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Experimental study of the free surface velocity field in an asymmetrical confluence

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The hydrodynamic behavior of open channel confluences is highly complex because of the combination of different processes that interact with each other. To gain further insights in how the velocity uniformization between the upstream channels and the downstream channel is proceeding, experiments are performed in a large scale 90 degree angled concrete confluence flume with a chamfered rectangular cross-section and a width of 0.98m. The dimensions and lay-out of the flume are representative for a prototype scale confluence in e.g. drainage and irrigation systems. In this type of engineered channels with sharp corners the separation zone is very large and thus the velocity difference between the most contracted section and the separation zone is pronounced. With the help of surface particle tracking velocimetry the velocity field is recorded from upstream of the confluence to a significant distance downstream of the confluence. The resulting data allow to analyze the evolution of the incoming flows (with a developed velocity profile) that interact with the stagnation zone and each other, causing a shear layer between the two bulk flows. Close observation of the velocity field near the stagnation zone shows that there are actually two shear layers in the vicinity of the upstream corner. Furthermore, the data reveals that the shear layer observed more downstream between the two incoming flows is actually one of the two shear layers next to the stagnation zone that continues, while the other shear layer ceases to exist. The extensive measurement domain also allows to study the shear layer between the contracted section and the separation zone. The shear layers of the stagnation zone between the incoming flows and the one between the contracted flow and separation zone are localized and parameters such as the maximum gradient, velocity difference and width of the shear layer are calculated. Analysis of these data shows that the shear layer between the incoming flows disappears quite quickly, because of the severe flow contraction that aids the flow uniformization. This is also accelerated because of a flow redistribution process that starts already upstream of the confluence, resulting in a lower than expected velocity difference over the shear layer between the bulk of the incoming flows. In contrast, the shear layer between the contracted section and the separation zone proves to be of a significantly higher order of magnitude, with large turbulent structures appearing that get transported far downstream. In conclusion, the resulting understanding of this analysis of velocity fields with a larger field of view shows that when analyzing confluence hydrodynamics, one should pay ample attention to analyze data far enough up and downstream to assess all the relevant processes.