Available online at www.sciencedirect.com
ScienceDirect
Journal of Hydrodynamics
2011,23(4):527-534
DOI: 10.1016/S1001-6058(10)60146-1
www.sciencedirect.com/science/journal/10016058

SOME NEW DATA AND FORMULAS FOR RESISTANCE FLOW IN FLUVIAL OPEN CHANNELS*

YANG Sheng-fa, HU Jiang
Department of River and Ocean, Chongqing Jiaotong University, Chongqing 400074, China,
E-mail: ysf777@163.com
LI Dan-xun, WANG Xing-kui
State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Beijing 100084, China
GUO Yakun
School of Engineering, University of Aberdeen, Aberdeen, AB24 3UE, UK

(Received July 16, 2009, Revised June 15, 2011)

Abstract: Flow resistance in fluvial open channels, especially in steep gravel-bed channels, still presents challenges to researchers and engineers. This article presents some new data from both the flume experiments and field measurements. Data analysis using the divided hydraulic radius approach shows that the relative roughness plays a significant role in the bed form resistance. A new set of formulas that incorporate the relative roughness are proposed. As compared with several existing formulas, the proposed formulas can be used to better estimate the bed form resistance.

Key words: open channel flow, flow resistance, relative roughness, steep gravel-bed, flume experiments, field measurements

Introduction

An accurate prediction of the water stage is of great importance for hydraulic design and flood forecast. In natural rivers, the water stage at a station is influenced jointly by the flow discharge, the energy slope, the geometry of the channel, and the configuration of the river bed. At stable river reaches, the flow discharge and the energy slope are closely correlated following a relatively fixed pattern, as can be fairly understood. Therefore, the accurate prediction of the water stage for any incoming flow discharge largely depends on the estimation of the flow resistance of the channel.

The research on flow resistance dates back a long time. The classical experiments of Nikuradse reveal a relationship between the resistance coefficient and the Reynolds number[1]. In fluvial open channel flows, the bed resistance is complicated due to the presence of various bed forms, such as vegetation, ripples, dunes, and anti-dunes. Recently, many studies were carried out to understand the flow resistance caused by unsubmerged and submerged vegetation[2-7]. The flow resistance changes with the development of bed forms[1,8]. The overall bed resistance consists of two components: the resistance due to the skin friction and the resistance due to the form drag. Thus, one possible approach to better understand the overall bed resistance is to separately investigate these two components. Einstein and Barbarossa[9], among others, pioneered the separate study of the two resistances by using the divided hydraulic radius approach. Following this approach, for example, Shen proposed an equation with the parameter $\omega D / \nu$ [10].

Similar to the divided hydraulic radius approach, the divided energy slope approach assumes that the total energy slope can be separated into two components related to the grain friction and the bed form resistance, respectively. Along this line, Yang et al.[11] presented a set of empirical formulas for calculating flow resistance. In their analysis, the equivalent roughness size was taken as 2-D without full justifica-

* Project supported by the National Natural Science Foundation of China (Grant No. 50779082), the National Basic Research Program of China (973 Program, Grant No. 2007CB407202).
Biography: YANG Sheng-fa (1970-), Male, Ph. D., Professor