

MAPPING OF RIVER BED – METHODS FOR HYDRAULIC MODELING

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Validating sedimentary processes plays a key role in experimental hydraulics. Numerical models of sedimentation are complicated to use and the results are often not reliable. For a general understanding of these complex processes, river bed mapping can substantially aid in the design of particular projects. This paper gives a brief description of methods that are currently available for the purpose of river bed mapping in hydraulic modeling. Lastly developing of new instrumentation using laser technology will be performed.

1 Introduction

The development of erosional damage below spillways is practically impossible to describe by numerical methods. So the hydraulic model test remains the only precise and reliable method of studying the process of erosion. The dimensions of the scour holes form an important criterion for the choice of the measures to be taken against river bed deformation. As scour holes in the immediate vicinity of a structure constitute a safety risk, great efforts are being made to identify criteria of similitude and scales of conversion for erosion processes. Use of Froude's law gives a similitude of flow velocity distributions and their dynamic effects on the erodible bed, so that quantitative results are also obtained from erosion studies. This method will only make sense, however, if various conditions relating to flow patterns, model geometry, particle size and particle density are fulfilled. If this is not the case, it is necessary to resort to empirical or semi-empirical dimensional relationships for converting the scour dimensions obtained from the model to prototype values.

River flow transports sediments of different types and rates. Sediment transport, which varies with the flow rate, results in changes in river bed configuration which may lead to changes over the whole length of the river. The main problems in this context are reservoir sedimentation, the potential risk to the vulnerable turbines, and river bed erosion

downstream of the dams. Model tests with erodible beds and with a realistic representation of sediment transport will be accurate if the conditions underlying Froude's law are satisfied. Model tests using erodible beds need support from prototype much more than any other types of model tests do.

2 Methods of determining river bed deformations

2.1 Contour Marking with Wool Threads

Shots are taken of scour patterns to allow comparison of river bed deformations under different operating conditions. Following a test run, the water is let out in several stages and scour contour lines are marked with coloured strings (Fig.1). Placing the strings is a lengthy job. Therefore, this method is time-consuming, especially where a series of case studies is to be carried out. Quantitative evaluation – calculation of volume percentages – is possible only if the shots taken are digitized and evaluated with the help of a CAD method.



Figure 1: River bed mapping with wool threads

2.2 Digital Photogrammetry

The photogrammetric method permits evaluation without calling for manipulations on the model. A special photographic technique using two cameras is needed. The costs of the subsequent treatment of the shots taken are with the introduction of digital photography greatly reduced, but they are still considerable.

2.3 Projection Moiré

This is a method which takes advantage of an optical phenomenon. A line grid is projected vertically onto an undisturbed reference plane and a photograph is taken by a adequately inclined camera. The grid is again projected onto the deflected surface and another photograph is taken. Both photographs are then superimposed. The superposition picture shows a pattern of dark and bright (Moiré) lines of equal elevation. After being digitized and evaluated with the help of a CAD method, this picture enables us to make some quantitative evaluation of the observed process.

2.4 Scanning the river bed by means of a probe following the outline of the ground surface at a close distance

In this method, a mechanical probe is made to approach the surface. The nearness of the surface is indicated by a sensor. Depending on its design, the sensor mounted at the tip of the probe may work according to different principles: conductivity, pressure, optical principle, etc. The advantage of this method lies in the fact that river bed movement can be observed even during the flowing process. Its disadvantage is the large amount of time needed to obtain an appropriate number of measuring points for representing the surface.

2.5 Scanning the river bed by means of optical distance sensors

In this method the mechanically moved probe is replaced by a laser-operated distance measuring instrument. It measures light travel time according to the principle of phase correlation. The method itself is well known and is in use in many branches of science and industry. However, in each speciality it experiences different changes and adjustments which make it possible and easier to use, and also provide better measuring results. In laboratory conditions in which hydraulic modeling takes place, it is easy to take full control of horizontal and vertical position of the instrument. This eases the measuring process, reduces the amount of uncontrolled parameters and even enables the automation of measuring process. In a modern arrangement, controlled by the computer and adequate software, such system enables the researcher to fully focus on the results instead of measurement itself. This, of course, brings us to the topic of trustworthiness and accuracy of the results of optical river bed scanning.

3 Accuracy of the results of laser river bed mapping

For the brief determination of the accuracy of a laser-operated distance measuring instrument, in Hermann-Grengg Laboratories of Technical University of Graz, some very simple measurements were executed. Since an older instrument was already in use in the laboratory, the comparison between that and a new instrument was understood

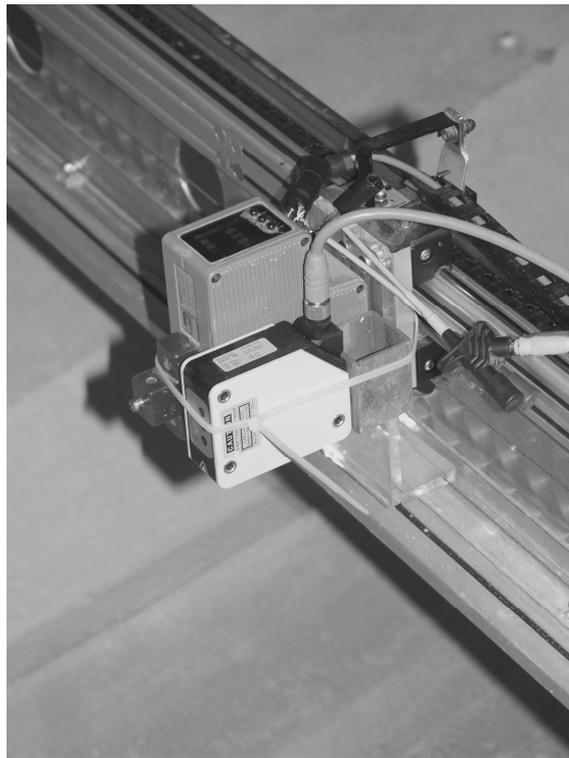


Figure 2: Laser-based distance measurement instrument

The instrument is set in an automatic measuring system, built in accordance with principles mentioned above (Fig. 2). For the purpose of the comparison the river bed was replaced by a series of hard objects with different shapes (Fig. 3).

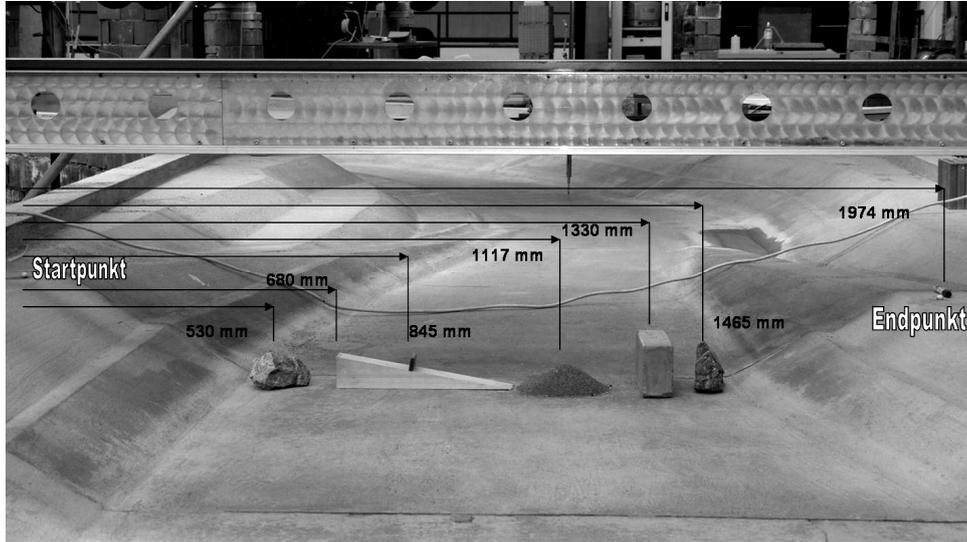


Figure 3: Measured objects disposition

The objects were measured using classic optical instrument and both laser sensors. Some raw results of the measurements are shown on a graph (Fig. 4).

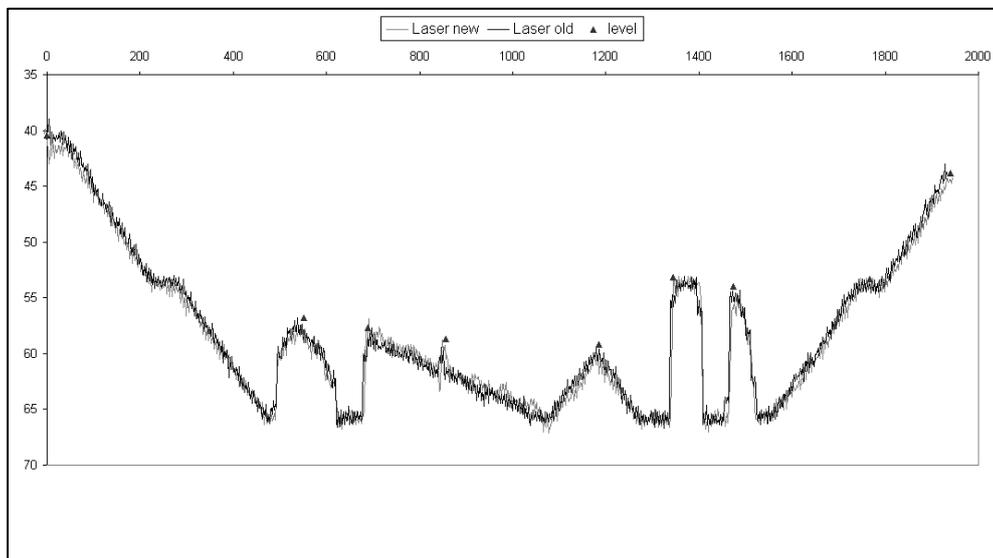


Figure 4: Actually measured values of two laser-distance sensors compared with classically leveled values

We can see that the signals scatter around the real value in smaller range and also the vertical distance between laser measurements and classical measurements. The vertical offset of both laser measured curves is a consequence of inaccurate calibration of the instruments, and can be very simply eliminated by proper calibrating procedure before measurements or by comparison of the results with the results of classical measurements and performing a corresponding linear adjustment.

The scattering is a normal phenomenon at every electronic instrument and we have no influence on it. Therefore it is necessary to obtain a statistical evaluation of this phenomenon to get a useful shape of measuring results. Even a very simple statistical method can be successfully used for scattering elimination. Introducing moving average reduces the scatter significantly, and the difference between the results of measurements taken by two different sensors becomes visible (Fig. 5).

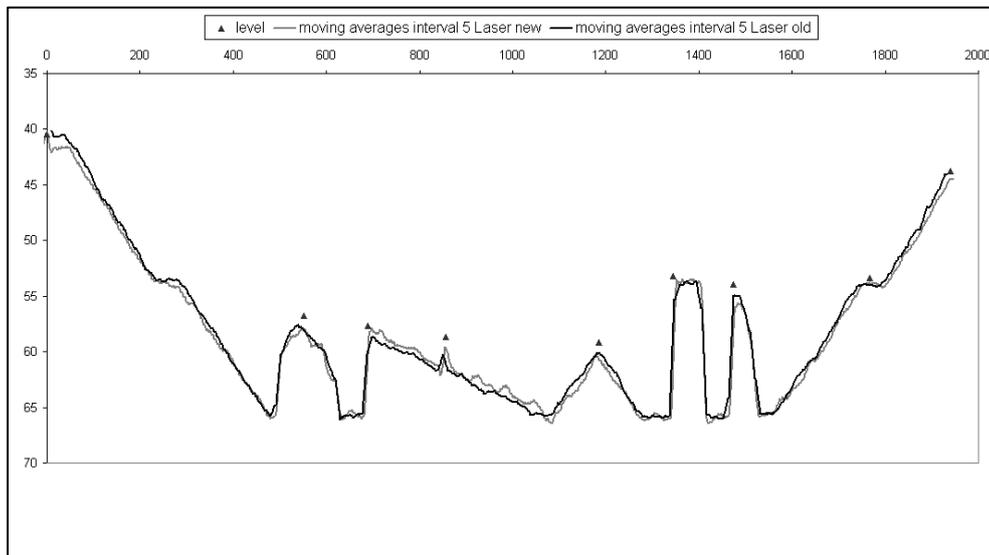


Figure 5: Comparison of moving average of last 5 values for both laser sensors with actual level of measured objects

Regarding to the next graph (Fig.6), it is obvious that a better method should be used, which is possible, because there is a large number of useful statistical tools which can be used.

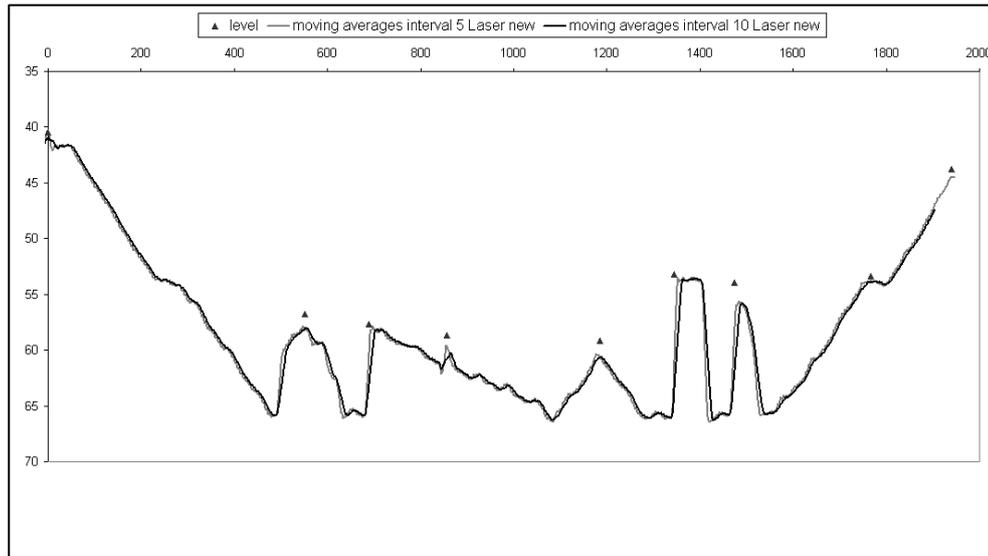


Figure 6: Comparison of moving average of last 5 and moving average of last 10 values for the same laser sensors

In this case only the difference between the moving average using last 5 versus 10 values is presented. We can see how gain in eliminating scatter at the same time negatively influences on accuracy of obtaining a real shape of the measured objects.

Conclusions

Regarding to the latest experiences in modeling and mapping river bed deformations in hydraulic laboratories it is obvious that some methods which only, say ten years ago, held as too costly, are becoming a part of our everyday use. It is very much the same with laser-based distance sensors. This allows the researchers to divert their matter of interest from developing some measurement techniques to the field of result analyses and it also makes laboratory measurements less time consuming and leaves more time for the research work. The latest developed laser-based distance measuring instruments use triangulation as a method of significant decrease of the scatter, which provides the results of a great precision. This reduces the need to perform some questionable statistical methods in otherwise strictly precise scientific and research procedures.