Numerical and experimental study of a natural surface proposed as a morphodynamic streamflow measurement system

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ABSTRACT

Water is a limited resource and a suitable management is required so that population could satisfy their own needs. A correct water management necessarily means having proper tools in order to precisely measure discharge in rivers and channels. There exist many different structures or devices installed in a river or in a channel with the purpose of streamflow gauging. As long as Catalonia rivers are concerned, not only must streamflow gauging be useful for measuring big discharges properly, but also for the little ones, as rainfall in the Mediterranean climate is quite changeable troughout the year. Rainfall during the dry season can not be forgotten, quite the opposite, as it happens during the majority of the year we must consider it very seriously. With reference to the precision of current streamflow measurement methods, this could be much better. Generally gauges are only useful to measure certain values of streamflow. When flow occurs out of this domain the results obtained are not reliable at all. The main purpose of this master thesis is to deal with a new system of streamflow gauging, which is believed to measure properly any discharge.

The unexpected discovery of a very remarkable flow over an eroded stone by water led to a research in order to design a new stremflow gauging. This discovery was made by professor Allen Bateman in River Tordera while doing other tasks. The main feature of such flow was its symmetry. Not only was soft the flow, but also the stone surface itself. These were the reasons for thinking of designing a morphodynamic gauge, a structure capable of measuring continuously any discharge.

In order to study the geometrical characteristics of this surface, it was necessary to build a cement mould. Once a large number of points of this surface were measured, it was time to find the mathematical expression of a symmetrical and differentiable surface as close as possible to the measured one. Afterwards a scaled model with a geometrical enlarged scale equal to 2.5:1 was built and placed in the Fluid Mechanics Laboratory so as to be studied accurately. The same problem was developed using one-dimensional and three-dimensional computational techniques with the aim of complement the experimental works. The similarity in the results is quite remarkable.

Thanks to the large number of measurements made, a computer program has been elaborated. This program is able to calculate the streamflow discharge very precisely using the depth water measured at any point of the structure for any geometrical scale. Such a method could be assessed as an useful improvement. Moreover, this streamflow measurement system also permits drawing on the surface the curves corresponding to the water levels of different discharges. By this way any people, even not having any knowledge at all related with streamflow measurement, can easily assess an aproximate value of discharge. Other important topics linked with streamflow gauging have also been dealt with in this master thesis. Firstly it has been studied the behaviour of the structure imagining that it could hold a layer of sediments of a certain thickness. As far as hydraulic behaviour is concerned, this situation is equal to shorten the structure from its upstream reach and it has been stated the required correction to be made when such situations take place. The first approaches in designing suitable ways of loosing energy and fish passage facilities have also been made for this particular structure.

To sum up, it is plain that the flow over this surface permits the measurement of a large domain of discharges in an easy and precise way. Furthermore it is stated that this structure is capable of cleaning itself and do not interrupt sediments or nutrients travelling along with water in normal conditions. It must also be pointed out that the gauge station could be built using concrete pieces made on factory and put together once transported to the river, which would incredibly simplify the process of construction. Despite all these advantages, it is necessary to develop a system for loosing energy as well as fish passage facilities according to the considerations made in this master thesis in order to consider the whole stramflow measurement system fully designed.