# DISCUSSION / DISCUSSION

# Discussion of "Stability of concrete macro-roughness linings for overflow protection of earth embankment dams"[1]

## H. Chanson

P.A. Manso and A.J. Schleiss presented a challenging and detailed study of embankment overflow spillway systems. There are indeed numerous applications worldwide for both dam refurbishments and new structures.

During the last two decades, a number of embankment dam spillways were designed with concrete overtopping protection shaped in a stepped fashion (Chanson 2001, pp. 220–230). During the 1990s, the construction of secondary stepped spillways accounted for nearly two thirds of dam construction in the United States (Ditchey and Campbell 2000). The preferred construction method was roller-compacted concrete overlays placed on the downstream slope. Figure 1 presents two examples. Figure 1a shows the Melton dam secondary spillway completed in 1994. With a discharge capacity $Q_{des} = 2800$ m$^3$/s, it is the world's largest embankment stepped spillway (Chanson 2001, pp. 221–223). Figure 1b shows a newer embankment dam designed and built with a secondary stepped spillway system ($Q_{des} = 481$ m$^3$/s). Although most research on stepped spillway hydraulics focused on steep chutes for gravity dams (average invert slope $\alpha \approx 50°$), recent studies have added new insights to the complicated overflow hydrodynamics (Chanson and Toombes 2001, 2002; Gonzalez 2003).

A very different concept of overflow embankment spillway is the minimum energy loss (MEL) weir design. The concept of a MEL weir was developed by the late Gordon R. McKay (1913–1989) to allow the passage of large floods with minimum energy loss, hence with minimum upstream flooding. The first MEL weir design was the Sandy Creek weir at Clermont Queensland, Australia (built in 1962; Fig. 2a). The largest MEL weir is the Chinchilla weir in

Queensland, Australia (built in 1973), which is listed as a "large dam" by the International Commission on Large Dams (Fig. 2b). A MEL weir is typically curved in plan with converging chute sidewalls, and the overflow spillway chute is relatively flat (Fig. 2). The downstream energy dissipator is concentrated near the channel centreline away from the banks. The in-flow Froude number remains low and the rate of energy dissipation is small compared with that of a traditional weir. For example, both Clermont and Chinchilla weirs were designed to give no afflux at design flow $Q_{des}$. In 1974, the Chinchilla weir passed a discharge of 1130 m$^3$/s with a measured afflux of less than 100 mm (Turnbull and McKay 1974). Ideally, a MEL weir could be designed to achieve critical flow conditions at any position along the chute and, hence, to prevent the occurrence of a downstream hydraulic jump (Chanson 1999, pp. 418–419). This is not always achievable because the variations of the tailwater flow conditions with discharge are often important. Minimum energy loss weirs are typically earthfill structures, and the spillway section is protected by concrete slabs. Construction costs are minimal. A major inconvenience is the overtopping risk during construction, e.g., Clermont weir in April 1963 and Chinchilla weir in 1972 and 1973. In addition, an efficient drainage system must be installed underneath the chute slabs.

In summary, embankment overtopping has become an attractive design option. Several design techniques may be considered, including concrete block linings, precast concrete steps, roller-compacted concrete overlays, and the minimum energy loss weir design.

**H. Chanson.** Department of Civil Engineering, The University of Queensland, Brisbane QLD 4072, Australia (e-mail: h.chanson@mailbox.uq.edu.au).

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**Fig. 1.** Embankment dam stepped spillways: (*a*) Melton dam secondary spillway on 30 January 2000. Completed in 1916, the Melton dam was equipped in 1994 with a secondary spillway ($Q_{des}$ = 2800 m$^3$/s, step height $h$ = 0.6 m). (*b*) Choctaw 8A dam auxiliary spillway (courtesy of Craig Savela and the U.S. Department of Agriculture Natural Resources Conservation Service) ($Q_{des}$ = 481 m$^3$/s, $h$ = 0.61 m, crest width $B_{crest}$ = 51.8 m).

**Fig. 2.** Minimum energy loss weirs: (*a*) Sandy Creek weir at Clermont, Queensland, Australia, built in 1963. Dam height = 6.1 m, $Q_{des}$ = 850 m³/s, $B_{crest}$ = 116 m. View from the right bank on 3 September 2002 (courtesy of Keith James). (*b*) Chinchilla weir, Queensland, Australia, built in 1973. Dam height = 14 m, $Q_{des}$ = 850 m³/s, $B_{crest}$ = 410 m. View from the right bank on 8 November 1997.

(*a*)



(*b*)



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