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Dimensional analysis of bar formation in sand bed channel

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Abstract

Bars are important features in stream channel processes as they determine the flow and transport pattern. Many experimental works and field studies have been carried out which provides more information on this phenomenon. Several formulae are theoretically and empirically proposed for the bar height determination. Based on these considerations, a new relationship was developed which has considered two major groups of parameters namely, hydraulic characteristics and sediment characteristics. Establishment of the independent variables was carried out using dimensional analysis approach.

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Keywords: bar height formation; dimensional analysis; empirical formulae; hydraulic characteristics; sediment characteristics

1. Introduction

There are three types of alluvial rivers. Straight alluvial rivers occur at the upstream zone, meandering features in the middle zone and braiding commonly develop at the downstream zone. Urbanization and migration of the population centered at the middle zone because of the abundant nutrients rich land and flat terrain. Demand for economic and social development coupled with the rapid increase of the urbanization had eventually developed flood problems in many areas because of the massive erosion and sedimentation along rivers. Mitigating measures have induced straightening and deepening of these rivers which have substantially resulted in the emergence of alternate

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bars, destabilization of channel and had induced side bank erosion as shown in Figure 1 [1; 2]. [3] stated that alternate bars are often observed in channelized alluvial streams at lower stages of flow.

Fig. 1. Alternate bars in Japan (after Ikeda, 1984)

Generally, the aim of this study is to identify the bar formation in terms of bar height. This can be investigated by carrying out an experimental work with varying flow rate and channel size. The objective of this paper was to establish the selected parameters that contribute to the development of channel bar and to evaluate their significance.

2. Bar formation prediction and governing equations

Previous experimental works and field studies covered a wide range of hydraulic variables in determining bar height. It is often an uphill task to select the most suitable method required with an appropriate consideration factor which is important to establish the bar height formation.

[1] proposed empirical formulas on the basis of dimensionless analysis, using data obtained from previous studies. He included variables, namely Froude number, dimensionless shear stress, Reynolds number, width to depth ratio, $\frac{B}{D}$ and width to grains size, $\frac{B}{d_s}$ to determine bar height. Figure 2 shows the definition of bar height H_B and depth of scour from the reach average bed surface, η_B, determined at a point to the lowest depression in a bar unit. In relation to the maximum bar height, H_B is defined as the difference in elevation between the highest and the lowest point in a bar unit.

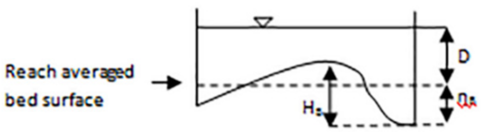

Fig. 2. Sketch of Bar Height and Depth of Scour (Ikeda, 1984)

[2] undertook an experimental study in the same year to investigate the formation and behaviour of alternate bars. The aim of investigation was to establish a criterion that would enable assessment of the possibility of alternate bar formation for certain channel geometry and bed material. The experiment found that total height of alternate bars only varied with grain size, d_s. Therefore, the parameter of width to mean grains size ratio, $\left(\frac{B}{d_s}\right)^{0.15}$, described the