CHANSON, H. (2013). "Propagation of surge waves in channels with large-scale bank roughness." *Journal of Hydraulic Research*, IAHR, Vol. 51, No. 6, pp. 740-742 (DOI: 10.1080/00221686.2013.863229) (ISSN 0022-1686).

Propagation of Surge Waves in Channels with Large-Scale Bank Roughness. Discussion

Hubert CHANSON (IAHR Member), School of Civil Engineering, The University of Queensland, Brisbane, Australia

Email: h.chanson@uq.edu.au (Corresponding Author)

Full correspondence details:

The University of Queensland, School of Civil Engineering,

Brisbane QLD 4072, Australia

Tel.: (61 7) 3365 3516 - Fax: (61 7) 3365 45 99,

Email: h.chanson@uq.edu.au

CHANSON, H. (2013). "Propagation of surge waves in channels with large-scale bank roughness." *Journal of Hydraulic Research*, IAHR, Vol. 51, No. 6, pp. 740-742 (DOI: 10.1080/00221686.2013.863229) (ISSN 0022-1686).

Propagation of Surge Waves in Channels with Large-Scale Bank Roughness. Discussion

In open channels, a sudden rise in water elevation generates a positive surge. Positive surges are commonly observed in man-made channels (Bazin 1865, Treske 1994) and a natural occurrence is the tidal bore in macro-tidal estuaries (Tricker 1965, Chanson 2011a). The positive surge may propagate upstream or downstream (Fig. 1). It is a rapidly-varied flow and the flow properties immediately upstream and downstream of the front must satisfy the continuity and momentum principles (Rouse 1938, Liggett 1994). The authors investigated positive surge waves in a long channel with a range of sidewall configuration. Their configuration corresponded to a downstream surge configuration (Fig. 1, Right). The contribution is a welcome addition to the literature on rapidly-varied unsteady open channel flows. In this discussion, it is shown that the effects of boundary friction were previously documented, and a recent investigation provided some insight into the energy dissipation induced by large-scale sidewall roughness.

The shape of a positive surge is closely linked with its Froude number F_s, defined as: $F_s = (V_w+U_1)/(gh_1)^{1/2}$ and $F_s = (V_w-U_1)/(gh_1)^{1/2}$ for a surge propagating upstream and downstream respectively in a rectangular prismatic channel, where V_w is the surge celerity, U_1 is the initial flow velocity, g is the gravity acceleration and h_1 is the initial flow depth (Henderson 1966, Liggett 1994). When the surge Froude number is between unity and 1.4 to 1.6, the surge front is smooth and followed by a train of secondary undulations: that is the undular surge (Treske 1994). For larger Froude numbers, a breaking bore is observed with a marked roller extending across the whole channel width (Koch and Chanson 2009). The effects of boundary roughness on positive surges were tested in laboratory channels (Chanson 2010, Docherty and Chanson 2012). The undular surge data exhibited some wave amplitude attenuation trend close the theoretical development of Ippen and Kulin (1957), while the wave period and wave length data compared favourably with the wave dispersion theory for gravity waves un intermediate water depths (Dingemans 1997). Detailed velocity measurements showed the significant impact of bed roughness on the unsteady flow motion (Chanson 2010, Docherty and Chanson 2012). The bed roughness induced an attenuation of the undular free-surface effect on the velocity field in an undular surge. In a breaking surge, the bottom rugosity enhanced the transient recirculation motion next to the bed beneath and behind the roller during the front passage.

The effect of sidewall macro-roughness was tested on undular surges with a rapid constriction and expansion ($\Delta B/B = 0.235$, $L_c/B = 1.52$) (Chanson 2011b). The undular surge lost up to one third of its potential energy per unit area as the result of form drag generated by the constriction/expansion, including the generation of large scale surface scars after the sidewall expansion (Fig. 2). Figure 2 illustrates some surface scars associated with the propagation of a positive surge past an abrupt expansion. The regular sidewall macro-roughness investigated by the authors may be regarded as a succession of rapid constriction/expansion, and the above observations would predict a decay in wave height with increasing distance consistent with the authors' report. Detailed velocity measurements (Chanson 2011b) showed further the existence of energetic turbulent events behind the surge after it passed the constriction/expansion

section. These events appeared to be some kind of macro-turbulence advected behind the surge front. Recent CFD modelling showed indeed the production of large-scale vortices beneath a positive surge front and their upstream advection (Furuyama and Chanson 2010, Lubin et al. 2010). Evidences of advected macro-turbulence were also reported in natural channels (Chen 2003, Wolanski et al. 2004, Chanson et al. 2011).

In summary there is some existing literature on the effects of boundary friction and sidewall macro-roughness on positive surges, including in terms of the instantaneous velocity field. It is hoped that the present discussion will guide future researchers to the fairly broad range of relevant studies. Some more detailed comparative analyses between the literature and the authors' results would be some useful addition to the research literature on positive surge waves.

Notation

B = channel width [m] between constriction

h = water depth [m]

F_s = surge Froude number

g = gravity acceleration [m/s^2]

L_c = constriction length [m]

Q = volume discharge [m^3/s]

V_w = surge celerity [m/s]

U = flow velocity [m/s]

ΔB = channel width enlargement [m] on each side

Indices

b = base flow

1 = initial flow conditions

2 = flow conditions immediately after the surge front

References

Bazin, H. (1865). Recherches Expérimentales sur la Propagation des Ondes. ('Experimental Research on Wave Propagation.') *Mémoires présentés par divers savants à l'Académie des Sciences*, Paris, France, Vol. 19, pp. 495-644 (in French).

Chanson, H. (2010). Unsteady Turbulence in Tidal Bores: Effects of Bed Roughness. *Journal of Waterway, Port, Coastal, and Ocean Engineering*, ASCE, Vol. 136, No. 5, pp. 247-256 (DOI: 10.1061/(ASCE)WW.1943-5460.0000048).

CHANSON, H. (2013). "Propagation of surge waves in channels with large-scale bank roughness." *Journal of Hydraulic Research*, IAHR, Vol. 51, No. 6, pp. 740-742 (DOI: 10.1080/00221686.2013.863229) (ISSN 0022-1686).

Chanson, H. (2011a). *Tidal Bores, Aegir, Eagre, Mascaret, Pororoca: Theory and Observations*. World Scientific, Singapore, 220 pages.

Chanson, H. (2011). Undular Tidal Bores: Effect of Channel Constriction and Bridge Piers. *Environmental Fluid Mechanics*, Vol. 11, No. 4, pp. 385-404 & 4 videos (DOI: 10.1007/s10652-010-9189-5).

Chanson, H., Reungoat, D., Simon, B., and Lubin, P. (2011). High-Frequency Turbulence and Suspended Sediment Concentration Measurements in the Garonne River Tidal Bore. *Estuarine Coastal and Shelf Science*, Vol. 95, No. 2-3, pp. 298-306 (DOI 10.1016/j.ecss.2011.09.012).

Chen, S. (2003). Tidal Bore in the North Branch of the Changjiang Estuary. *Proc. Intl Conf. on Estuaries & Coasts ICEC-2003*, Hangzhou, China, Nov. 8-11, Intl Research & Training Center on Erosion & Sedimentation Ed., Vol. 1, pp. 233-239.

Dingemans, M. W. 1997. *Water wave propagation over uneven bottoms*. Advanced series on ocean engineering , Vol. 13, World Scientific, Singapore.

Docherty, N.J., and Chanson, H. (2012). Physical Modelling of Unsteady Turbulence in Breaking Tidal Bores. *Journal of Hydraulic Engineering*, ASCE, Vol. 138, No. 5, pp. 412-419 (DOI: 10.1061/(ASCE)HY.1943-7900.0000542).

Furuyama, S., and Chanson, H. (2010). A Numerical Solution of a Tidal Bore Flow. *Coastal Engineering Journal*, Vol. 52, No. 3, pp. 215-234 (DOI: 10.1142/S057856341000218X).

Henderson, F.M. (1966). *Open Channel Flow*. MacMillan Company, New York, USA.

Ippen, A. T., and Kulin, G. 1957. The effect of boundary resistance on solitary waves. *Journal La Houille Blanche*, Vol. 12, No. 3, pp. 390-400.

Koch, C., and Chanson, H. (2009). Turbulence Measurements in Positive Surges and Bores. *Journal of Hydraulic Research*, IAHR, Vol. 47, No. 1, pp. 29-40 (DOI: 10.3826/jhr.2009.2954).

Liggett, J.A. (1994). *Fluid Mechanics*. McGraw-Hill, New York, USA.

Lubin, P., Chanson, H., and Glockner, S. (2010). Large Eddy Simulation of Turbulence Generated by a Weak Breaking Tidal Bore. *Environmental Fluid Mechanics*, Vol. 10, No. 5, pp. 587-602 (DOI: 10.1007/s10652-009-9165-0).

Rouse, H. (1938). *Fluid Mechanics for Hydraulic Engineers*. McGraw-Hill Publ., New York, USA.

Treske, A. (1994). Undular Bores (Favre-Waves) in Open Channels - Experimental Studies. *Jl of Hyd. Res.*, IAHR, Vol. 32, No. 3, pp. 355-370.

Tricker, R.A.R. (1965). *Bores, Breakers, Waves and Wakes*. American Elsevier Publ. Co., New York, USA.

CHANSON, H. (2013). "Propagation of surge waves in channels with large-scale bank roughness." *Journal of Hydraulic Research*, IAHR, Vol. 51, No. 6, pp. 740-742 (DOI: 10.1080/00221686.2013.863229) (ISSN 0022-1686).

Wolanski, E., Williams, D., Spagnol, S., and Chanson, H. (2004). Undular Tidal Bore Dynamics in the Daly Estuary, Northern Australia. *Estuarine, Coastal and Shelf Science*, Vol. 60, No. 4, pp. 629-636 (DOI: 10.1016/j.ecss.2004.03.001).

CHANSON, H. (2013). "Propagation of surge waves in channels with large-scale bank roughness." *Journal of Hydraulic Research*, IAHR, Vol. 51, No. 6, pp. 740-742 (DOI: 10.1080/00221686.2013.863229) (ISSN 0022-1686).

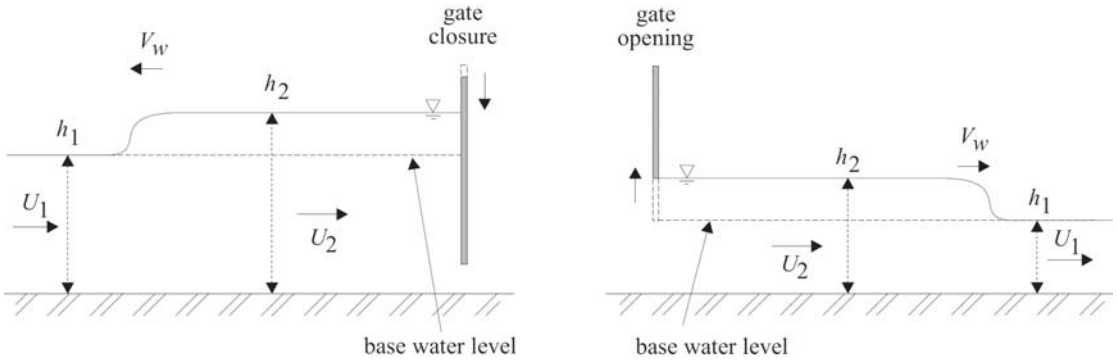

Figure 1 Definition sketch of positive surges induced by gate operation: upstream surge propagation (Left) and downstream surge propagation (Right)

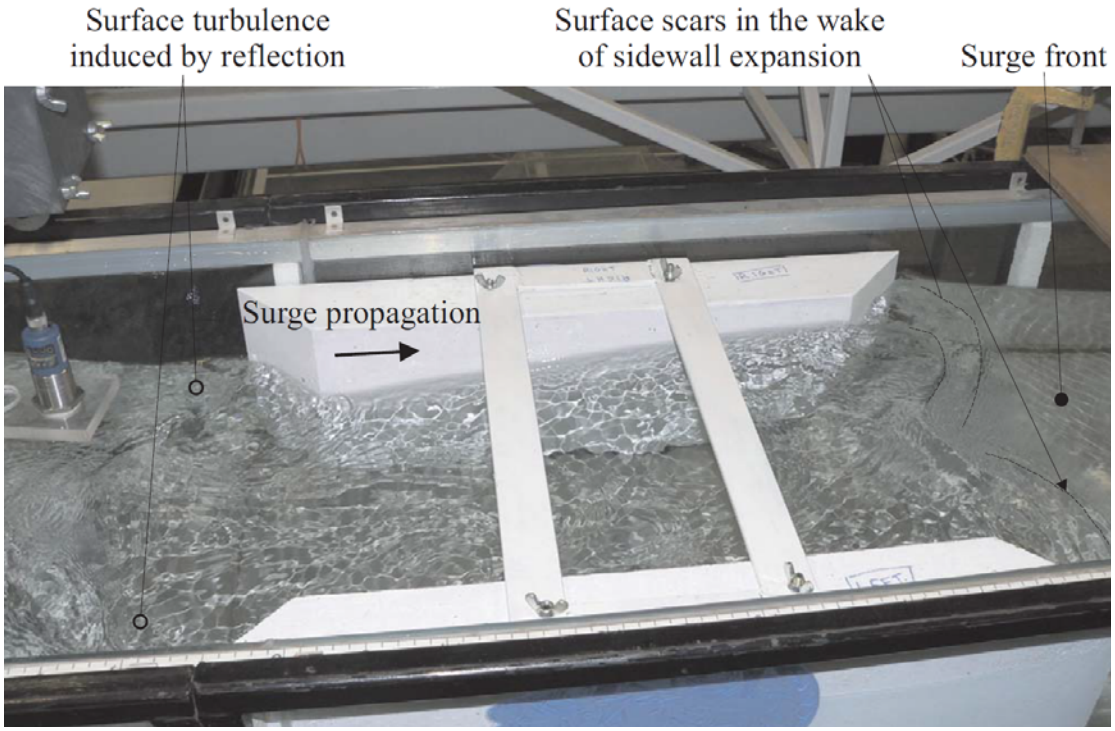

Figure 2 Undular positive surge propagating upstream through a constriction/expansion: the leading edge of the surge just passed the sudden expansion (surge propagation from left to right) - Flow conditions: Q_b = 0.0232 m^3/s, h_1 = 0.1552 m, V_w = 1.15 m/s, undular surge (F_s = 1.15) (Chanson 2011b) - Note the surface scars induced by the surge propagation past the sidewall expansion