BED-LOAD TRANSPORTMETER FOR FINE SAND "SPHINX"

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ABSTRACT

A new bed-load transportmeter has been designed particularly for very fine bed material (below 400 μ). The basic conception is the same as for the so-called Delft-bottle used for measuring transport by turbulent suspension.

The instrument is of the flow-through type. The flow enters through a narrow and relatively high nozzle and is conducted, first by a rectangular tube with the same cross section as the nozzle, then by a wider circular tube curved spiralwise into settling chambers. The flow leaves the instrument by a wide slit high at the rear end.

The disposition of the tubes and settling chambers has been developed during tests in the Hydraulic Laboratory at Delft. Field tests regarding the method of suspension and of handling still have to be carried out.

The laboratory investigation has resulted in a hydraulic efficiency (ratio between flow through tube apparatus, and product of nozzle area and flow velocity outside) between 0.9 and 1.1, depending on the working conditions. With very fine sand, a small amount (up to 15 per cent) may be flushed through the exit tube and get lost for the measurement.

INTRODUCTION

For the measurement of coarse-grained bed load, several instruments of the trap type have been used successfully. One of them, the "Bottom Transportmeter Arnhem" [1] has given satisfaction for a number of years in the Dutch rivers upstream of the tidal reaches. For sand of smaller grain size than about 400 μ, however, it cannot be applied because too much sand leaves the instrument through the wire mesh at the rear. In order to counteract this, a finer screen was tried. It failed, however, because the screen clogged to such an extent that the flow through the apparatus was impaired.

A new type of bed-load meter has been designed through cooperation between the Research Department of the Rijkswaterstaat and the Hydraulic Laboratory at Delft. Its basic idea is the same as that of the so-called "Delft bottle" [2] which has proven entirely successful in measuring the transport of sand in turbulent suspension. In this instrument the water enters through a nozzle in front. It passes through several chambers in the interior, in which the transported sand settles, and leaves through orifices at the rear. The cross section of the nozzle and the area of the exit orifices have been designed in such a way that the flow through the apparatus is equivalent to the nozzle area. Then the flow up to the nozzle is undisturbed.

An instrument of this type, suitable for placing on the river bed and provided with a flexible connection between the nozzle and the body analogous to the "Arnhem," is now being developed. Up to the present time the hydraulic properties have been investigated in the laboratory. A trial apparatus will be used for field tests regarding the construction of the connection between the nozzle and the body and the method of suspension.

DESCRIPTION OF THE INSTRUMENT

Figure 1 and photo I show the final model of the instrument after the laboratory experiments, constructed from perspex. In order to obtain an equivalent flow, the nozzle area has to be restricted. It has been made narrow and relatively high in order to include as much as possible of grains moving in saltation. For the laboratory experiments the nozzle was connected to the body of the instrument by a rigid tube of the same cross section as the nozzle.

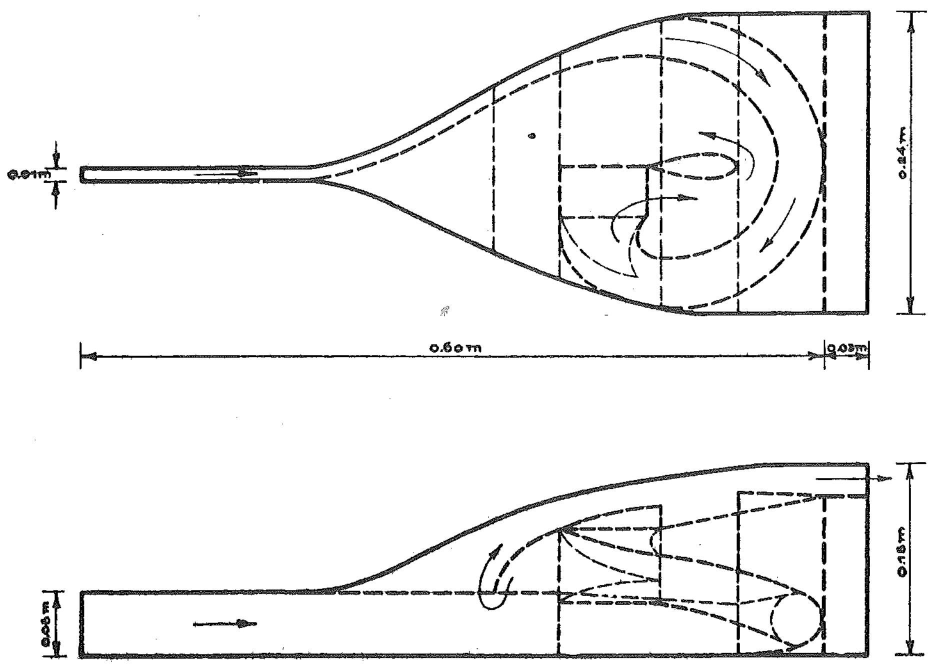

Fig. 1 - The apparatus.

Since the flow keeps the same velocity as long as the cross section remains constant, the sand is carried along readily. In order to restrict the energy loss in the interior, the tube gradually expands to a circular cross section before entering the settling chambers. The circular tube is curved upward spiralwise so that its mouth is above the floor in the first settling chamber providing sufficient room for settling. The spiral flow is accompanied by secondary currents which effectively prevent settling of material before the settling chambers are reached. In tests with considerable transport of sand, the formation of ripples in the first rectangular tube was sometimes observed, but in the spiral tube only minor deposits occur.

After leaving the spiral tube, the water consecutively enters the first and second settling chambers, which are situated in the wide and high rear part of the instrument.

Most of the coarser grains settle in this second chamber. Thereafter the water flows back again into the third chamber in the triangular forepart. Here the finer portion of the sand is deposited. The flow leaves the instrument through a wide exit tube, the upper side of which is formed by the roof of the instrument. Here a fourth settling chamber is arranged by locally lowering the floor of the tube. The exit tube is extended a small distance beyond the rear wall of the first and second settling chamber in order to avoid disturbance of the outflow by the eddies in the wake of the apparatus.

HYDRAULIC INVESTIGATIONS - Figure 2 shows the static and dynamic pressures at different points along the route of the flow through the instrument and also the coefficient of hydraulic efficiency, which is defined as the ratio between the flow through the instrument and the

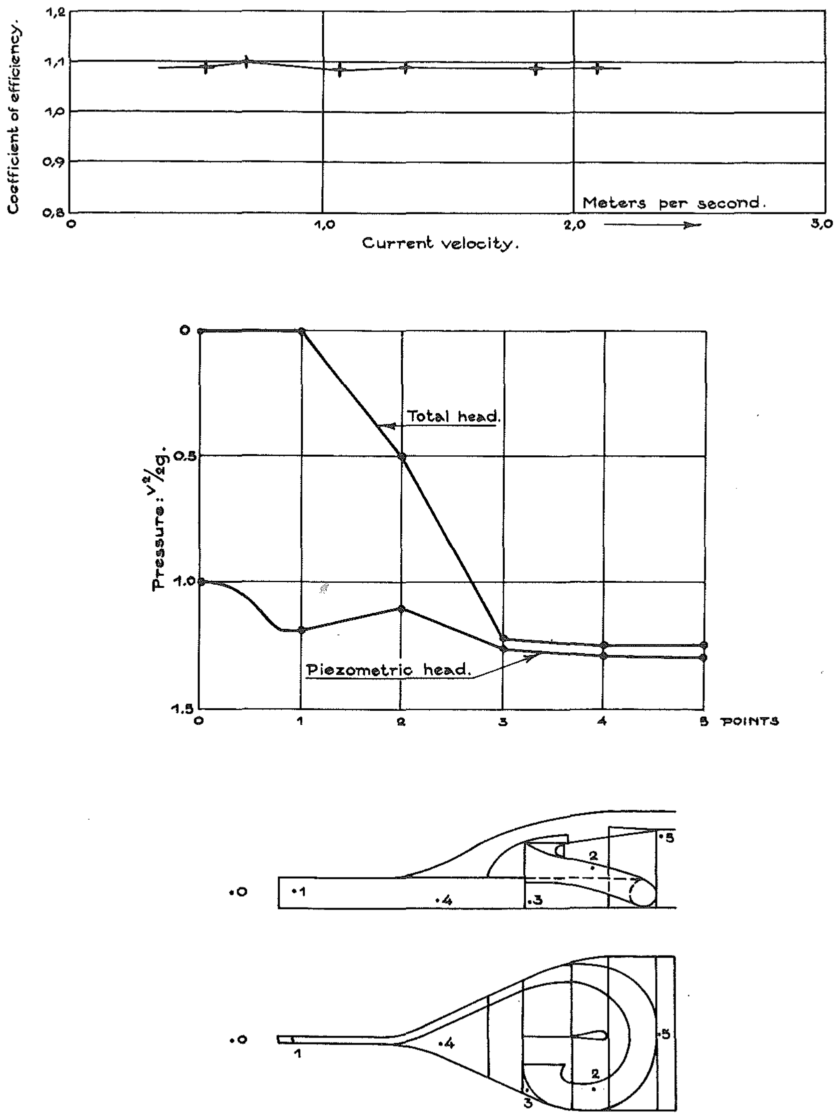

Fig. 2 - Coefficient of efficiency and pressure distribution.

product of nozzle area and flow velocity outside. As may be seen, this ratio is practically constant for different flow velocities at a value of nearly 1.1. When much sand is carried along, resulting in riffle formation in the entrance tube, the coefficient is slightly lowered. In extreme conditions it varies between 0.9 and 1.0.

Another series of tests has been carried out with the purpose of finding if and how much sand is carried by the flow right through the apparatus and so is lost from measurement. Figure 3 shows the results with sand of median grain size slightly above 200 μ. Eight per cent was lost. In other tests with still finer sand (consisting of the fraction of the sand of Fig. 3 below 90 μ), 12 to 15 per cent was lost through the exit tube.

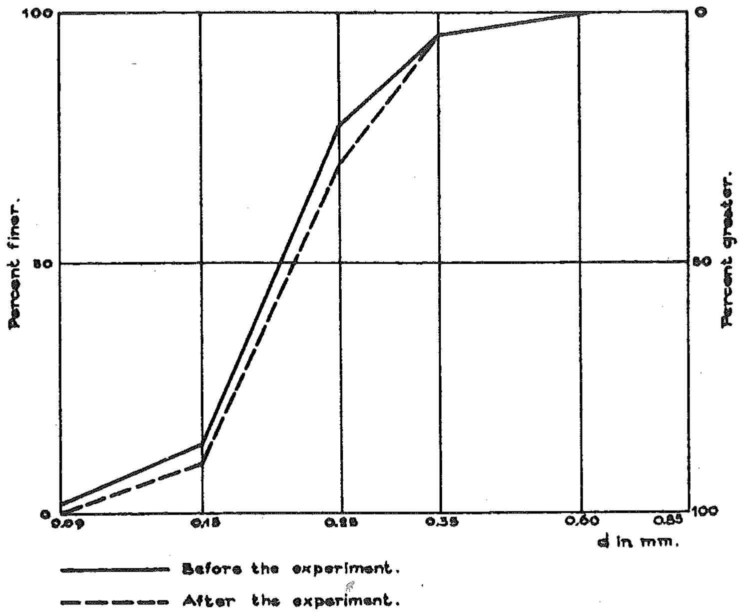

Fig. 3 - Size distribution curves of test sand.

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[1] Proceedings of IAHR, Berlin, 1937.

[2] Measurement and Analysis of Sediment Loads in Streams. Chapter X, Section 84, p. 152. Iowa, 1940.