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Measurement and data acquisition on the pressure field in tests carried out on a reduced model of a stilling basin

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Abstract

A free falling jet from an arch dam spillway produces a pressure field in a stilling basin. The field changes according to the waterfall height, jet aeration, discharge, cushion height and stilling basin length. To study this field, a hydraulic model was built and a data acquisition system was set up.

To measure the pressure, piezoresistive transducers are used with instrumentation amplifiers which can be adjusted to the pressure range we wish to measure.

To acquire data, a PC and a data acquisition card are used.

A program was designed for storing and an initial processing of the data. By means of this program the data are obtained from each channel and are stored in a file. This file contains pressure data and some particular characteristics of the system for each session.

These data can later be further processed in order to obtain conclusions on the design of the stilling basin.

Introduction

In arch dams with free falling from the crest, an important aspect to be taken into account in the design is the stilling basin. This dissipating structure must return the waters to their channel with the expected amount of stilling, avoiding undesired damage to the dam, the channel and the dissipating structure.

On entering the basin, the falling nappe has three zones:

I Free nappe zone: the flow has similar characteristics to the free fall.
II Impact zone: relatively high pressures appear in the bed.
III Wall jet zone: a submerged hydraulic jump is formed.

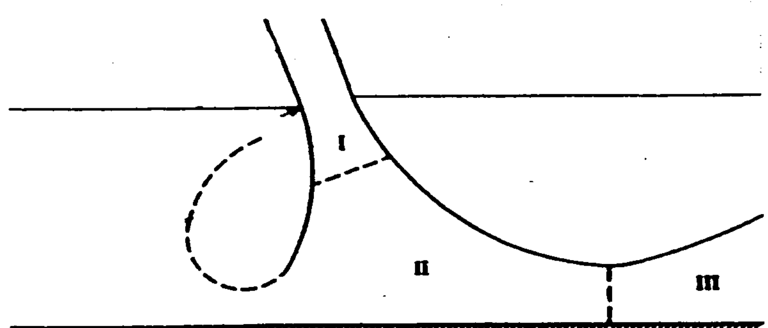

Figure 1. Diagram of a water jet inside a cushion.

Of the three areas the second is that which is studied in order to analyze the field of pressures that it exerts on the bed. This will be a function of the fall height, aeration of the jet, the discharge, the height of the cushion of water and the length of the basin.

Hydraulic model

In order to carry out this study, we used the model shown in Figure 2.

The main dimensions are:

The fall height may vary from 2 to 7 m.
The total maximum discharge is 0.05 m^3/sec.
The width of the approach canal and the basin is 1.2 m.
The height of the water cushion in the basin cannot exceed 1.4 m.
The maximum length of the basin is 4 m.

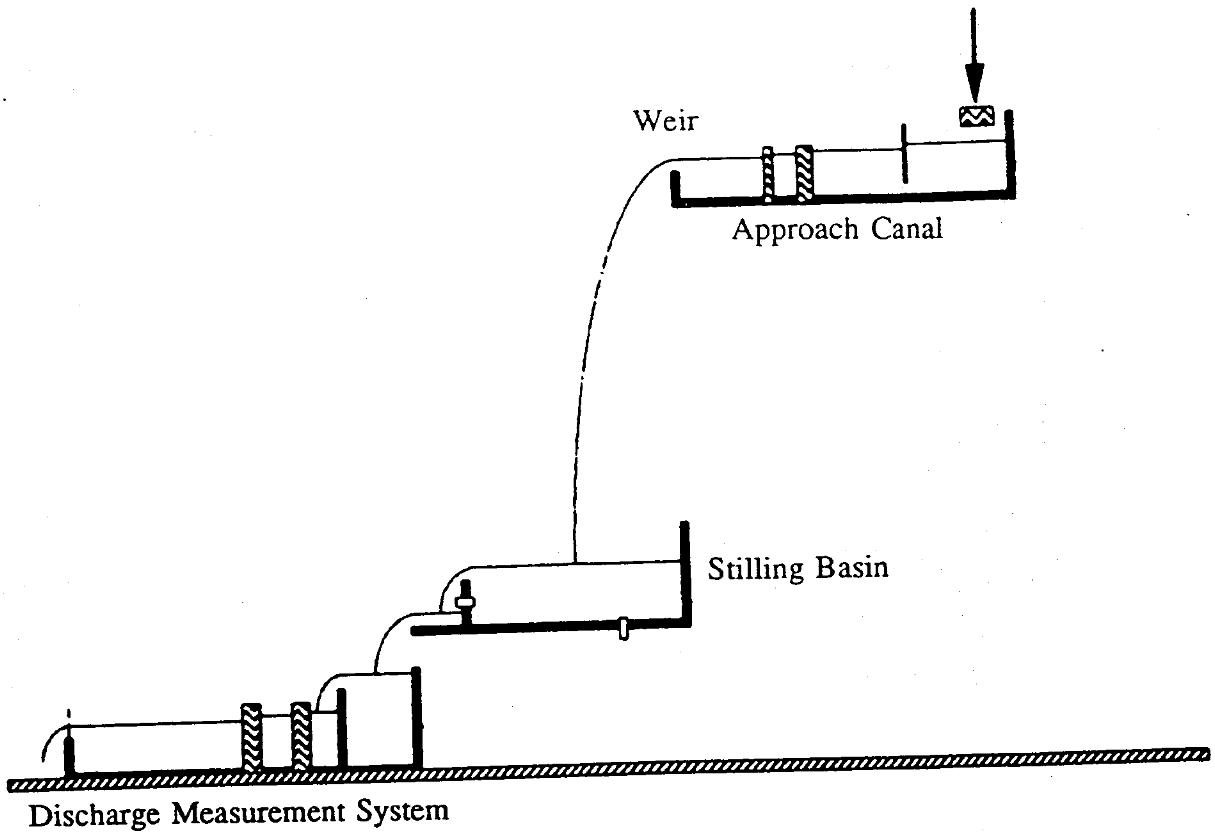

Figure 2. Diagram of the hydraulic model.

The stilling basin is fixed, whereas the weir and its approach canal may be situated at different heights.

Instrumentation

Traditionally, piezometers have been used for the pressure measurements. This system of measurement is only suitable for obtaining mean values, since the inertia of a column of water and the elasticity of the walls make it impossible to register rapid variations in pressure. This is the case presented here. It was also desired to carry out quantitative measurements and be able to register them. In order to achieve this, piezoresistive sensors are used. In these, the sensitive element is a semiconductor which changes its resistance. We thus obtain an electric signal proportional to the pressure.

Two types of pressure sensors are used:

-a relative pressure sensor, which has a nil response for atmospheric pressure. For higher pressures it is positive and for lower ones negative.

-an absolute pressure sensor. In this type the nil response is obtained when there is also zero pressure, so it will always be positive.

In general the signal obtained from these sensors is too small to work with it directly, so it is necessary to use amplifiers to process it. The sensor is basically a Wheatstone bridge and the signal obtained is floating, so it is necessary to use an instrumentation amplifier. This was designed on the basis of three operationals due to their good characteristics and easy construction. Each amplifier can thus be adjusted to each sensor in particular.

Calibration of the sensors

As the sensors determine the values of the pressure measurement, we must guarantee that they work correctly. Therefore, a calibration of the sensor is carried out, consisting of taking data for different pressures of a water column and thus determining the response of the sensors. The results obtained show that they have a linear behavior [3].

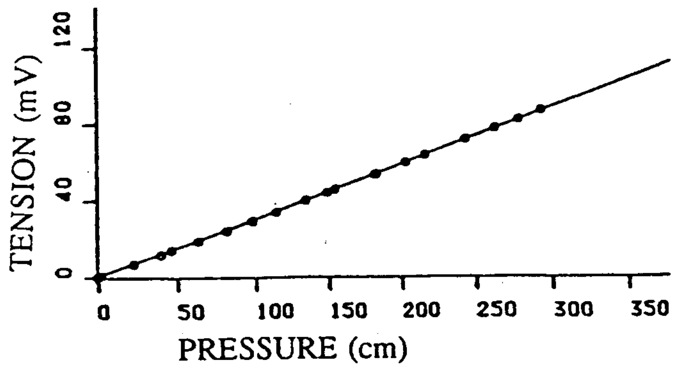

Figure 3. Calibration curve of the sensors.

Figure 3 shows the curve obtained from the calibration.

Data acquisition

To obtain the data we use a PC with a data acquisition card for the conversion from analog to digital. The card has 16 analog channels with 10 bits resolution, whose margin of input voltage was 0 to 5 V. The amplifiers are adjusted to obtain the greatest variation in voltage for a desired margin of pressures, and not to lose the resolution of the converter.

A program was developed for data acquisition and initial processing. It was made in language C, and was adapted to the characteristics of the acquisition card.

Its main characteristics are:

- Selection of different test variables. By means of a menu it is possible to change the number of sensors that it is desired to use, the

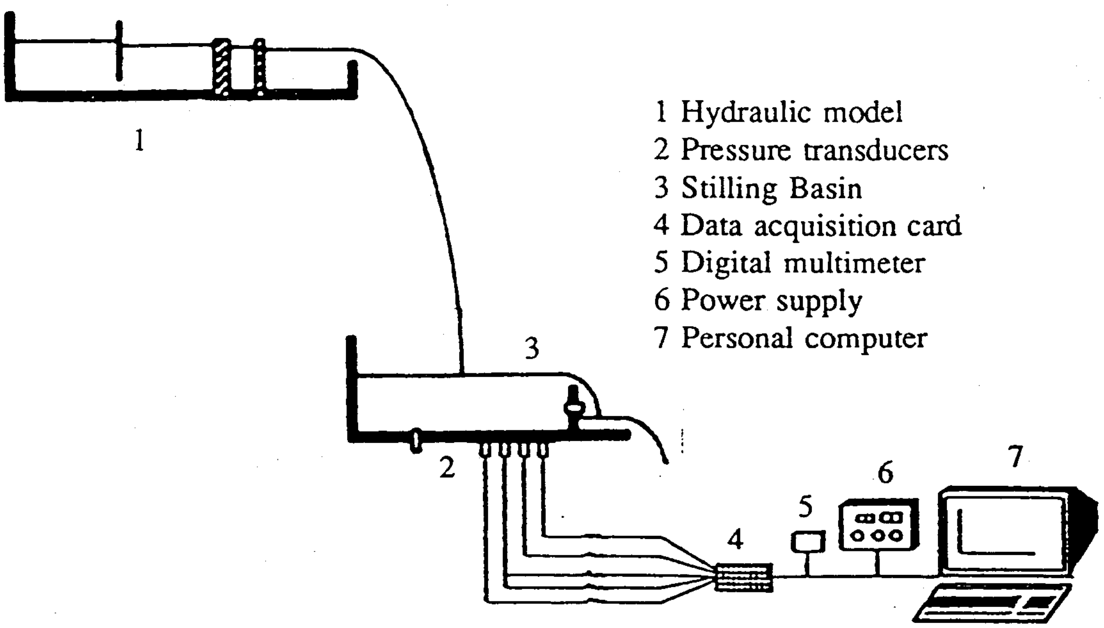

Figure 4. Diagram of the complete measuring system.

total sampling time - which give us the data acquisition speed, which can vary between 240 and 8 data/second - information concerning the geometry of the hydraulic model, such as the height of fall, the discharge, positions of the sensors, etc.

- Data acquisition. This acquires the data according to the above specifications, and stores them in memory.

- Monitoring of the sensors. This option is very useful for checking that the system works correctly. It shows different values of the sensors in real time, such as: instant pressure in metres of water column and in values of the A/D converter, average pressure, typical deviation, and maximum and minimum values so far.

- Recording of the data on magnetic medium. As well as the data obtained, certain information on the geometry of the hydraulic model is stored for a later process.

- Diagram of the data on screen (see Fig. 5). When a series of pressures has been taken, the results obtained are shown on screen so that we can check that the results for each test are correct, and program the following ones.

- Diagram of the histogram (see Fig. 6). This shows the function of

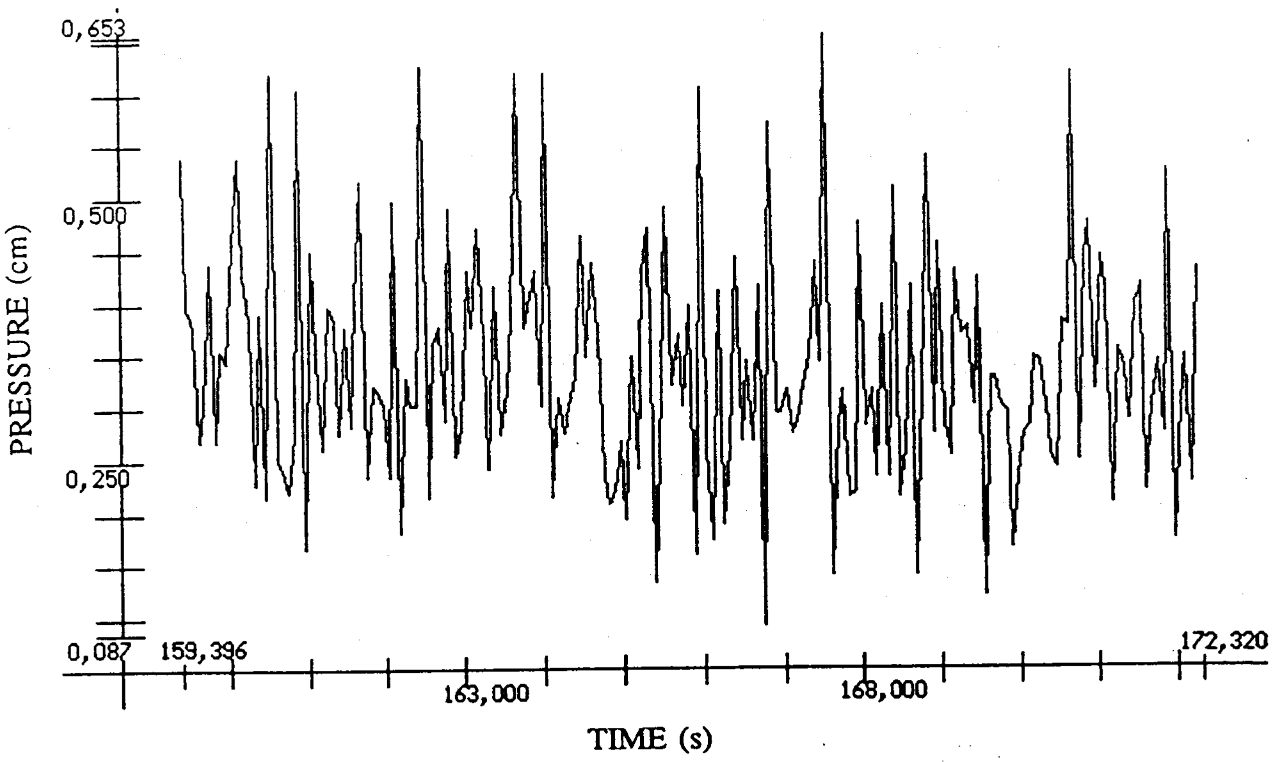

Figure 5. Screen of the data drawing function.

density of probability of the samples taken in the form of a histogram.

- Reading of data from the disc. This makes it possible to recover data from a file that has previously been obtained by this same program, so that they can be shown again.

- Commands of MS-DOS. This makes it possible to go to the shell of the operating system in order to perform any operation from it.

- Change in the number of samples to be taken. By default, 2400 data are taken for each channel. By means of this function it is possible to change this number.

- Zero calibration of the sensors. By means of this option it is possible to calibrate the zero pressure of all the sensors. This information is stored on a file, which is read at the beginning of the program and updated each time a new calibration is made. This consists in leaving the sensors without water and taking samples for this situation. We associate atmospheric pressure for the values taken.

- Calibration of a sensor. As in the previous paragraph, the signal is calibrated, although in this case only for a single sensor for any water height. This calibration is also stored in the calibration file mentioned

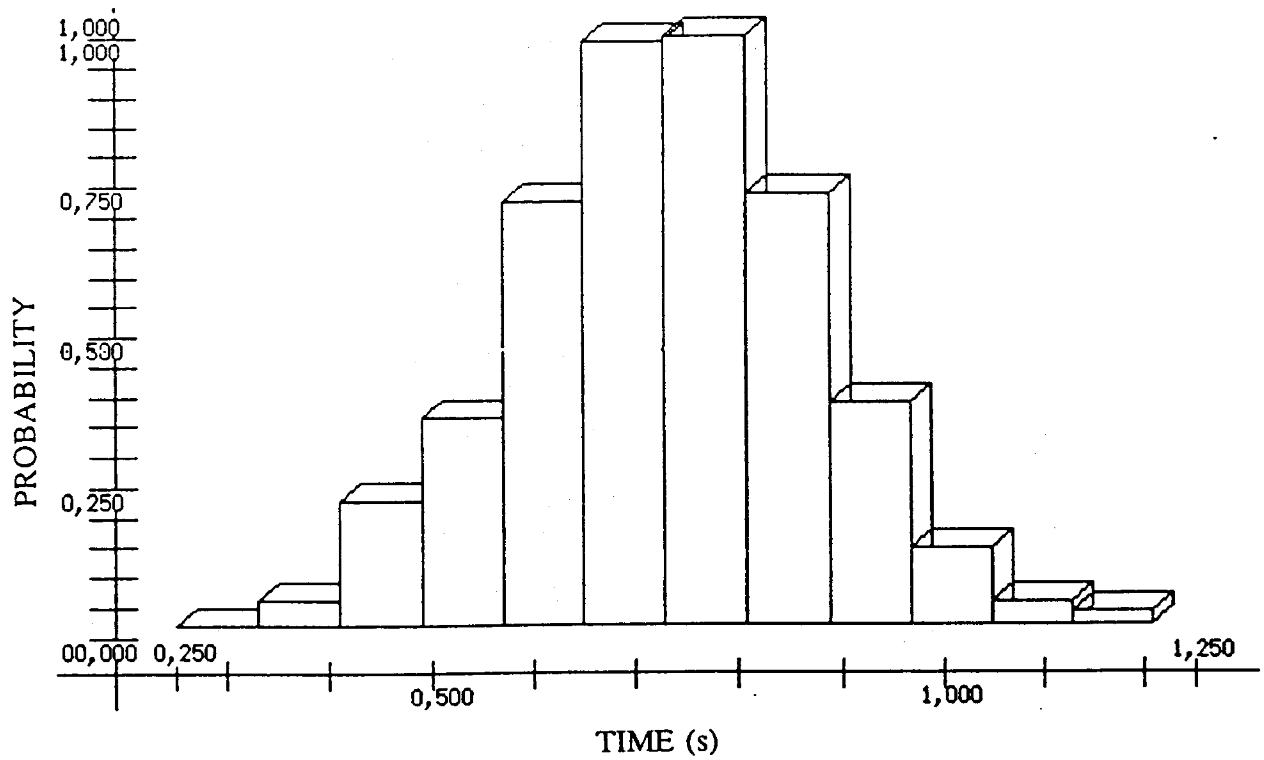

Figure 6. Screen of the data histogram.

above. Thus, the calibration is made simply and rapidly each time that it is necessary.

- Print-out of parameters. The values of the initial selections that governed the sampling are printed.

- Print-out of a message. Any message can be printed. Together with the previous print-out, this provides a record of data, information and comments on the tests.

- End of program. If data have been taken and not stored on the disk, a warning is given. Program ends.

By means of the system described above, the campaign of tests corresponding to two doctoral theses [1,2] was made. Another is currently being carried out which extends this study using the same equipment to carry out the tests.

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Bibliography

1. Armengou Orús, Jaime. "Vertido libre por coronación en presas bóveda. Análisi del campo de presiones en el cuenco amortiguador". Tesis Doctoral, E.T.S. de Ingenieros de Caminos, Canales y Puertos. Universidad Politécnica de Cataluña. Barcelona. 1991.

2. Castillo Elsitde, Luis G. "Metodología experimental y numérica para la caracterización del campo de presiones en los disipadores de energía hidráulica. Aplicación al vertido libre en presas bóveda". Tesis Doctoral, E.T.S. de Ingenieros de Caminos, Canales y Puertos. Universidad Politécnica de Cataluña. Barcelona. 1989.

3. Castillo, L.G., Dolz, J., Polo, J.."Acquisition and analysis of data to characterize dynamics actions in hydraulic energy dissipators". XXIV IAHR Congress. September, 1991. Madrid.