بسم الله الرحمن الرحيم

MONA MAGHRABY

شبكة المعلومات الجامعية

التوثيق الالكتروني والميكروفيلم

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جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

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MONA MAGHRABY

Ain Shams University

Faculty of Engineering

Irrigation and Hydraulics Department

Study of Counteracting the Secondary Flow in Open Channel Bends

A Thesis Submitted in Partial Fulfillment for the Requirements of the Degree of Philosophy Doctorate in Civil Engineering

(Irrigation and Hydraulics Dept. – Civil Engineering)

By

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B.Sc. in Civil Engineering -Public Works Dept.-2007

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STATEMENT

This Thesis is submitted as a partial fulfilment of Degree of Philosophy Doctorate in Civil Engineering (Irrigation and Hydraulics Dept.), Faculty of Engineering, Ain Shams University.

The author carried out the work in this thesis, and no part of it has been submitted for a degree or a qualification at any other Scientific entity.

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……………………

DEDICATION

I would like to dedicate this work to those who suffered to educate, prepare, and help myself to be as I am,

TO

MY FATHER & MY MOTHER

Also, thanks to

MY SISTERS & MY BROTHERS

&

MY MANAGERS AT WORK

For their encouragement and support to complete this work

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ABSTRACT

Name: Shaimaa Said Abdou Aly

Title: Study of Counteracting the Secondary Flow in Open Channel Bends

Institute: Faculty of Engineering, Ain Shams University

Specialty: Irrigation and Hydraulics Department

This thesis comprises of three parts, **part 1** presents the study of the main hydraulic features of flow as super-elevation, velocity distribution, and the secondary flow using Large Eddy Simulation (LES) without any protection for the bed and banks. In this part, a suitable turbulent model is chosen in addition to checking of the capability of this model. The results of a previous laboratory experiments are used to validate the predicted results from the numerical model. **Part 2** aims to study the efficiency of a new protection technique (water screen) to counteract of the secondary flow numerically in addition to choosing the optimum flow ratio for this technique. **Part 3** presents the suitable transverse location of the new technique close/a way the outer bank in the curved open channel.

The results reveal that LES and realizable k-ε turbulent models are capable to predict the main flow characteristics for the curved open channel. The new technique (water screen) can counteract the curvature-induced secondary flow on condition that the induced flow from tube is not less than 20 % of main flow. The position of water screen effect on the secondary circulation cell. The new technique has a negative effect on the outer bank if the distance is increased away the outer bank.

Keywords: bank and bend protection techniques; bank erosion; turbulent model; open channel bend; redistribution velocity; secondary flow.

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Titled

Study of Counteracting the Secondary Flow in Open Channel Bends

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The cost and time of physical experiments motivated the researchers to explore the capability of numerical models in solving complex equations.

In terms of the importance of reducing the influence of the curvature induced circulation secondary flow on the bed and banks, investigation of the turbulent are become essential.

This thesis comprises from three parts as follows:

1. **Part 1**: Studying of the main hydraulic features of a curved open channel without protection technique.
2. **Part 2**: Studying of the efficiency of the new protection technique (water screen) besides choosing the optimum flow ratio for this technique.

3. **Part 3**: Assessing the suitable transverse location a way/close of the outer bank for the water screen in the curved open channel.

To conduct this study, several simulations are applied on a curved open channel and validated of the predicted results with the measured results from K. Blanckaert's experiment (Q89).

Regarding Part 1, The results of this part revealed that the used turbulent model can predict velocity distribution and visualizing of the secondary flow circulation cells. The predicted results have a good agreement with K. Blanckaert's experiment (Q89).

Regarding Part 2, The results revealed that the new technique (water screen) can counteract the curvature-induced secondary flow on provided that the induced flow from tube is not less than 20 % of main flow.

In this part, a new empirical formula is developed to calculate the velocity reduction near the outer bank by flow ratio.

$$\Delta \mathbf{V}\ (\%) = \mathbf{16.4}\left(\frac{\mathbf{Q_{Jet}}}{\mathbf{Q_{Channel\ inlet}}}\right)^{\mathbf{0.423}}$$

Regarding Part 3, The results revealed that the position of the new protection technique effect on the secondary circulation cell and the new technique have a negative effect on the outer bank if the distance are increased away the outer bank.

In this part, a new empirical formula is developed to calculate the velocity reduction near the outer bank by distance ratio.

$$\Delta \mathbf{V}\ (\%) = -\mathbf{0.150}\left(\frac{\mathbf{X}}{\mathbf{B}}\right)^{\mathbf{2}} + \mathbf{1.44}\left(\frac{\mathbf{X}}{\mathbf{B}}\right) + \mathbf{75.55}$$

Table of Contents

List of Figures