Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 162 (2016) 349 – 356

Procedia Engineering

www.elsevier.com/locate/procedia

International Conference on Efficient & Sustainable Water Systems Management toward Worth Living Development, 2nd EWaS 2016

Investigation of the Optimum Connection of a Fish Pond with the Adjacent Main Riverine Flow

George Pechlivanidis[a], Yiannis Savvidis[a,*], Evangelos Keramaris[b], Christopher Koutitas[c]

[a]*Alexander Technological Educational Institute of Thessaloniki, Department of Civil Engineering T.E., Sindos, 57400 Thessaloniki, Greece*
[b]*University of Thessaly, Department of Civil Engineering, Pedion Areos, 38334 Volos, Greece*
[c]*Aristotle University of Thessaloniki, Department of Civil Engineering, 54124, Thessaloniki, Greece*

Abstract

The optimum design of the opening through which a fish refuge pond communicates laterally to the main flow of a river was investigated. The study was based on the realization of physical and mathematical models. The physical modeling was realized via laboratory experiments which included the use of an open channel with a lateral reservoir. The flow characteristics measurements were realized with the PIV method. The mathematical simulations were based on the development of a 2DH hydrodynamic model and a quasi 3D sediment transport model. The study led to the optimum technical design of the system.

Peer-review under responsibility of the organizing committee of the EWaS2 International Conference on Efficient & Sustainable Water Systems Management toward Worth Living Development

Keywords: River, Fishpond; Physical; Mathematical; Models;

1. Introduction

The design of river and coastal hydrodynamic projects is significant because these projects are directly related to important environmental and ecological issues. The studies of water flows in rivers and coastal zones have been initiated before several decades both experimentally in laboratories or field and also numerically via mathematical

* Corresponding author. Tel.: +302310013691
E-mail address: savvidis@aqua.teithe.gr

Peer-review under responsibility of the organizing committee of the EWaS2 International Conference on Efficient & Sustainable Water Systems Management toward Worth Living Development
doi:10.1016/j.proeng.2016.11.074

models. There are a lot of experimental researches focusing on the turbulent characteristics of the flow [1, 2, 3, 4]. Successful examples of modelling studies have also been realized by several researchers [5, 6, 7]. Savvidis et al. [8] studied the waters flushing of the harbor of Nea Moudania (N. Greece) both based on field measurements and mathematical simulations; Christopoulos et al. [9] presented an integrated numerical model for the optimization of harbour layout design. Concerning the laboratory experiments recent research works were based on modern techniques like the Particle Image Velocimetry Method (PIV). The PIV method is an optical method of fluid visualization which is used to obtain instantaneous velocity measurements. Other techniques used to measure flows are: a) Laser Doppler Velocimetry and b) Hot-Film anemometry. The main difference between PIV and those techniques is that the former produces two dimensional vector fields, while the other techniques measure the velocity at one single point. Authors of this study have performed experiments based on this procedure. More specifically, they have investigated experimentally the turbulent characteristics of open-channel flow over a permeable or impermeable bed using a PIV [10, 11, 12].

In this study the optimum design of the opening through which a fish refuge pond communicates laterally to the main flow of a river was investigated both experimentally and numerically. That optimum design would be determined by minimizing the potential sedimentation phenomena in the fish refuge basin. The measurements of the flow characteristics in the laboratory were realized with the PIV method, while the mathematical simulations were based on the development and application of a 2D-depth average- hydrodynamic model and a quasi 3D sediment transport model.

2. Methodology

2.1. Experimental Setup - Measurements

Experiments were conducted in a horizontal channel with 7.0 m length, 25 cm height and 50 cm width (and a lateral square basin 1m^2) in the laboratory of Hydraulics in the Department of Civil Engineering of Alexander Technological Educational Institute of Thessaloniki, Greece. The measurements were carried out for total water channel depth h=10 cm and for water depth in the lateral basin h=15 cm for entrance flow velocity 0.07 m/s. Consequently, a scale of the order of 1:10 was used to the physical model (in the laboratory experiment). Three cases concerning the communication of the main channel with the lateral basin (fish refuge) were examined: in case 1 the lateral reservoir is fully connected to the main stream opening, in case 2 a parallel to the opening groin, of 50 cm length, is placed starting from the upstream end of the opening while in case 3 an oblique groin of the same length is built upstream. The experimental set-up is shown in Figure 1.

PIVs use the particle concentration method to identify individual particles in an image and follow their flow; however, tracking particles between images is not always a straightforward task. Individual particles could be “followed” when the particle concentration is low, a method called particle tracking velocimetry, whereas laser speckle velocimetry is used for cases where the particle concentration is high. The experimental uncertainty of the measured velocity with this technique is approximately ± 2%. The PIV system used for the measurement of the velocity distribution in the flow domain was a two dimensional one consisting of a twin pulsed Nd: Yag lasers (532 nm wavelength, 300 mJ / pulse at 10 Hz), a cross correlation 8bit 1Kx1K CCD camera (Kodak, MEGAPLUS ES 1.0), a synchronizer, a computer, an image acquisition system and a PIV analysis software (Insight 3G). The laser beams were combined and formed a 1mm wide sheet by using semi-cylindrical optics. The camera image size had 1600 × 1192 pixel array and the dimension of the velocity field was kept to 291 mm × 214 mm for all the experiments. This means that the resolution of the captured images was typically 5.5 pixel/mm or that the pixel length was 0.1818 mm. The laser was installed above the tank at a distance of 50 cm from the illuminated water free surface, while the camera viewed from an orthogonal direction. Twin images were recorded with a time separation of 2 msec. The plane photographs were divided into interrogation spots measuring 32 × 32 pixels (5.79 mm × 5.79 mm). The cross correlation between the interrogation spots determined the mean displacement of the particles and thereof the velocity vector. The cross correlation operation was based on the correlation theorem, stating that the correlation on the spatial domain becomes multiplication on the frequency domain. Correlation made use of the FFT. Adjacent interrogation spots were overlapped by 50%, providing a resolution of about 3 mm. After that calculation, the velocity data were filtered with a signal-to-noise filter, a peak height filter, and global and local filters in order to remove error vectors.