The impact of stress history on bed structure

Ockelford, A.M. and Haynes, H.

Recent research has started to focus on how prolonged periods of sub-threshold flows may be capable of imparting structural changes that contribute to increased bed stability. To date, this effect (termed 'stress history') has been found to be significant in acting to increase a bed's critical shear stress at entrainment threshold. However, it is supported by only limited, qualitative and often speculative information on the mechanisms of this stabilization process in grade-specific studies. As such, this paper uses high resolution laser scanning to quantitatively ascertain the granular mechanics underpinning the relationship between stress history and entrainment threshold for beds of a range of grain size distributions. Employing a bed slope of 1/200, three grain size distributions with median grain sizes (D_{50}) of 4·8 mm [uniform ($\sigma g = (D_{84}/D_{16})0.5 = 1{\cdot}13$; bimodal ($\sigma_g = 2{\cdot}08$); and, unimodal ($\sigma_g = 1{\cdot}63$)] were exposed to antecedent stress histories of 60 and 960 minutes duration. Antecedent shear stress magnitude was set at 50% of the critical shear stress for the D_{50} when no stress history period was employed. Two laser displacement scans of the bed surface (approximate area 100 mm × 117 mm) were taken, one prior to the antecedent period and one after this period, so that changes to surface topography could be quantified (resolution of x = 0·10 mm, y = 0·13 mm and z = 0·24 mm). Rearrangement of bed surface structure is described using statistical analysis and two-dimensional (2D) semi-variograms to analyse scaling behaviour. Results reveal vertical settlement, changes to bed roughness and particle repositioning. However, the bed grain size distribution influences the relative importance of each mechanism in determining stress history induced bed stability; this is the focus of discussion in this paper.

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