Sediment feeding effects on the bed morphology in channel confluences

Sebastián Guillén[1,2], Mário J. Franca[2], Anton J. Schleiss[2], António H. Cardoso[1]

[1]CEHIDRO, Instituto Superior Técnico, Avenida Rovisco Pais, Lisboa, Portugal
[2]Laboratory of Hydraulic Constructions (LCH), Ecole polytechnique fédérale de Lausanne (EPFL), Station 18, 1015 Lausanne, Switzerland

Phone: +351 218 418 148
E-mail: sebastian.ludena@ist.utl.pt

Introduction: Within the fluvial network, confluences with low discharge and momentum ratios, where a small steep tributary with a unit high bed load joins a large low-gradient main channel with considerably weaker unit bed load, are commonly observed in nature. Leite Ribeiro et al. (2012) carried out a set of experimental tests to study the morphodynamics of this kind of confluences, supplying sediment only in the tributary and only with clear water fed to the main channel. As a continuation of that work, the purpose of this paper is to analyze the effects of the sediment feeding into the main channel on the bed morphology at equilibrium, by comparing the results obtained by Leite Ribeiro et al (2012) with those obtained from a new set of tests carried out in the same laboratory confluence but with sediment feeding in both channels.

Methods: For this purpose three experimental tests were carried out in the same 8.5 m long and 0.5 m wide laboratory flume used by Leite Ribeiro et al (2012). As a tributary, a 4.9 m long and 0.15 m wide PVC channel was used. The confluence angle was kept the same (• = 90º) (see Figure 1).

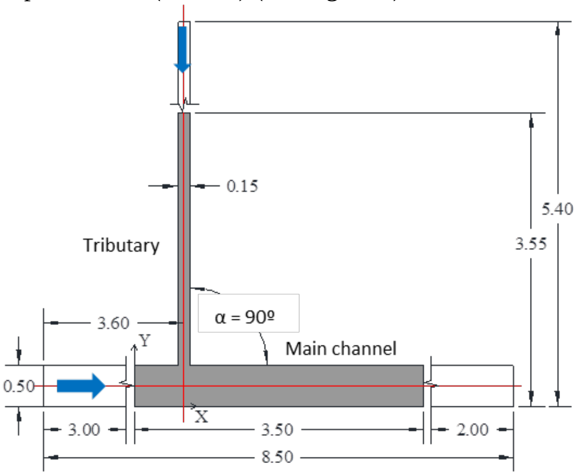

Figure 1. Plan view of the laboratory confluence.

Channel dimensions and discharge ratio ($Q_r = Q_t/Q_m$) were kept identical to Leite Ribeiro et al. (2012). Nevertheless, the total discharge at the post confluence ($Q_{p\text{-}c}$) was increased up to 30 l/s to ensure sediment transport capacity in the main channel. That increase of the $Q_{p\text{-}c}$ led, in turn, to a decrease of the momentum ratio ($M_r = M_t / M_m$) in comparison to the tests of Leite Ribeiro et al. (2012) (see Table 1).

Table 1: Tested scenarios. Q_t, Q_m, Q_r, M_t, M_m, M_r, are tributary, main channel discharge, discharge ratio, tributary, main channel momentum and momentum ratio respectively.

Test nº	Q_t	Q_m	$Q_{p\text{-}c}$	$\mathbf{Q_r}$	M_t	M_m	$\mathbf{M_r = M_t / M_m}$
	[l/s]	[l/s]	[l/s]	**[-]**	[N]	[N]	**[-]**
1	3.0	27.0	30.0	**0.11**	2.15	13.38	**0.16**
2	3.9	26.1	30.0	**0.15**	2.80	12.98	**0.22**
3	5.6	24.4	30.0	**0.23**	4.00	11.03	**0.36**
Leite Ribeiro (2012)	2.0	18.0	20.0	**0.11**	1.33	5.94	**0.22**
	2.6	17.4	20.0	**0.15**	1.73	5.66	**0.31**
	3.7	16.3	20.0	**0.23**	2.28	5.01	**0.46**

During the tests, sand (0-4 mm d_{65} =1.4 mm) and a mixture of 80% of sand (0-4 mm d_{65} = 1.4 mm) and 20% of gravel (4-8 mm d_{65} =2.3 mm) were supplied to the main channel and to the tributary, respectively, by means of independent sediment feeders with constant sediment rates, 0.5 and 0.3 kg/min for the tributary and main-channel respectively.

Each test was run until equilibrium, i.e. when the solid discharge measured at the outlet was equal or larger than 90% of the sediment fed. Systematical surveys of bed topography and water level were performed during the tests, allowing the verification of the equilibrium state.

Bed topography, water level, bed surface grain size distribution and velocities were measured during the tests and when equilibrium was reached.

Results: By comparing the results from the performed tests with those obtained by Leite Ribeiro et al (2012), the main striking difference lies in the presence of erosion at the tributary mouth and along the outer bank of the main channel, not verified previously. Modification in the shape and size of such morphological features as the deposition bar and bed tributary penetration into the main channel, due to the different total discharge at the post-confluence, were also observed.

Acknowledgement: This research is developed within the framework of the Joint Doctoral Initiative IST-EPFL. funded by FCT and LCH/EPFL.

References: [1] Leite Ribeiro M., Blanckaert K., Roy A.G., Schleiss A.J. (2012). Flow and sediment dynamics in channel confluences. *J Geophysical Research: Earth Surface* **107 (F1)**:1-19