FLOOD-FLOW CHARACTERISTICS OF EQUATORIAL NATURAL RIVERS IN SARAWAK, MALAYSIA

Sai Hin Lai[1], Nabil Bessaih[2], Puong Ling Law[2], Nor Azazi bin Zakaria[1], Aminuddin bin Ghani[1] and Yau Seng Mah[2]

[1]River Engineering and Urban Drainage Research Centre (REDAC), Universiti Sains Malaysia,

14300 USM, Nibong Tebal, Pulau Pinang

[2]Department of Civil Engineering, Faculty of Engineering, Universiti Malaysia Sarawak, 94300 UNIMAS, Kuching, Sarawak

E-mail: redaclai@eng.usm.my[1]

ABSTRACT

A study on two natural rivers during flood events located in the outskirt of Kuching city, Sarawak is carried out. This paper presents the results obtained from the field measurements, including velocity distributions, stage discharge relationships, roughness behaviours and discharge estimation. These have illustrated a large difference in velocity between the main channel and floodplain under flood conditions, and the effects of momentum transfer between deep and shallow flow, which include reduction in main channel velocity and discharge capacity, leading to a reduction in compound section capacity at depth above bankfull. Another significant characteristic for flow in natural rivers is that the floodplain regions are found to behave as a storage reservoir instead of conveying excess water. Flow resistance relationships have been presented in terms of Manning's coefficient and Darcy-Weisbach friction factor, showing the complex nature of flow resistance in flooded natural rivers and further explaining the danger inherent in the conventional practices of extrapolating inbank data for the analysis of overbank flows. Results for discharge estimation have been shown for comparison with actual data, the errors incurred by applying empirical methods to compound channel flows have been quantified and found to depend on the particular method used.

Keywords: *Discharge Estimation, Flow Resistance, Natural River, Overbank Flow, Velocity Distribution*

1.0 INTRODUCTION

A large number of hydro-engineering problems are related to open flow in compound channels. An understanding of flow in compound channels or natural rivers with floodplains is essential in practical problems of flood mitigation and floodplain management. It is therefore important for flow simulation to be correct not only on the water surface elevation, but also the sectional discharge and velocity distribution, during the event of overbank flows. Unfortunately, most of the studies that have been carried out are based on idealised experimental laboratory investigations. Field study is rare, partly because compound channel flow conditions occur typically under flood conditions when acquisition of data is difficult and sometimes dangerous. In the work presented, an attempt was made to focus on natural rivers under flood conditions.

2.0 THEORETICAL CONSIDERATIONS

In open channel flow prediction, it is usually assumed that the flow is parallel and has a uniform velocity distribution (steady-uniform flow) and that the slope of the channel is small. Under such conditions, the convection acceleration is zero, and the streamlines are straight and parallel. Since velocity does not change, the velocity head will be constant; therefore, the energy grade line and water surface will have the same slope as the channel bottom. Based on the above assumptions, a series of empirical methods of discharge estimation in open channels and rivers have been developed. The simplest of these are uniform flow equations attributed to Chezy and Manning, with parallel development in pipe flow leading to the Darcy-Weisbach equation. The uniform equations may be written as follow:

The Chezy equation gives

$$V = C(RS_o)^{1/2} \tag{1}$$

The Manning equation gives

$$V = (R^{2/3}S_o^{1/2}) / n \tag{2}$$

The Darcy-Weisbach equation for channel flow gives

$$V = [(8gRS_o) / f]^{1/2} \tag{3}$$

where V is the average cross-sectional velocity, R is the hydraulic radius $= A/P$, A is the cross sectional area, P is the wetted perimeter, S_o is the bed slope, g is gravitational acceleration, C is the Chezy roughness coefficient, n is the Manning roughness coefficient and f is the Darcy-Weisbach friction factor [1].

In analysing the flow through open channels of regular sectional shape and hydraulic roughness, it is sufficient, in general, to use the overall hydraulic radius as the parameter, which characterises the properties of the cross section. It is then possible to calculate the discharge through the channel from one of a range of well-known uniform flow formulas in term of the channel roughness, slope and depth as given above.

However, if the cross-sectional shape is irregular, this could lead to considerable errors. One particularly important example of this occurs on the occasion of a compound section consisting of a deep main channel with associated shallow floodplains. In this case, a sudden change of depth would happen at the transition between the main channel and the floodplain. Moreover, the hydraulic roughness of the floodplain is often greater than that of the main channel. The combined effects of the greater depth of flow and smaller hydraulic roughness of the main channel can lead to significantly higher velocity than those occurring on the floodplain. This velocity difference inevitably results in a lateral mass and momentum transfer mechanism, which can greatly reduce the channel discharge capacity.