Bedform Morphology Under Combined Flows

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Combined flow, which commonly refers to a combination of unidirectional and wave-induced oscillatory flow,is omnipresent in natural environments and generates a range of bedforms on sandy bottoms.However,few experimental studies have focused on the relationship between the morphology and flow conditions of combined-flows.Arnott & Southard(1990), Dumas et al.(2005) and Takagawa(2009) examined relatively long(>8sec) oscillatory periods, while Yokokawa(1995) and Sekiguchi & Yokokawa(2008) examined shorter period(<2sec) waves. There is thus a wide range of unexplored conditions for such bedforms, especially with intermediate oscillatory periods. Recently, Perillo et al.2009) reported examples with 5sec period and in the present paper we describe one set of conditions for a 4 & 6sec period.Experiments were conducted using the Large Oscillatory Water-Sediment Tunnel(LOWST) in the Univ. of Illinois, which has a test section 12.5 m long, 0.8 m wide and 1.2 m high. Half of the tunnel height was filled with uniform 250μm diameter sand. The oscillatory velocity was fixed at 25 cm/sec, whilst the superimposed unidirectional velocities,Uu,were varied between 0 & 40 cm/sec.Longitudinal one-beam sonar data was obtained every 30 sec to measure the bed morphology and its spatio-temporal development.In these conditions, distinctive bedform types were observed:2D Ripples,3D Symmetric Small Ripples(SSR), Asymmetric Small Ripples(ASR),Asymmetric Large Ripples(ALR) with rounded crests, and dune-like ALR. Short descriptions of each bedform are;2D Ripples: symmetrical, straight-crested ripples with sharp crests, with wavelength(λ) of about 20-30cm.3D-SSR: nearly symmetric ripples with sharp crests but whose crestlines were discontinuous.ASR: asymmetric ripples with λ of about 15cm, discontinuous crestlines.ALR with rounded crests:Asymmetric current-affected ripples with rounded crests,λ of about 20-30 cm. Dune-like ALR:Asymmetric bedforms with a λ of about 60 cm. From these results, we recognize three boundaries in the combined flow "phase diagram": a)2D to 3D between Uu= 5 & 10 cm/s for 6sec and Uu= 10 & 20 cm/s for 4sec ,b) symmetrical to asymmetrical ripples at Uu= 10 and 20 cm/ s for both 6 sec and 4sec, and c)a bedform size boundary, between small and large ripples, at Uu = 20 & 30 cm/s for both 6 & 4sec.We will show how, compared with the previous studies, the present experiments appear to show an effect of oscillation period on the boundaries of the bedform phase-diagram.