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ORIGINAL ARTICLE

Construction of a Concrete Bend Channel as a Hydraulic Model

[1]Maryam Abdolahpour, [2]Mehdi Yasi, [3]Javad Behmanesh, [4]Mohammad Vaghefi

[1]Master of Hydraulic Structures, Dept. of Water Engineering, Urmia University, Urmia, Iran.
[2,3]Assist. Professor, Dept. of Water Engineering, Urmia University, Urmia, Iran.
[4]Assist. Professor, Dept. of Civil Engineering, Persian Gulf University, Bushehr, Iran.

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ABSTRACT

There are lots of complex phenomena which still need to be investigated. Although mathematical and theoretical procedures can help engineers to solve the problems and find some answers but these ways never can show the actual behavior of the phenomena as well as it can be seen in the real world. Physical models are a good way for investigation complex phenomena of the fluid flows and their characteristics. Physical models could help the engineers to solve many problems before they get into operation and involved with sever troubles so construction of physical models with a sufficient scale has been considered by engineers. To evaluate hydraulic characteristics of the flow, bed and hydraulic structures, the hydraulic laboratories need to be supplied by large enough models. In this regards, a concrete armored channel with a 90 degree bend have been constructed in the hydraulic laboratory of Urmia University as the largest laboratory 90 degree bend channel in Iran. The purpose of construction was to obtain appropriate results from researches which can be generalized to the real world and finding data more close to the natural data. By this way solving the scientific problems will be possible more easily. This study presents the construction process of the channel and some case studies which have been carried out on this channel.

Key words: Concrete Channel, 90 Degree Bend Channel, fixed bed channel.

Introduction

By constructing models using established laws of hydraulic similitude, model performance can be scaled up to prototype size. Models provide designers with an opportunity to test and verify prototype performance in a relatively low-cost and easily modified model. Models also allow project stakeholders to become more involved in the design process, as they see firsthand the effects of design modifications (USBR). Although the ability of model hydraulic performance analytically and computationally is constantly improving, physical models are still an extremely valuable tool. Physical models are often the most feasible and most economical way to incorporate three-dimensional complexity. Physical models can also include the effects of physical processes that may not be understood well enough to be accurately incorporated into computer simulations. An important consideration in the design of a physical model is the selection of an appropriate scale. A model that is larger than necessary will be uneconomical, while a model that is too small may make it difficult to simulate and measure the important physical processes. Modeling experience and a good understanding of the important physical processes in a given flow situation are used to ensure that the correct scale is selected for a physical model study (Novak, 1981).

There are lots of hydraulic laboratories in the world and they are developing with large enough hydraulic models to accurate for education and research. They are getting supply with new facilities to make the experiments more close to the real world. And also, there are some standards and technical notes which trying to present the best design criteria.

Corresponding Author: Mohammad Vaghefi, Assist. Professor, Dept. of Civil Engineering, Persian Gulf University, Bushehr, Iran.
E-mail: vaghefi52@gmail.com

The Bureau of Reclamation began testing hydraulic models in 1930 in the laboratory of the Colorado Agricultural Experiment Station in Fort Collins, Colorado. Physical aspects of the laboratory have not changed significantly since the 1940's, but the sophisticated model studies and use of modern data acquisition equipment and instruments have kept pace with the state of the art in hydraulic laboratory practice. The early years of hydraulic model testing were almost exclusively devoted to studies involving adequacy and safety of large structures and appurtenances such as spillways and energy dissipaters. In later years, it was determined that many smaller structures were being overdesigned due to the lack of satisfactory design guidelines. Therefore, an increased effort was focused on developing general design criteria suitable for a wide variety of structures (USBR). Armfield has been designing and supplying open channel facilities to hydraulic laboratories through the world for over 40 years (Armfield, 2004).

Green design country has presented some construction criteria for different concrete channels which is considering where a concrete channel needs to be constructed and its hydraulic design criteria such as: maximum velocity, bed and bank slope and its shape (GCDS, 1999).

Selecting of hydraulic models is one of the most important objectives that should be considered in construction processes (USBR).

Usually channels are of rectangular prismatic section. The dimensions of the working cross-section and length are the principal features which determine both the functional suitability and the cost of a channel. Depending on customer requirements, channels can be designed to incorporate the following alternative features:

- Fixed bed or variable slope
- Open circuit or re-circulating sediment load
- Choice of working section materials (glass, metal, wood).
- Inclusion of a wave generator and beach
- Sediment sampling (Armfield, 2004).

In the present study, a rectangular concrete channel was constructed in the hydraulic laboratory of Urmai University. The channel was constructed with 1m width, 0.6m depth, a 10m straight reach in the upstream and 6m straight reach in the downstream. A 90 degree bend was connecting these two straight reaches. The channel was designed as a fixed bed channel with a lining of Crystal stone by the ability of changing to movable bed. The pump system was recirculation. Various steps of the construction have been summarized in this study. This channel is large enough to investigate hydraulic phenomena and because of its abilities after the construction of the channel, lots of project and educational thesis have started on it. This study presents three different master theses which have been done by this channel.

Steps for Construction of the Channel:

The basic requirements of construction the rectangular channel was as follows:

- Delivery of land and cue points
- Create a temporary network coordinates (Figure 1 shows creation of channel coordinate).

Fig. 1: Creation of a temporary channel coordinates

- Create an accommodation for project factors
- Mapping the positions of executive sites including the Reinforcement scheme, steel works, and painting (Figure 2)..

Fig. 2: Mapping and identifying important points

- Entering needed machinery for the project to the workshop
- Preparation and implementation schedule of the project

After all, the construction process was begun. The implementation of the plan and construction of the channel and its facilities needs a high accuracy. So it should be noted that the base elevation code is precisely synchronized with fixed points, otherwise the channel will not have hydraulic coordinates during the operation. If some conflict occurs, depending on the flow regime, the influence of upstream and downstream can cause to destruction and undesirable changes in the flow characteristics.

Excavation and Destruction Process:

The first step is to create an appropriate floor for construction the channel. After determination the channel location according to longitudinal and transverse profiles, excavation process was started. The main excavation was related to upstream and downstream reservoir. Figure 3 shows a part of excavation works which is related to destruction of downstream reservoir.

(a) (b)

Fig. 3: Excavation works (a) Destruction works (b) Providing necessary depth for the reservoir

Volume of materials which were used in this step including: the amount of 1.57 m^3 destruction of concrete, 1.6 m^3 excavation and foundation and carrying 230 m^3 of concrete soil and mass materials by hands or machines.

Reinforcement Process:

Reinforcement process has been done according to provided list offers. Obviously, all the reinforcements should be free of any oil, waste and corrosive materials. Based on each reinforcement specifications, they were being cut, bent and installed.

Installation of the reinforcements was performed by considering the appropriate distances. Also, covering of the concrete, length of covering and cut overlapping in the correct positions were considered.

Used materials in this phase were including 35.6 Kg of A_2 ribbed bar with 10 mm in diameter for reinforced concrete. 2059.85 Kg of A_3 ribbed bar with 120mm to 180mm in diameter for reinforced concrete. Figure 4 shows channel bed and bank reinforcement.

Fig. 4: Reinforcement process (a) Tightening ribbed bars (b) placing Water stop inside the reinforcements

Formwork Process:

Formwork has been done based on presented procedures in the executive technical reports. Being in a stable form and strength, being clean and smooth their inner surface were controlled. Inner surface of the plates were soaked up with oil to prevent damaging of the concrete during opening the plates and could create a smooth surface. In order to create a smooth curve with maximum precision at the bend reach of the 90 degree bend channel, 1o cm width plates were used for curved reach of the channel. Used materials in this phase were including 170 m^3 of steel plates for formwork of inner and outer straight banks. 13.22 m^3 steel plates used for curved surface formwork. Figure 5 shows formworks related to outer bank of the curved reach of the channel.

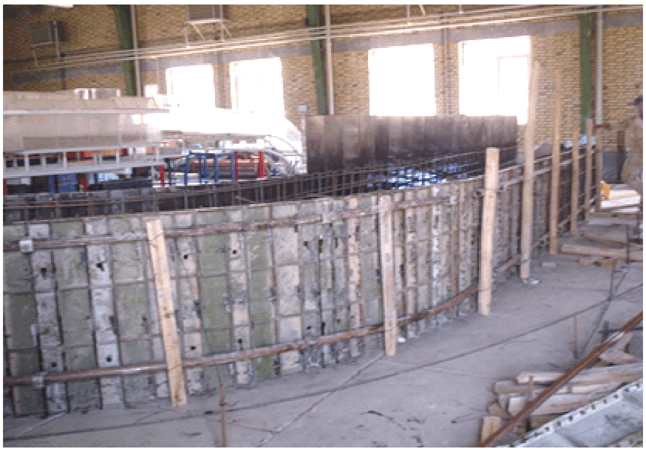

Fig. 5: Formworks of outer bank of bend reach.

Concreting Process:

The main constituent materials of concrete are cement, gravel, sand and water. Preparation of concrete was performed near the channel construction. This caused to prevent the separation of the materials thus a homogeneous mixture were obtained. Vibration of the concrete has been done carefully during the concreting to ensure about exiting of the air in the mixture. Figure 6 shows a sample of vibration phase during concreting which is related to inner bank of the band reach.

After the concreting of the banks and bed were finished, one of the most important steps of concreting was stated. It was maintaining moisture of the concrete to obtain more strength concrete. This step can be done with different methods.

Fig. 6: Vibration the concrete just after falling the concrete.

One of these methods is using water. In this regards to keep humidity of the channel concrete water was used. Thus giving additional moisture with water was used to prevent moisture loss in the concrete. Figure 7 shows photos of concreting steps of inner and outer banks of the channel. The dry concrete needs more moisture.

(a) (b)

Fig. 7: Concreting process (a) Wet concrete (b) Dry concrete.

400 m^3 volume of the concrete)300 kg cement in 1 m^3 concrete(was used for the banks and floor and 19.22 m^3 concrete for spraying to repair some damaged areas of the concrete surface

Stone Work:

After concreting, lining of the inner surface of the channel was started. In this regards, Isfahan crystal stone was used. It should be mentioned that before starting stone work, surveying and finding the elevation of important points of the channel have been done.

Controlling of the exact slope of the channel with high precise could be possible by sureying along the channel during the construction of the channel. Figure 8 shows a part of surveying which is related to finding bed and top walls elevations before stone work.

Fig. 8: Surveying process, (a) Surveying elevation the banks, (b) Surveying bed elevation.

126 m^2 stones were used for lining the bed and the banks of the channel. Figure 9 shows some steps of stone works at the straight reach and at the bend reach of the channel.

Fig. 9: Stone works, (a) Straight reach (b) Curved reach

Construction and Installation of the Gates:

Four sluice gates were constructed and installed along the tunnel, at the outlet of the upstream reservoir, inlet of the channel, entrance of downstream reservoir and outlet of downstream reservoir, respectively. Figure 10 shows the sluice gate of the entrance of the channel as an example.

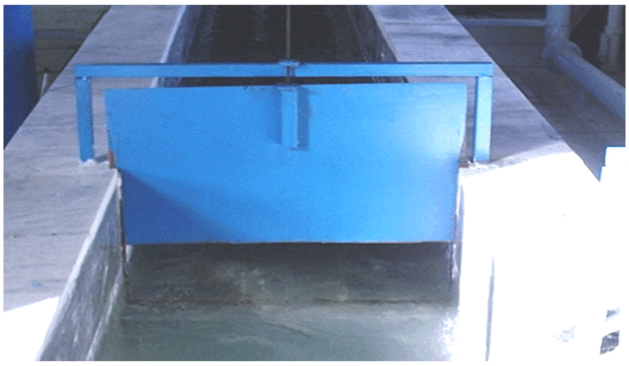

Fig. 10: Sluice gate at entrance of the channel.

229.58 Kg iron with 3mm in thickness has been consumed to construct the gates.

Case Studies on the Channel:

The channel has the capability of performing various types of researches. One of the projects which has been done successfully on this channel was performance of sharp crested weir on the channel bend. The main hypothesis for the uniform distribution of flow across the bend and along the weir crest is the change of the weir crest profile from horizontal to sloping crest. In this regard, this study was testing the performance of sharp crested weir on the channel bend to find the optimum design for the weir crest. The results presented some criteria for best design and also the performance of sloping and horizontal crested weirs were compared. Figure 11, shows photos of experimental setup of this study which has been dons as a master thesis (Abdolahpour, 2010).

Fig. 11: Experimental setup (a) Horizontal crested weir (b) sloping crested weir.

Broad crested weirs and also have been tested on the bendway of the channel and new results have been presented (Valimohammadi, 2010). Prediction of local scour depth below an underwater pipeline in a river crossing was another experimental study which was performing on this channel. The channel design as a movable bed for this study and various bad material sizes was tested (Ataeiyan, 2011).

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