TECHNICAL REPORT

ISO/TR 9212

Second edition
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Hydrometry — Measurement of liquid flow in open channels — Methods of measurement of bedload discharge

Hydrométrie — Mesurage du débit des liquides dans les canaux découverts — Méthodes de mesurage du débit des matériaux charriés sur le fond

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In exceptional circumstances, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example), it may decide by a simple majority vote of its participating members to publish a Technical Report. A Technical Report is entirely informative in nature and does not have to be reviewed until the data it provides are considered to be no longer valid or useful.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TR 9212 was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 6, *Sediment transport*.

This second edition cancels and replaces the first edition (ISO/TR 9212:1992), of which it constitutes a technical revision.

Introduction

The bedload is the material transported on or near the bed by rolling or sliding (contact load) and the material bouncing along the bed, or moving directly or indirectly by the impact of bouncing particles (saltation load). The knowledge of the rate of sediment transport in a stream is essential in the solution of practically all problems associated with the flow in alluvial channels. The problems include river management, such as design and operation of flood control works, navigation channels and harbours, irrigation reservoirs and canals, and hydroelectric installations. Knowledge of the bedload transport rate is necessary in designing reservoir capacity because virtually 100 % of all bedload entering a reservoir accumulates there. Bedload should not enter canals and distributaries, and diversion structures should be designed to minimize the transfer of bedload from rivers to canals.

The bedload-transport rate can be measured either as mass per unit time or volume per unit time. Volume measurements should be converted to a mass rate. Measurements of mass rate of movement are made during short time periods (seconds, minutes), whereas measurements of volume rates of movement are measured over longer periods of time (hours, days). Regardless of whether the mass or volume rate is measured, the average particle size distribution of moving material should be determined. Knowledge of particle size distribution is needed to estimate the volume that the bedload material will occupy after it has been deposited. Knowledge of particle size distribution also assists in the estimation of bedload transport rates in other rivers transporting sediment.

The movement of bedload material is seldom uniform across the bed of a river. Depending upon the river size and gradation, the bedload may move in various forms, such as ripples, dunes, or narrow ribbons. Its downstream rate of movement is also extremely variable. It is difficult to actually sample the rate of movement in a river cross-section, or to determine and verify theoretical methods of estimation.

Hydrometry — Measurement of liquid flow in open channels — Methods of measurement of bedload discharge

1 Scope

This Technical Report reviews the current status of direct and indirect bedload-measurement techniques. The methods are mainly based on grain size distribution of the bedload, channel width, depth and velocity of flow. This Technical Report outlines and explains several methods for direct and indirect measurement of bedload in streams, including various types of sampling devices.

The purposes of measuring bedload transport rates are to:

a) increase the accuracy of estimating total sediment load in rivers,

b) gain knowledge of bedload-transport that cannot be completely measured by conventional suspended-sediment collection methods,

c) provide data to calibrate or verify theoretical transport models, and

d) provide information needed in the design of river diversion and entrainment structures.

NOTE The units of measurement used in this Technical Report are SI units.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 772, *Hydrometric determinations — Vocabulary and symbols*

ISO 4363, *Measurement of liquid flow in open channels — Methods for measurement of characteristics of suspended sediment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 772 and ISO 4363 and the following apply.

3.1
bedload
material transported on or near the bed by rolling, sliding and bouncing

3.2
bedload transport rate
quantity of bedload passing through a section of the stream per unit width in unit time

NOTE The bedload transport rate is expressed in kilograms per metre (of width) per second.

3.3
bedload transport model
mathematical relation of hydraulic and sediment variables which can be used to estimate the bedload transport rates of sediment

3.4
bedload sampler efficiency
ratio of the amount of bedload collected by the sampler to the amount of bedload that would have passed through the sampler width in the same time in the absence of the sampler

4 Measurement of bedload

4.1 General

Bedload can be measured by direct measuring bedload samplers or by indirect methods.

a) Direct measuring bedload samplers:

   In this method, a mechanical device or sampler is required for measuring the bedload transport rate. The bedload sampler is designed so that it can be placed directly on the channel bed in the flow, or beneath the channel bed to collect a sample of the bedload over a specific time interval. A sample thus obtained represents a time-averaged mass per unit width per unit time.

b) Indirect measurement of bedload:

   All other methods of bedload measurement in which no mechanical device, or bedload-sampler is used, are indirect methods.

4.2 Principle

4.2.1 Measurement using bedload samplers

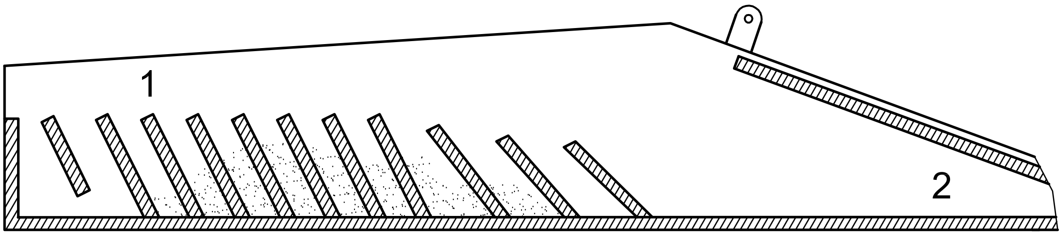
4.2.1.1 Basket or box type sampler

This type of sampler consists of a basket or box, usually made of mesh material on all sides except the front and bottom. The bottom may be solid or of loosely woven iron rings, to enable it to conform to the irregular shape of the stream bed. The sampler is placed on the channel bed with the help of a supporting frame and cables. A steering fin or vane(s) attached to the basket assures positioning of the instrument in the direction of the flow. The sediment is collected in the basket by causing a reduction of the flow velocity and/or screening the sediment from flow for a measured time period.

Since a part of the bedload is dropped in front of the sampler, the efficiency of basket type samplers is only of the order of 45 %, for average sediment sizes varying from 10 mm to 50 mm. However, due to their large capacity, basket type samplers are well suited for measuring of transport rate of large-sized sediment.

4.2.1.2 Pressure-difference sampler

This type of sampler (see Figures 1 to 6) is designed so that the velocity of water entering the sampler and the stream velocity is approximately equal. Equalization of velocity is accomplished through creation of a pressure drop at the exit due to a diverging configuration between the entrance and the exit. These are flow-through samplers that trap coarse material behind baffles or in a mesh bag attached to the exit side or in a specially designed chamber.



Key

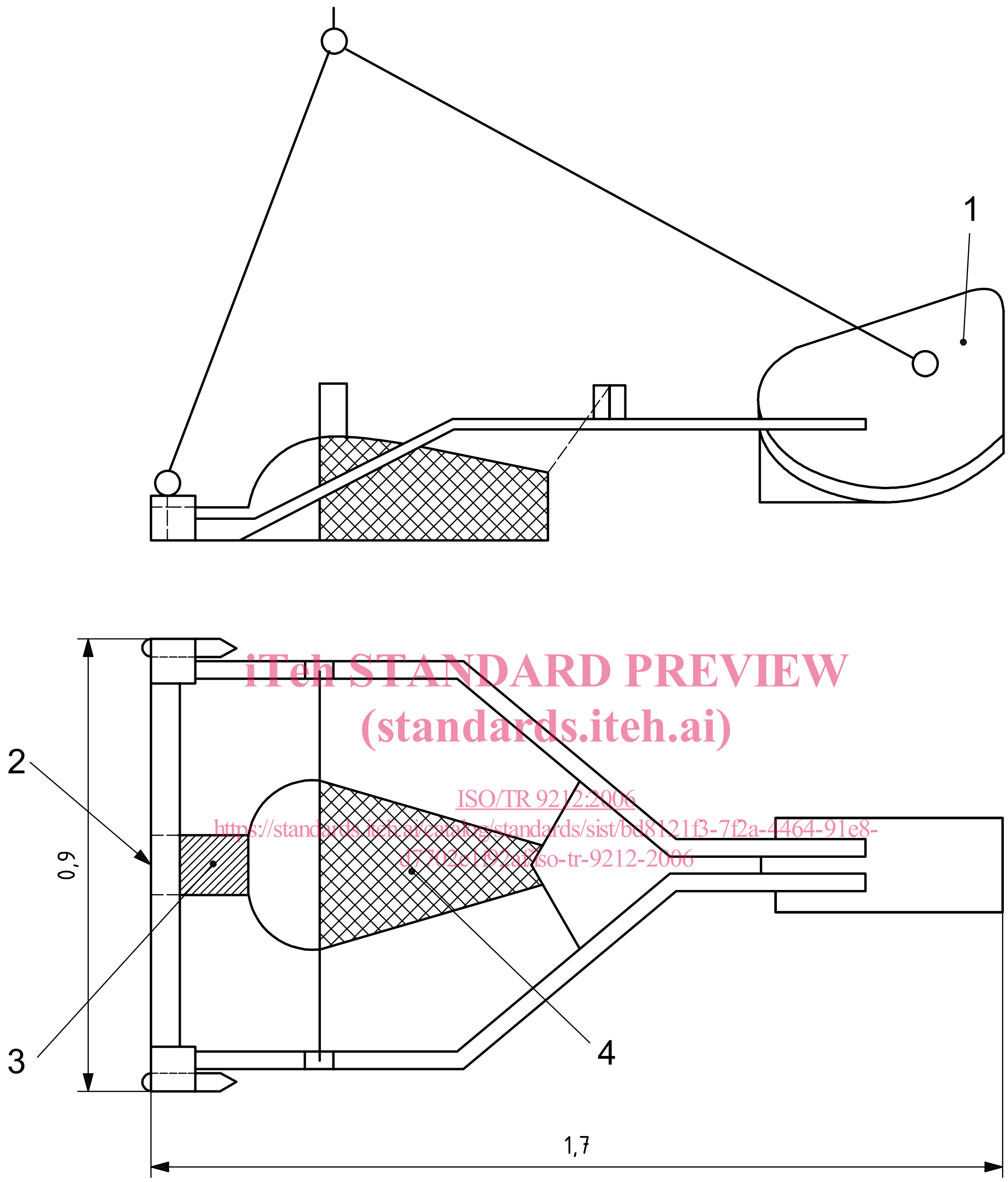
1 transverse partitions

2 entrance

NOTE This is a pressure-difference bedload sampler. The SRIH sampler was the first of this type to be developed. Such samplers can sample particles as small as fine sand to as large as 200 mm. Efficiencies are extremely variable.

Figure 1 — Scientific Research Institute of Hydrotechnics (SRIH) sampler

Dimensions in metres



Key

1 steering fin

2 entrance

3 rubber connection

4 mesh bag

NOTE This is a pressure-difference bedload sampler. The Arnhem, or Dutch, sampler is comprised of a rigid rectangular entrance connected by a diverging rubber-neck to a basket of 0,2 mm to 0,3 mm mesh. Efficiencies are variable, but generally about 70 %. It is suitable for collection of fine bedload material. The fine net of the sampler can get clogged leading to a drop in efficiency of the sampler.

Figure 2 — Arnhem sampler

Dimensions in millimetres

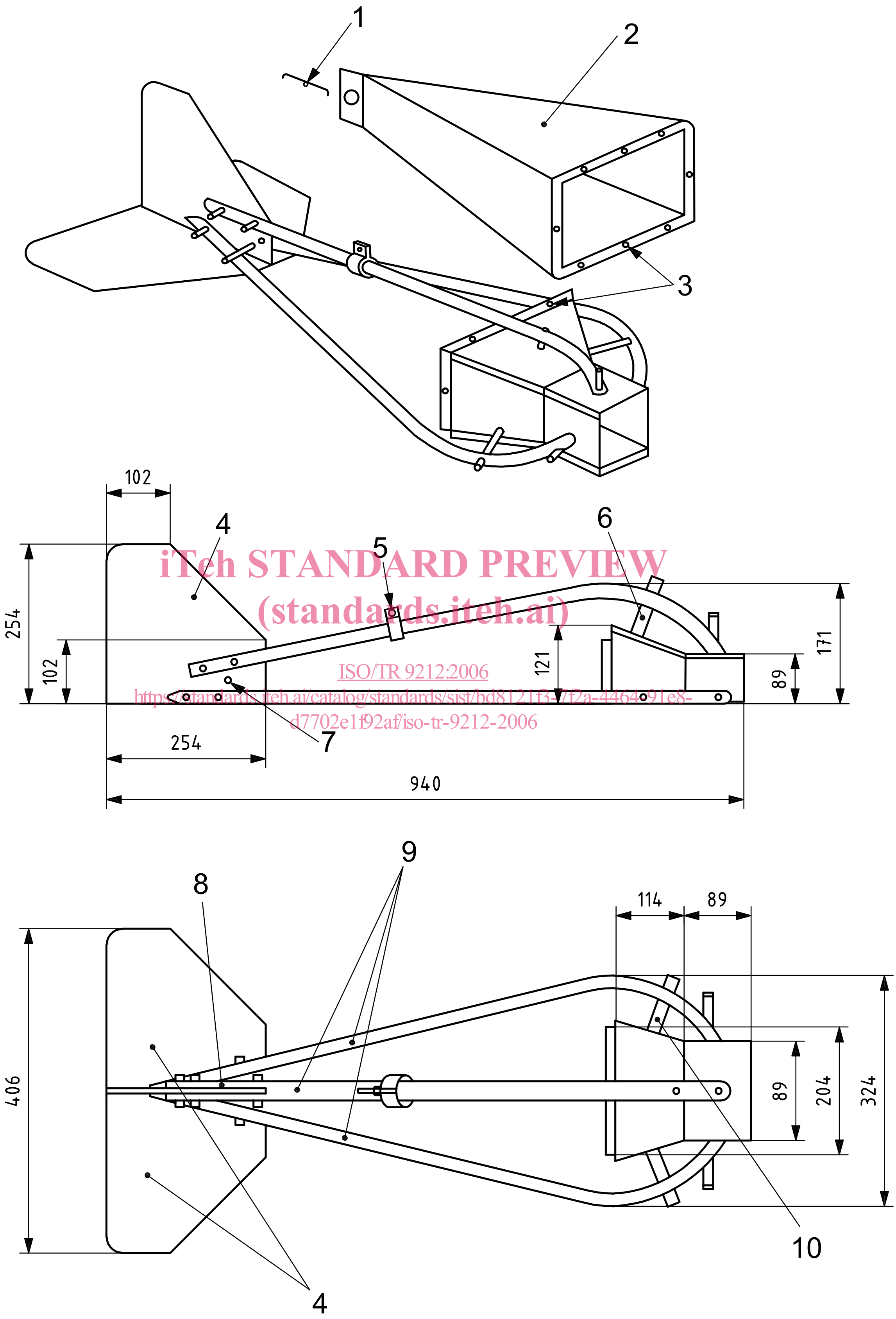


Figure 3 — Helley-Smith bedload sampler