Development of a new bedform predictor

To maintain the function of rivers such as irrigation, drinking water supply, navigation and to protect against flooding, it is of great importance to gain more insights in the behaviour of rivers. An element of central interest in the behaviour of rivers are bedforms, especially dunes on the bottom of these rivers. Due to flow separation and associated energy dissipation, dunes form the main source for hydraulic roughness on the riverbed. The roughness in turn, is a key element in predicting flow conditions and corresponding water levels. The generally non-uniform unsteady flow in rivers causes occurrence of different types of bedforms with varying hydraulic roughness. This research only considered ripples, dunes, washed-out dunes and upper stage plane bed bedform types.

A large number of bedform predictors have been developed for estimating the dimensions of these bedforms. The predictors of Allen (1978), Van Rijn, (1984), Julien and Klaassen (1995), Karim (1995) and more researchers, relate dune dimensions to sediment transport capability. However, none of these bedform predictors explicitly relates free surface effects in combination with the sediment transport mode to dimensions of dunes. As a result, these predictors encounter difficulties in making suitable estimations of dune dimensions and occurrence of upper stage plane beds under relatively low Froude and high Suspension numbers in large rivers as they are mainly based on flume experiments (Naqshband, 2014).

With the use of 861 measurements consisting of 300 flume measurements and 561 field measurements, two new empirical based bedform predictors for bedform height and length of ripples, dunes and washed-out dunes, considering free surface effects in combination with the sediment transport mode were developed. The newly developed bedform height predictor (eq. 1 and fig. 1), was found to obtain good estimations for especially dune heights compared to existing bedform predictors. The newly developed bedform length predictor (eq. 2 and fig. 2), was found to estimate bedform lengths of ripples, dunes and washed-out dunes rather poorly. For dune height and washed-out dune height and length predictions it is important to address free surface effects in combination with the sediment transport mode.

$$\frac{H}{d} * \left(\frac{d}{D_{50}}\right)^{0,3} = 17.70 * \left(1 - e^{-0.405 * F_r * \frac{u_*}{w_s}}\right)\left(1.244 - F_r * \frac{u_*}{w_s}\right) \qquad (1)$$

$$\frac{\lambda}{d} * D^{*-1} = \quad 3.333 * F_r * \frac{u_*}{w_s} \ - 0.225 \quad (2)$$

Ripple dimensions are not necessarily linked to free surface effects in combination with the sediment transport mode and washed-out dunes behave differently in the transition to upper stage plane bed compared to dunes. Therefore, it is concluded that these bedform types cannot be treated the same in predicting bedform dimensions.

Figure 1: Bedform Height of different bedforms

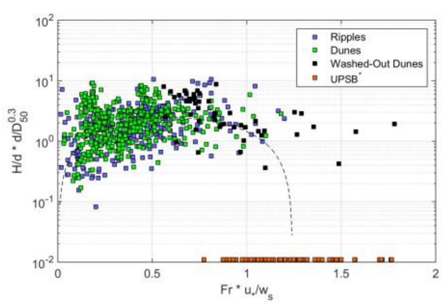
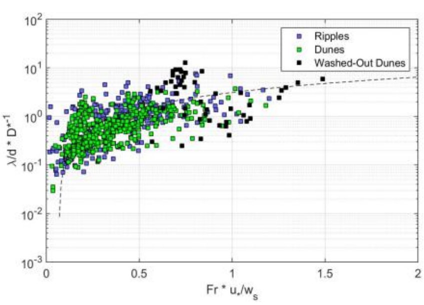


Figure 2: Bedform length of different bedforms



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