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JET FLOW ON STEPPED SPILLWAYS[A]

Discussion by Hubert CHANSON[2]

The authors presented an interesting discussion of the nappe flow regime above stepped spillways. The writer would like to add some information on energy dissipation calculations of nappe flow and discuss the comparison between the rate of energy dissipation with nappe flow and skimming flow. It will be shown that, in fact, more flow energy is dissipated with a skimming flow regime (fig. A-2).

ENERGY DISSIPATION IN NAPPE FLOW REGIME

In a nappe flow regime, the total head loss on the spillway ΔE equals the difference between the maximum head available E_o and the residual head at the spillway toe. For an un-gated spillway (fig. 1), the writer (CHANSON 1993) showed that it yields :

$$\frac{\Delta E}{E_o} = 1 - \left(\frac{0.54 * \left(\frac{y_c}{h}\right)^{0.275} + \frac{3.43}{2} * \left(\frac{y_c}{h}\right)^{-0.55}}{\frac{3}{2} + \frac{H}{y_c}} \right) \qquad [A1]$$

On figure A-1, equation [A1] is compared with experimental data (MOORE 1943, RAND 1955, HORNER 1969, STEPHENSON 1979). The results indicate a reasonable agreement.

For professional engineers, equation [A1] is simpler than equation (2) and it does not require an empirical estimate of the rate of dissipation at each step.

COMPARISON OF ENERGY DISSIPATION BETWEEN NAPPE AND SKIMMING FLOWS

Several researchers (ELLIS 1989, PEYRAS et al. 1991), including the authors, suggested that there is much higher energy dissipation in nappe flows than in skimming flow situations. But, in a recent paper (CHANSON 1994), the writer showed that, for long stepped channels where uniform flow conditions are reached, higher energy dissipation takes place in a skimming flow regime.

Such a result is illustrated on figure A-2 where the energy dissipation with nappe flow (HORNER 1969) are compared with energy dissipation of skimming flow data. Figure A-2 shows consistently that the nappe flow data indicate a lesser energy dissipation than skimming flow data. Note that, although figure A-2 suggests that the difference is small, it is more appropriate to consider the residual energy (i.e. $[1 - \Delta E/E_o]$). HORNER's (1969) data show that the residual energy with nappe flows is 50 to 100% larger than for the skimming flow data (fig. A-2).

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For long chutes where uniform flow conditions are reached, higher energy dissipation takes place in a skimming flow regime. But, for short channels, nappe flows would dissipate more kinetic energy than skimming flows. In a nappe flow regime, energy dissipation takes place at each step. It is believed that nappe flow situations can dissipate higher energy than skimming flow regime on short chutes. It must be noted however that, for a given discharge, a nappe flow regime requires flatter slope and larger steps than a skimming flow regime. In some cases, such requirements might increase the cost of the structure or are not possible.

APPENDIX I. REFERENCES

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Fig. A1 - Energy dissipation in nappe flow regime - Comparison between equation [A1] and data (MOORE 1943, RAND 1955, HORNER 1969, STEPHENSON 1979)

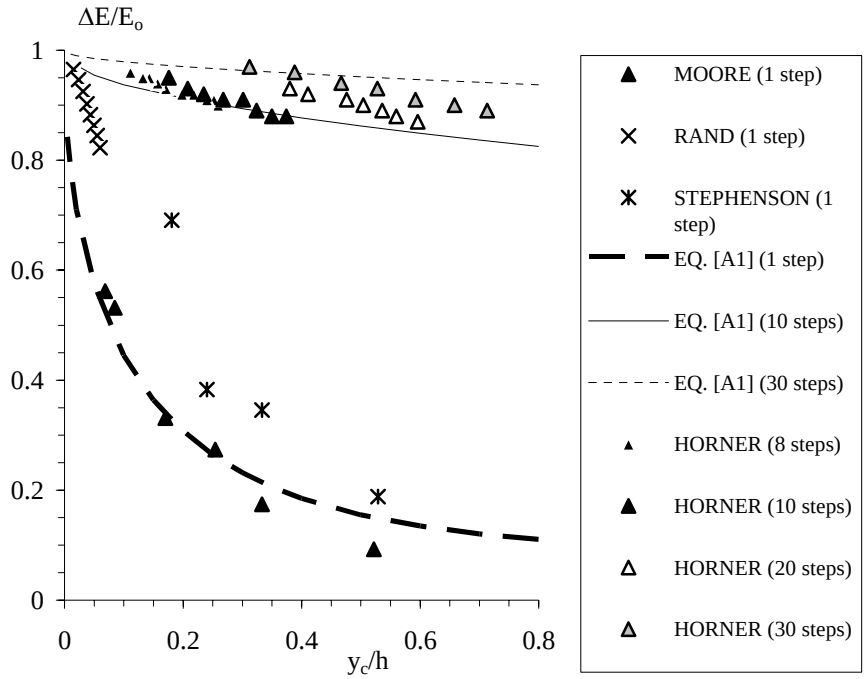

Fig. A2 - Comparison of the energy dissipation in nappe flow regime (HORNER 1969) and skimming flow regime (GRINCHUK et al. 1977, NOORI 1984, SORENSEN 1985, DIEZ-CASCON et al. 1991, PEYRAS et al. 1991, STEPHENSON 1991, BINDO et al. 1992, CHRISTODOULOU 1993)