Bed-Load Sampling in Sand-Bed Rivers

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Abstract: Bed-load sampling in sand-bed rivers was studied. A mechanical sampler called the Delft Nile sampler was designed and operated in flume and field conditions. The flume data obtained for different bed material sizes in the range of 280–1,070 μm were used to determine the sampling efficiency factor of the bed-load sampler. The sampling efficiency factor was found to be about 1.0 for bed material sizes larger than about 400 μm and about 1.5 for finer bed material sizes. Field measurements in the Nile river (Egypt) and in the Rhine river (The Netherlands) were taken to determine the proper number of samples to be taken in a cross section in relation to the errors involved. The bed-load sampler was equipped with an underwater video camera to facilitate visual observations of the bed-load sampling process. Based on the visual observations, five types of bed-load samplings were distinguished and a computation method was proposed to determine the proper mean bed-load transport rate from the collected samples at a certain sampling station. The error of the mean transport rate in a sampling station was determined as a function of the number of samples. The samples should be taken at different locations along a bed form (dune). Finally, the overall error of the cross-section integrated bed-load transport rate was determined as a function of the number of samples in a sampling station and the number of sampling stations in a cross section.

INTRODUCTION

Bed-load sampling in rivers is rather complicated, especially in conditions with combined bed-load and suspended-load transport. Considerable attention has been given to bed-load sampling in gravel-bed rivers (Einstein 1937; Hubbell 1964; Helley and Smith 1971; Emmett 1980; Hubbell et al. 1985; Carey 1985). In this paper, the sampling process in sand-bed rivers with combined bed-load and suspended-load transport is studied. The emphasis is herein laid on the bed-load transport process.

Bed-load transport is defined as the movement of bed material particles by sliding, rolling, and jumping along the bed (Bagnold 1966, Van Rijn 1984). In the lower transport regime these types of motions manifest themselves in the form of mini ripples (height of 0.01–0.05 m; length of 0.1–0.5 m) migrating over the upper side of larger-scale dunes. In the upper transport regime, with plane bed conditions, the bed-load transport process shows a sheet flow behavior, with a thickness on the order of 0.01–0.03 m. The accuracy of the bed-load transport measured by use of a mechanical sampler depends on its sampling efficiency (instrumental errors), on the sampling location with respect to the bed-form geometry (spatial variability) and on the near-bed turbulence structure (temporal variability). A detailed discussion was given by Van Rijn and Gaweesh (1992) and Gaweesh and Van Rijn (1992).

Typical sampling problems related to the instrumental design (sampler geometry) are: (1) The initial effect (disturbance of bed material when the sampler touches the bed); (2) the gap effect (space between sampler nozzle

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