ASCE

# Closure to "Hydrodynamics of a Broad-Crested Weir with Rounded Edges"

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This paper presents a closure to "Hydrodynamics of a Broad-Crested Weir with Rounded Edges" by Sunhanut Chaokitka and Hubert Chanson. https://doi.org/10.1061/JIDEDH.IRENG-10666.

The writers acknowledge the discussers' interest in the original paper.

The literature on broad-crested weir hydraulics spans more than 140 years (e.g., Bazin 1888; Woodburn 1932). Numerous publications covered the topic including several seminal hydraulic engineering textbooks (Rouse 1938, pp. 321–322; Jaeger 1956, p. 166; Castro-Orgaz and Hager 2017, pp. 422–425, 479–481), as well as a number of specialized handbooks (Bos 1976; Ackers et al. 1978; Bos et al. 1991). Several references included lengthy discussions on the design and operation of broad-crested weirs, e.g., more than 40 pages in Bos (1976, pp. 28–38, 121–152). A substantial number of studies investigated broad-crested weirs with sharp-edged upstream corner (e.g., Govinda Rao and Muralidhar 1963; Hager and Schwalt 1994; Sargison and Percy 2009), and the discussers appear to have overlooked pertinent literature on the topic. Several important studies already tested the effects of the upstream corner rounding on the weir performances (Bazin 1896; Woodburn 1932; Tison 1950; Harrison 1967), including publications in the ASCE *Journal of Irrigation and Drainage Engineering* (Ramamurthy et al. 1988). As stated by Ramamurthy et al. (1988, p. 70), the upstream corner rounding yields a gradual increase in discharge coefficient with increasing relative radius of curvature, and the result can be explained theoretically (Harrison 1967, p. 676). These features have already been accounted for and embedded into international standards for more than 50 years (e.g., BSI 1969; ISO 2021).

Within the wide literature on broad-crested weirs, low broad-crested weirs have been investigated for several decades (e.g., Woodburn 1932; Ramamurthy et al. 1988). Thus, it is inappropriate for the discussers to state that the research on the topic has been minimal. Table 1 of this closure summarizes a few pertinent studies of low broad-crested weirs with a ratio of crest length to weir height $L/\Delta z$ greater than 3. Fig. 1 of this closure shows two examples of low broad-crested weirs with rounded corners used at the University of Queensland (details in Table 1 of this closure); this low profile has been investigated both experimentally (e.g., Chanson 1996; Gonzalez and Chanson 2007; Chanson 2025) and numerically with computational fluid dynamics (CFD) modeling (Isaacs 1981; Toombes and Chanson 2011).

The Zhu et al. discussion presented some results for a configuration (Bai et al. 2023) markedly different to the original paper as shown in Table 1 of this closure (Chaokitka and Chanson 2026). The discussers' results must thus be considered with care because these were obtained in a relatively narrow flume. A key difference between low weirs in narrow channels and tall weirs in wide flumes is the existence of three-dimensional flow patterns (Rouse 1938; Baud and Hager 2000; Gonzalez and Chanson 2007). With a tall broad-crested in wide channels, the flow above the weir crest is not stationary. Underwater corner eddies are observed in the upstream reservoir next to the sidewalls. The elongated vortices with streamwise axis resemble tornadoes, photographed by Rouse (1938) and Baud and Hager (2000). The vortices interact with the weir overflow, in a manner not seen in the small broad-crested weir (Gonzalez and Chanson 2007, p. 108).

For low broad-crested weirs, the effect of the corner radius, relative weir length, and relative weir height was theoretically investigated, e.g., by Harrison (1967) and Ramamurthy et al. (1988). The theories were successfully checked against physical data (e.g., Bazin 1896; Woodburn 1932; Harrison 1967; Ramamurthy et al. 1988). The discussers' results followed earlier findings. A comparison between their data and previous physical data on low broad-crested weirs highlights further discrepancies, in terms of the free-surface profiles above the weir crest and of the rating curves, that need to be physically interpreted. Along the flat crest, a bottom boundary layer develops, in which the flow field is affected by the boundary shear stress (Isaacs 1981; Zhang and Chanson 2016) [details shown in Fig. 1(c) of this closure]. For long weir crests for relatively small upstream heads, the effects of the developing boundary layer become non-negligible. The discussers' numerical data suggested a change in rating curve for $(H_1 - \Delta z)/L \approx 0.3$–$0.4$, which was likely caused by the interactions of the developing boundary layer with the overflow above the crest and associated velocity field. Furthermore, the discussers' conclusion regarding a generalized

**Table 1.** Experimental investigations of low broad-crested weirs: Comparison with original paper

| Study | $B$ (m) | $L$ (m) | $\Delta z$ (m) | $r$ (m) | $L/\Delta z$ | $(H_1 - \Delta z)/\Delta z$ |
|---|---|---|---|---|---|---|
| Woodburn (1932) | 0.61 | 3.05 | 0.53 | 0 to 0.152 | 5.75 | 0 to 0.76 |
| Tison (1950) | 0.5 | 1.8 | 0.3 | 0 | 6 | 0 to 0.45 |
| Govinda Rao and Muralidhar (1963) | 0.61 | 0.1 to 3 | 0.3 | 0 | 0.33 to 10 | 0 to 8 |
| Ramamurthy et al. (1988) | 0.254 | 0.305 | 0.102 | 0 to 0.102 | 3 | 0.25 to 1.2 |
| Chanson (1996) and Toombes and Chanson (2011) | 0.25 | 0.42 | 0.065 | 0.028 | 6.5 | 0 to 2 |
| Bai et al. (2023) | 0.4 | 0.2, 0.5, 1.0 | 0.2 | 0 | 1, 2.5, 5 | 0 to 1.5 |
| Chanson (2025) | 0.4 | 0.39 | 0.066 | 0.030 | 5.9 | 0 to 1.6 |
| Original paper | 0.985 | 0.542 | 1.4 | 0.058 | 0.39 | 0 to 0.17 |

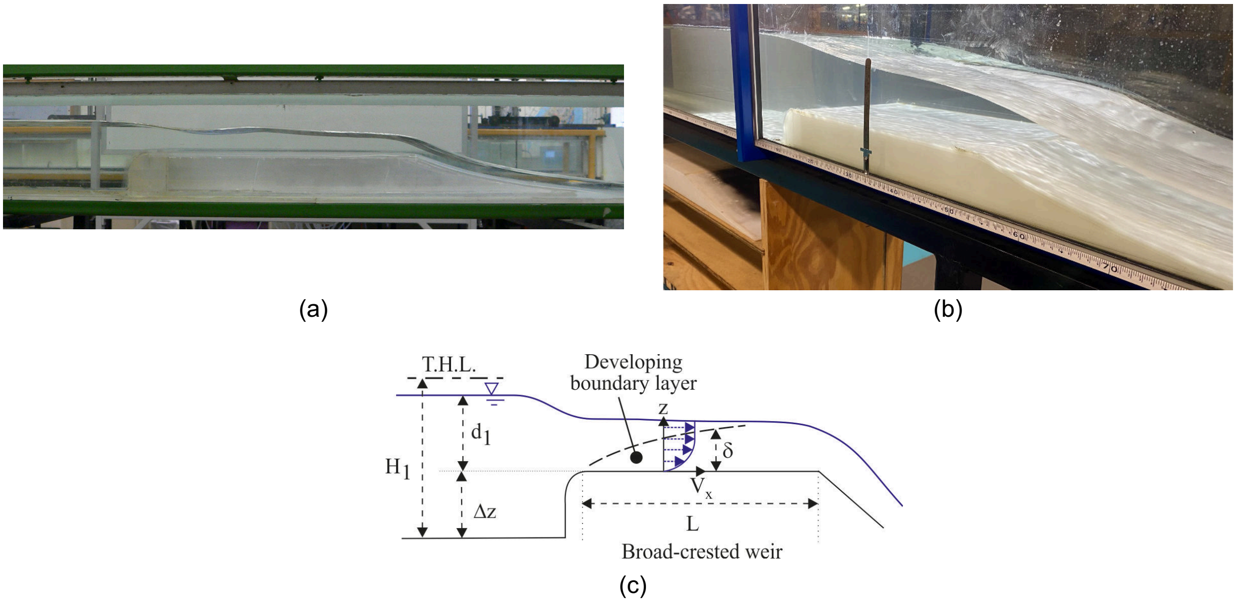


**Fig. 1.** Flow above low broad-crested weirs at the University of Queensland: (a) $B = 0.25$ m, $L = 0.42$ m, $\Delta z = 0.065$ m, $(H_1 - \Delta z)/L = 0.33$, $\Delta z/L = 6.5$; (b) $B = 0.4$ m, $L = 0.39$ m, $\Delta z = 0.066$ m, $(H_1 - \Delta z)/L = 0.33$, $L/\Delta z = 6$; and (c) definition sketch.

multilinear discharge coefficient relationship was drawn from only three weir height configurations, spanning a narrow range of 0.18–0.22 m, over which their data demonstrate no significant influence on the discharge coefficient. Broader conclusions on this basis to low-crested weirs in general warrant caution and further investigation.

All in all, the interest of the discussers is acknowledged, and their work is consistent with the broad literature on the topic spanning more than a century. Their numerical results confirm the impact of the upstream corner geometry on the broad-crested weir hydrodynamics, demonstrated by Rouse (1938), Harrison (1967), Ramamurthy et al. (1988), and many others.

## Notation

*The following symbols are used in this paper:*

$B$ = channel width (m);
$H_1$ = upstream total head (m);
$L$ = broad-crest length (m): $L = 0.542$ m in the original study;
$r$ = radius of curvature (m);
$V_x$ = longitudinal velocity component (m/s);
$z$ = vertical distance (m) measured perpendicular to and above the crest invert;
$\Delta z$ = vertical weir height (m);
$\tau_o$ = boundary shear stress (Pa); and
1 = upstream flow properties.

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