

ABSTRACT

This report covers the first of the two main parts of investigations which have been completed for the Water Research Commission by *Sigma Beta*. The main purpose of the investigations was to:

"Develop improved flow gauging structures for Southern African rivers"

under the sub-headings:

- (i) Upgrading of existing gauging stations through re-calibration and standardization.
- (ii) Development of an ideal new gauging structure which would require minimum maintenance and still provide acceptable results in sediment-laden rivers.

Compound sharp-crested and Crump weirs, where the crest height of the weir is varied in a number of steps across the river section, are commonly used for flow gauging in South African rivers. British standards require that dividing walls should be used with compound weirs in order to separate the flows over the different crest sections of the weir. Where dividing walls are not used, the standards require that these weirs should be calibrated in situ or in models.

Approximately 90 percent of the river flow gauging structures in South Africa consist of sharp-crested and Crump weirs without dividing walls. The calibration of these types of structures, in terms of the British standards is necessary in order to ensure internationally acceptable accuracies.

This report follows on an extensive series of calibration tests that were performed on compound sharp-crested and Crump weirs. These tests were performed in the hydraulics laboratories of the Civil Engineering Department of the University of Stellenbosch. Earlier results from tests on compound Crump weirs at the hydraulics laboratory of the Department of Water Affairs and Forestry in Pretoria are also included in this report. The main purpose of these tests was to determine the magnitude of errors that are introduced through the South African practice of using compound weirs without dividing walls for flow measurement. The effect of a number of parameters including pool depth, overflow height, step heights between adjacent weir crests, relative lengths of adjacent crests, etc. on the accuracy of the measurement was determined. In order to determine the worth of dividing walls, most of the tests were performed both with and without these walls. The results of these tests were used to develop discharge formulae and techniques in order to improve the accuracy with which the discharge can be determined from past and future water stage records. Recommendations are also included on sound practice for flow gauging with compound sharp-crested and Crump weirs.

The results of the study prove conclusively that accurate flow measurements are possible with sharp-crested and Crump weirs without dividing walls. The standard method of analysis used to date leads to the slight overestimation of discharge values when the flow depths above adjacent weirs differ by more than 50 per cent. This overestimation varies from an average of 7 percent when the flow over

the higher crest commences and reduces to zero when the flow depth above the higher crest becomes more than 50 percent of the depth above the low crest. This overestimation can easily be corrected by adjusting the discharge coefficient for the weir. Adjustments whereby the discharge coefficient is expressed as a function of the ratio of the effective head and effective pool depth behind the weir, prove to give very satisfactory results. Not only did this lead to accuracies of approximately 4 percent at the 95% confidence level, but the corrections also proved to be insensitive to shallow and irregular pool conditions.

Tests with dividing walls indicated under-estimation of the flow rate under certain circumstances if the head is calculated from water levels recorded upstream of the low crest of the weir. This under-estimation results from the assumption of constant energy levels upstream of different crests. The under-estimation can be as high as 15 to 20% in cases of a high step height in combination with a shallow pool whilst the overflow depths over adjacent weirs differ by more than 50 percent. This under-estimation can be reduced to less than 10 percent if the step height to pool depth ratio is kept below 0,5.

The results of the study have led to the recommendation that sharp-crested and Crump weirs without dividing walls can be used for flow gauging in rivers. Traditional discharge coefficients can be adapted to improve the accuracy of discharge calculations for this type of weir. Where dividing walls are not used, the step heights should be limited to ensure that the ratio of step height to pool depth does not exceed 0,5. In cases of very wide rivers with non ideal pool conditions dividing walls should be used and water levels should be recorded upstream of a number of the crests unless specific calibration tests are undertaken. This is especially true for the more important gauging stations where a high degree of accuracy is required.

It may be concluded that the one main objective of the study, viz. to

"Upgrade the calibration of existing gauging stations in order to provide reliable measurements"

has been achieved.

The results of the investigations related to the other main objective, viz, to:

"Develop an improved gauging structure for overcoming sedimentation problems"

are included in a separate report, WRC Report No. 442/2/94.