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Laboratory experiments on fine sediments erosion and deposition in an alternate bar system and its impact on bar morphodynamics
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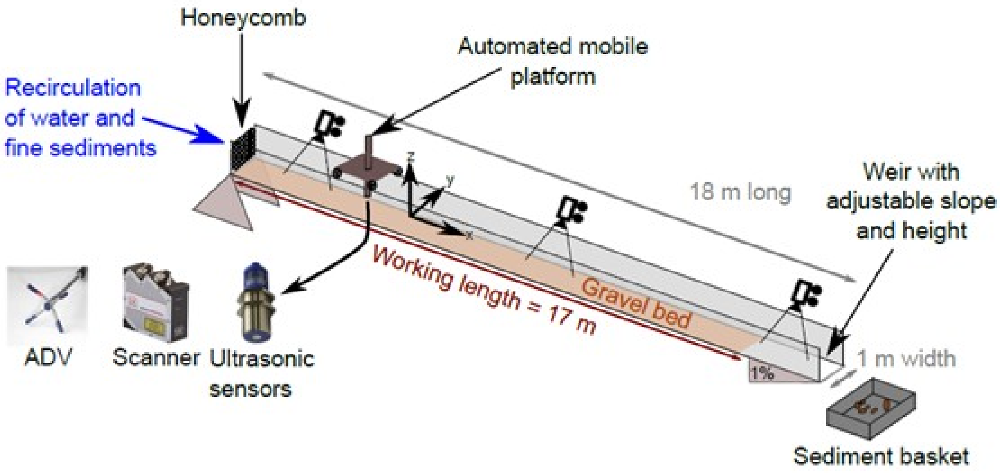
Alternate bars manifest as wave-like patterns in which the crest and trough alternate between the opposing riverbanks. They often appear in rivers largely constrained by embankments and characterized by a significant sediment input. Thewavelengths of these bars typically correspond to several times the river's width, while their heights are proportional to the water depth, although variations occur depending on the mobility of the bars. Forced alternate bars represent a specific category of alternate bars characterized by their stationary nature, originating from distortions in the bank line geometry, such as river bends or bridge piers within the river's cross-section. These bars can effectively trap fine sediments (clay, silt, and sand). The accumulation of these fine sediments contributes to gravel bar aggradation and fosters the development of riparian vegetation. This evolution can potentially increase flood risk in the medium to long term.
In this context, the current study is focused on elucidating the impact of unsteady flows and fine sediment infiltration, particularly silt, within a forced alternate gravel system. This understanding is pursued through a series of laboratory experiments conducted in an 18m long and 70 cm wide flume. As a first step, we established a reference case where forced alternate gravel bars were created under steady flow conditions. These bars were formed through successive cycles of transport, erosion, and sedimentation until equilibrium. Subsequently, in the second step, forced alternate bars were developed while introducing suspended fine sediments under steady flow conditions. The patterns of fine sediment infiltration observed within the forced alternate bars indicated that the tail end of the bars displayed a relatively higher level of clogging when compared to the bar heads and the central region of the bars. These findings are in agreement with observation of the patterns of fine sediment infiltration in the Arc and Isère rivers. Moreover, the forced alternate gravel bars developed in the presence of fine sediments display significant distinctions from the reference case in the majority of the experiments conducted, indicating a potential impact of their stability. Furthermore, we extended our investigation to examine the impact of the initial bed slope on the development of forced alternate gravel bars, both with and without the presence of suspended fine sediments, in comparison to our reference case. Additionally, we compared the geometric characteristics of the developed forced alternate bars, with and without fine sediments, to two existing theoretical models of forced bars found in the literature. This comparison highlighted the limitations of these models and the complexity of the phenomena.
In the third step, we conducted unsteady flow experiments, both with and without fine sediments. These experiments were designed to investigate various aspects, including the impact of unsteady flow on the dynamics and formation of forced alternate gravel bars; the potential influence of the initial bed topography on the formation of forced alternate bars; the effects of two successive flood events on the forced alternate gravel bar system, among other factors. Specifically, in the unsteady flow experiment conducted over the reference case, where a constant gravel supply rate was maintained throughout the experiment, our findings indicated that the first forced gravel bar became flatter and shorter, and the second forced bar vanished as the water discharge approached

its peak. Subsequently, during the falling limb of the hydrograph, the two forced alternate gravel bars redeveloped, each with different shapes.



Experimental facility