Automatic Real-Time Bridge Scour Measurements Using a Newly Developed Scourometer (SM263)

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I. Introduction

Bridge scour research has recently become an extremely important issue within the Korean water resources engineering community. The reasons are numerious but the three most important factors can be summarized as follows. First, the catastophic collapse of the Sung-Su Grand bridge has led to a reconsideration of safety measures and inspection methods for all bridges in the Han River system. These safety concerns have pushed local governments to include underwater structural integrity inspections and sediment scour measurements. Second, dams in the upper reaches of the Han system hinders sediment transport from upstream, thus accelerating the overall erosion downstream. The greater sediment transport budget is particularly striking just downstream of the Pal-Dang Dam. Third, relatively older small and medium sized bridges were designed and built without consideration of scour effects, and measurements show that these bridges do suffer from severe scour effects (Yeo and Kang, 1997).

The increased awareness of bridge scour problems has resulted in numerious bridge scour design methodolgies to be developed. The most common methods adapt empirical formula which have been based on measurements from all over the world for various conditions and bridge designs in vastly different river systems. Interestingly, there has been no single field experiment which continuously monitors bridge scour process under high flow or flood conditions. The reason is that inexpensive and adequate devices do not exist to monitor bridge scour processes for long enough time periods and obtaining spatially and temporally dense enough data sets. Without the proper data obtained under site-specific conditions, rational design methods cannot be developed. Consequently, the research reported here concerns the planning and development of an automatic and real-time bridge scour measurement system

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(Scour Measurement System, SMS).

II. System setup of Scour Measurement System (SMS)

The key feature of SMS is the newly developed SM263 scourometer. The SM263 is an underwater acoustic distance meter which can measure distances from the sensor face of 0.7 m to 78 m with an accuracy of 1 cm and a resolution of 0.15 cm. The device emits 263 kHz acoustic pulses to measure underwater distances by detecting the time-of-travel of acoustic waves running from the lens-face to the object. SM263 uses the latest and most reliable electronic parts and is controlled by a high-speed PIC micro-processor. The resulting system is very stable and an accurate underwater distance meter. The method of measuring scour depth continuously by using this kind of acoustic distance meter is explained well in authors' article (Lee and Yeo, 1998).

In order to insure practical and successful bridge scour measurements, not only must the scourometer be robust in harsh field conditions, but the system software must also be thoroughly prepared. The most important supporting component is a sampling control program located on an external computer. A cable from the controling computer to the instrument sends out sampling control signals to the SM263 and then the collected data is transmitted back to be stored on a hard drive. The program also controls communication between other devices during the measurement and performs the calculations necessary to calculate the distance from sensor to the mobile bottom. A power service component of the system converts and filters the DC power provided by a car battery to run host computer, sensors and communication devices for more than two weeks of continuous sampling. Often, success in a field deployment depends on management of a steady and reliable source of power, making this component of the SMS important.

Another extremely important component for real-time automation of the bridge scour measurement system depends on wireless communication. The scour sites are often remote and real-time data reporting is important for disaster prevention. For this reason, PCS data communication is used in SMS. PCS are now widely used and covers almost all areas of the Korean peninsula and thus provides an alternative to the conventional wireless communications such as a Radio Frequency (RF) modem. Figure 2.1 shows a block diagram of the SMS with the aforementioned devices.

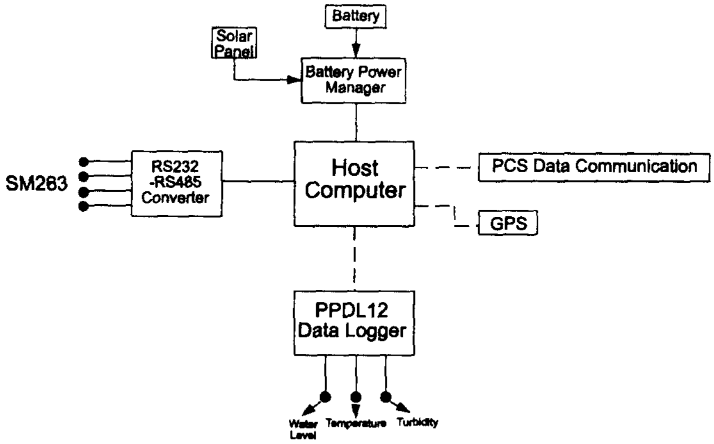

Figure 2.1 Block diagram of Scour Measurement System (SMS)

III. Deployment of SMS for real-time bridge scour depth measurement

The SeoHae Grand Bridge crosses the Asan Bay of West coast of Korea, and construction is scheduled for completion in 2001. During the construction of bridge piers, field engineers reported unexpected increases in the scour depths due to other developements in the Asan Bay region producing flow contraction in some sections of the channel. As a result, the Korea Highway Cooperation (KHC) held an advisory meeting to investigate the problems leading to the authors' participation in scour depth measurements near the SeoHae Grand Bridge piers. The project is comprised of three components: real-time monitoring of bridge scour processes; numerical simulation of proposed developments in Asan Bay to determine their effects on flow conditions and bridge scour; and physical model testing to study local bridge scour causes, as well as a preliminary study of bridge scour protection schemes.

Real-time bridge scour monitoring of the SeoHae Grand Bridge began with the design of an acoustic scourometer through cooperation between Myong-Ji University and Shin Chang Co., LTD. Within three months of design, implementation and testing the SM263 scourometer was completed. During the development stage, field tests of the SM263 were carried out at the SeoHae Grand Bridge construction site, other reservoirs and a laboratory tank. Finally, the automatic real-time bridge SMS was installed on the Pier 58 with four SM263's at the corners of the bridge foundation. Figure 3.1 is the scene taken after full installation of SMS on Pier 58. The reason for installing 4 SM263 on Pier 58 was due to the numerical simulation and depth sounding results which showed that Pier 58 was near the location of maximum flow and scour activity.

Another 5 SMS units are scheduled to be installed in April at Piers 61, 64, 90 and PF2 and PF3 piers in middle of 1998. After all these systems are converted to fully automatic, real-time operations, an unprecedented level of understanding of bridge scour processes will be achieved. Further, with the SMS units in place, it is natural for the system to be included in a long-term scour monitoring effort after construction on the bridge has been completed. Any changes in the bed, especially after construction has been completed, will be recorded and the appropriate counter-measures can be taken early for any scour detection.

Figure 3.1 shows a continuous history of bridge scour depth change at Pier 58 during a three-day initial deployment of the SMS from April 3 - April 7, 1998. The figure shows that during the experiment period there was not much change in scour depth and the depth remains nearly 9.95 m with nearly a 0.01 m fluctuation. The engineering interpretation of this result will be postponed until a few months of data are collected, but it can be said that the bottom change is very slow which may imply rocky bottom exposure to flow.

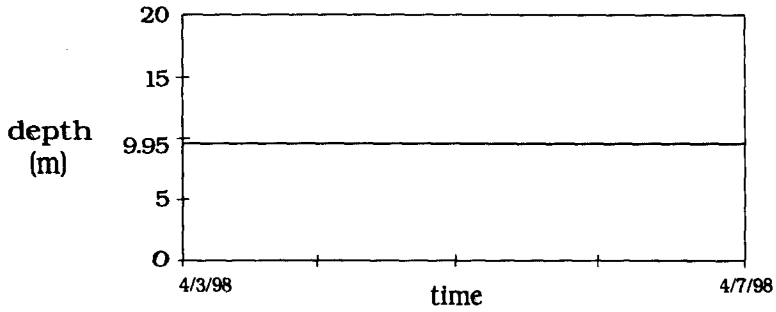

Figure 3.1 Depth change measured by SMS in the initial deployment.

The SMS has been operating continuously until now and has shown no problems yet. The installation of the SMS unit on Pier 58 and other piers are designed to resist harsh enviromental conditions at the deployment site. Every two weeks, maintenance people will inspect the SMS and transfer the measured data for analysis. At present, the sampling rate is set to one-minute after averaging every second (1 Hz) information. Figure 3.2 shows the SMS installed on bridge pier P58 with the inset picture showing the scourometer(SM263) itself.

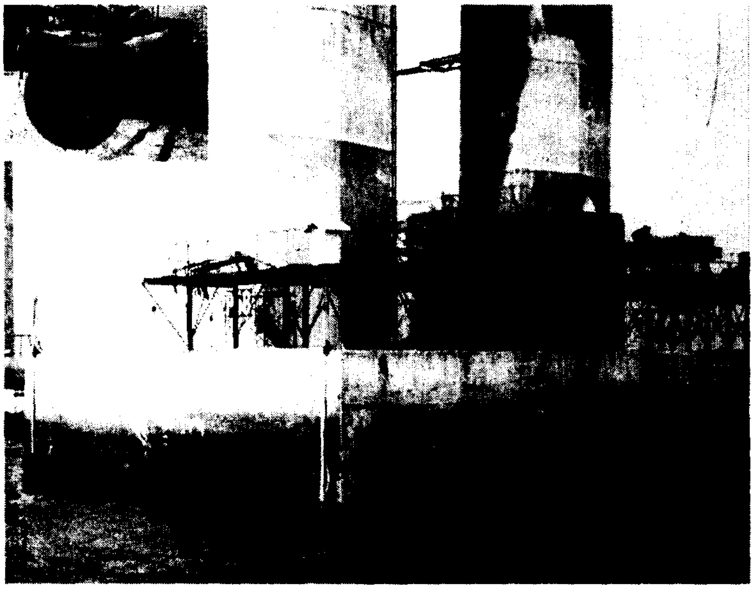

Figure 3.2 Field deployed SMS and its scourometer (SM263) near Pier P58.

IV. Conclusion

To monitor real-time bridge scour processes near the SeoHae Grand Bridge, the Scour Measurement System (SMS) was constructed and deployed successfully. This system continuously samples bridge scour-depth variations 24 hours a day, everyday and plays an important role in investigating and monitoring scour effects. With a newly developed scourometer, the SM263, the SMS has shown great potential for enhancing a rational approach to monitoring bridge scour depths with a fully automated, real-time operational unit that is a one-of-a-kind product.

To these authors' knowledge, if the SMS can be applied to scour research at other large bridges in the Han River system, it can surely settle some of the questions in the ongoing debate concerning bridge scour refilling rates. Because it can sample bridge scour processes second-by-second during flood stage water levels and flow rates, the refilling rate of scoured holes will be easily detected. The authors have already begun to realize the potential of the SMS system (Lee and Yeo, 1998), and the SMS can, in the future also be used operationally as a disaster prevention monitor. With the PCS data communication uplink, the SMS can send real-time scour depths to responsible agencies, and perhaps prevent the worst-case scenario of bridge collapse.

References

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