Paper No. 6245

The determination of the discharge over weirs by the electrolytic tank†

by

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Discussion

Professor O. C. Zienkiewicz observed that the accuracy of the results obtained by the Authors was remarkable and had demonstrated once again the usefulness of the electrolytic-tank apparatus when combined with skilled operation.

35. An interesting point was raised in § 9, where it was stated that "the head on the weir will adjust itself to such a value that the total energy of the flow is a minimum . . .", whilst it was implied logically, but somewhat tentatively, in § 12 that it might be possible to obtain other solutions in which both boundary condition and irrotational flow were satisfied but which were not correct since they did not correspond to the minimum energy principle. This statement required some clarification. The extremum principle often used in mechanics did not imply any additional restraints on a particular physical problem other than the satisfaction of Newton's laws and was usually used as an alternative aid in computation of a problem or the derivation of the basic equations. If, in fact, a solution was found in which the boundary conditions of the problem (e.g. zero pressure on free streamline) were satisfied and the flow was irrotational, then automatically all equations of equilibrium were satisfied and it appeared that nothing further could be gained from the use of the minimum principle.

36. In the case in question, Professor Zienkiewicz was very doubtful if alternative solutions could in fact be obtained for a free-falling nappe with velocities of approach below the critical; though on the other hand, a range of solutions might be possible where the velocity of approach was supercritical, all of which were, in fact, possible in practice. The contention made here was based on some relaxation and sketch solutions which Professor Zienkiewicz had at various times attempted. The question of uniqueness was incidentally no less in doubt in the case of the infinitely deep weir solved by relaxation¹⁰ than in the cases solved by the Author. In this case, although admittedly h_d was known to be zero, the value of the coefficient K (equation (17)) was indeterminate and it would appear that adjustment of the nappe could be made for different values of this coefficient. Relaxation solutions had at all stages pointed to the fact that this was not the case and that to satisfy the boundary conditions K tended to a unique value.

37. The case of the free overfall showed a whole range of solutions possible for $h_d > 0.5h_w$, i.e. for supercritical approach velocities and, in fact, a number of these had been shown by Rouse (p. 533 of reference 8).

The Authors, in reply, thanked Professor Zienkiewicz for his complimentary remarks regarding the accuracy of the results and for his very useful clarification of the statement made in § 12 about the minimum energy condition. This condition had been used, in the way he suggested, as an experimental aid in finding a solution.

39. The possibility of theoretically conceivable flows at greater energies than the

† Proc. Instn civ. Engrs, vol. 10, p. 59 (May 1958).

minimum had been put forward by the Authors in the light of the discussion by Rouse (p. 304 of reference 11), but no experiments had been made to substantiate this (the minimum having been established by approaching the solution with energy levels increasing from below).

40. In view of Professor Zienkiewicz's experience in finding that in relaxation solutions k tended to a unique value, the Authors shared his doubts that alternative solutions could be found, provided that the flow was controlled at the weir, i.e. the Froude number of the flow in the approach channel was less than unity.