Recently, to overcome these difficulties in river discharge measurement, after a thorough methodology review, we have developed the Automatic Discharge Acquisition & System (ADAMS). ADAMS scans the river cross-section and measures each cell (1m×1m) velocity using HADCP. In this paper we will discuss the framework and the practical implementation of ADAMS for remote measurement and control of the ADCP mounted device in rivers.

2. River Discharge Measurement Method of ADAMS

2.1 Theory for River Discharge Measurement

The river discharge is calculated from the sum of the products of river velocity and cross section area. The cross-section of river is divided into several segments. The width of each segment and the depth and mean velocity at a vertical in each segment are measured. The total discharge through the cross-section is then the sum of the products of velocity, width and depth of each segment (ISO, 1997).

The velocity-area methods fordetermination of discharge have several computational methods; the midsection or mean section method, velocity-depth integration method and velocity-contour method (Herschy, 1995).

With ADAMS we have used all of the above integration methods according to the individual user's selection. In order to integrate areas and sectional velocity-areas partly requiring tedious and costly procedures, the cubic spline interpolation procedures and Kriging method are also used. In general practice, the cubic spline interpolation procedure is recommended.

2.2 Velocity Profile and filtering Process

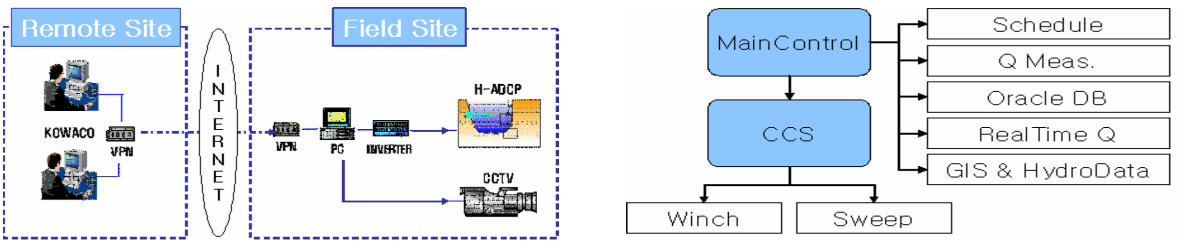
River velocity measurements are made in each vertical at a sufficient number of points distributed between the water surface and bed to define effectively the vertical velocity profile. The velocity profile is the essential process for making the mean velocity. Six smoothing and averaging procedures are tested by Muste(2004), attempting to improve data usage for mean velocity.

The water velocities with HADCP are contaminated by side-lobe effects and the temporal flow variations inherent in turbulent flows. A major constraint in horizontal profiling is the reflection of the acoustic pulses from boundary. Bottom contamination causes the velocity to become biased to lower velocities because the Doppler shift from the bottom is zero (Kim, 2002). Overcoming the side-lobe problems ADAMS uses the special filter and the outside of filter is applied for the velocity curve equation (Herschy, 1995).

3. Development of ADAMS

ADAMS is composed three pieces, each at a different location: the field measurement point, base site and remote site (Fig. 1a). The field site is supported by several hardware components. Several sensors are installed, such as ADCP for flow velocity, YSI for water quality and a CCTV for the monitoring instruments. The base site is made to collect and control each site sensor. Other instruments include two winches for moving the sensors, a sweep cart and a PC used for local control. The remote site also has an office, which is 250km distant from the field site and the main control point. The remote site and base site are connected via VPN internet technology. In the near future the data communication method will be changed from the VPN to CDMA method, the base and field measurement site will be combined and the total size of ADAMS will be reduced.

The ADAMS software System is composed of two modules, each with a distinct functionality, either MCS or CCS. Each module, as an independent program, communicates with the other via telnet communication in order to increase the modularity and functionalities (Fig. 1b). The MCS is the main control system to handle the overall software system, such as the discharge calculations, Oracle data communication, real time display, etc.



a. Hardware system b. Software Schematic Relationship Diagram

Fig. 1. ADAMS System(Park, 2005)

4. Field application and results

4.1 Characteristics of Measuring Site

The newly developed ADAMS was installed at the Jindong Stage site, which is the key control point for flood control and water conservation. The Jindong stage station is located in the lower Nakdong River basin(Fig. 2).

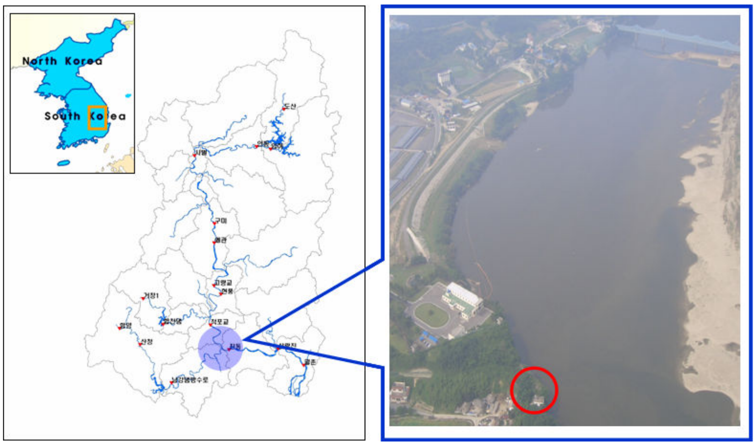


Fig. 2. Location of the Jingdong gauging station within the Nakdong river basin, Korea.

4.2 Application and Configuration

Daily discharges have been measured over one year since ADAMS was installed. The operating process is as follows. First, after being given the start command, the suspended garbage is removed using a sweep cart. This is followed by measurement of the velocity profile using H-ADCP & the Cart. The discharge measurements are taken twice one measurement: one is the downward and another is the upward direction. If the difference is within the 5% difference range, the data is accepted.

In order to eliminate the scattering of velocity by turbulent flow, we evaluate the coefficient of variation which is defined standard deviation over average velocity. Figure 3 shows that after 100sec/ section the coefficient of variation is not dramatically reduced. So ADAMS spends the 100seconds for each measuring section. The figure 3 shows The coefficient of velocity variation according to time length.

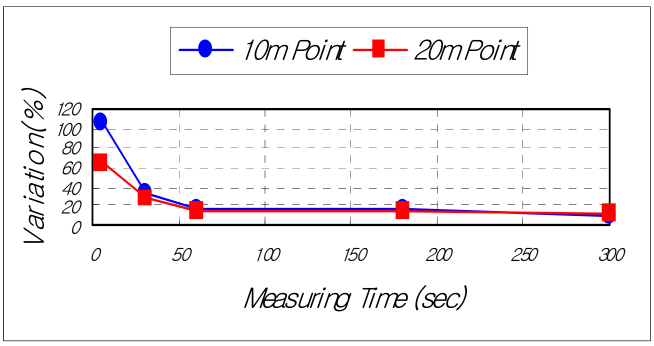
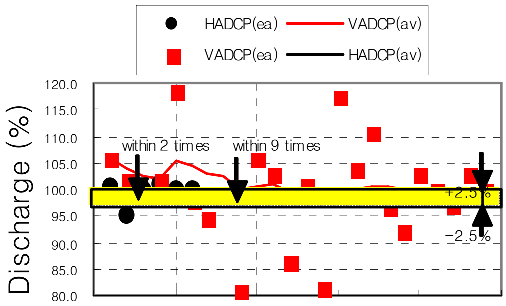


Fig. 3. The coefficient of velocity variation according to time length(KOWACO, 2005).

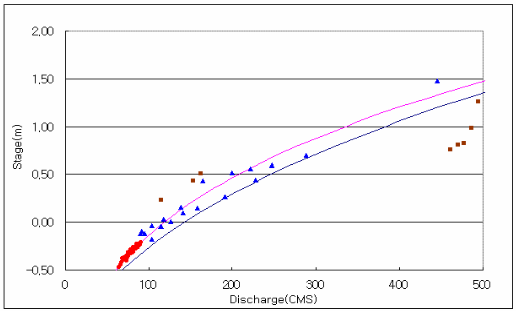
4.3 Analysis

The products obtained by ADAMS provide a special variation of the velocity vector, isovels contour and 3D velocity shape. The ADAMS' discharges were compared to results obtained by a Q-boat and ADCP over the same periods. The results showed that the Q-boat and ADCP system had larger variations in discharge measurements. The results obtained using ADAMS at the Jindong stage site show less than a 5% uncertainty and are 4 times more efficient then those obtained using the ADCP or Q-boat system (Fig. 4a).

The figure 4b shows the historically used rating cure (black) and the ADAMS developed line (red). Through this analysis ADAMS results give the very narrow band and very small variation compare to historical measurement and rating curve.



a. Q-boat and ADCP



b. Historical (black) & ADAMS Curve (red)

Fig 4. Comparison between ADAMS and other method

5. Results and Future Development

ADAMS will provide solutions for obtaining the continuous daily river discharges at key control points,such as at the Jindong station on the Nakdong river in Korea. Through this study we can summarize the results as follows;

- ADAMS leads to standardized pre-measurement procedures and give consistent river discharge by setting values.
- It does not need any field work by engineers and reduces the measuring costs from $70,000 to $5,000 per year at each site.
- The results using ADAMS at the Jindong station show less than a 5% uncertainty and are 4 times more efficient then those obtained using the Q-boat and ADCP system.
- One of outstanding merits using ADAMS is it gets the real-time daily discharge directly compared to historical rating cure method, which is created only after collecting data for one year.

ADAMS provides the most accurate river flow measurements by scanning the river cross section. ADAMS features a ubiquitously accessible system, real time automatic discharge measurement, remote control via the internet. This system can be used to measure any large river, river mouth or tributary river affected by backwater, all of which have a very difficult measuring real time discharge. The next generation of ADAMS will feature an upgrade with improved portability and GPS integration.

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