TECHNICAL REPORT

ISO TR 9212

First edition
1992-11-01

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

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

Reference number
ISO/TR 9212:1992(E)

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.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:

— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;

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Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 9212, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*, Sub-Committee SC 6, *Sediment transport*.

This document is being issued in the type 2 Technical Report series of publications (according to subclause G.4.2.2 of part 1 of the ISO/IEC Directives) as a "prospective standard for provisional application" in the field of measurement of bedload discharge, because there is an urgent need for guidance on how standards in this field should be used to meet an identified need.

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Printed in Switzerland

This document is not to be regarded as an "International Standard". It is proposed for provisional so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat.

A review of this type 2 Technical Report will be carried out not later than two years after its publication with the options of: extension for another two years; conversion into an International Standard; or withdrawal.

Annex A of this Technical Report is for information only.

Introduction

Bedload generally is considered that portion of the total sediment transported in a stream that is in almost continuous contact with the bed. Such sediment creates numerous problems for engineers responsible for river management, especially in the design and operation of flood-control works, navigation channels and harbours, irrigation reservoirs and canals, and hydroelectric installations. Knowledge of bedload transport rate is necessary in designing reservoir capacity, because virtually 100 % of all bedload material entering a reservoir accumulates there. Bedload material must be kept from entering canals and distributaries, and diversion structures must be designed to minimize the transfer of bedload material from rivers to canals.

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

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

Measurement of liquid flow in open channels — Methods for 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 size distribution of the bedload material, channel width, depth and flow velocity. This Technical Report outlines and explains several methods for direct and indirect measurement of bedload in streams, including discussion of various types of sampling devices.

The purposes in measuring bedload transport rates are to:

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

b) gain knowledge of bedload material 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.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Technical Report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Technical Report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 772:1988, *Liquid flow measurement in open channels — Vocabulary and symbols.*

ISO 4363:1977, *Liquid flow measurement in open channels — Methods for measurement of suspended sediment.*

3 Definitions

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

3.1 bedload-transport model: Mathematical relation of hydraulic and sediment variables which can be used to predict the bedload-transport rates of sediment.

3.2 bedload-sampler efficiency: Ratio of the quantity of sediment trapped in a bedload sampler to the quantity of the sediment in the stream that would be transported as bedload through the section occupied by the sampler without the sampler in position.

4 Units of measurement

The units of measurement used in this Technical Report are SI units. The transport rate of bedload is expressed preferably in kilograms per metre (of width) per second.

5 Measurement of bedload

5.1 General

Two types of bedload transport measurement methods are used, namely:

a) Methods in which mechanical devices or samplers are required. The bedload sampler is designed so it can be placed directly on the channel bed in the flow or beneath the channel bed to collect a sample of the moving bedload material over a specific time interval. A sample thus obtained should represent a time-averaged mass per unit width per unit time.

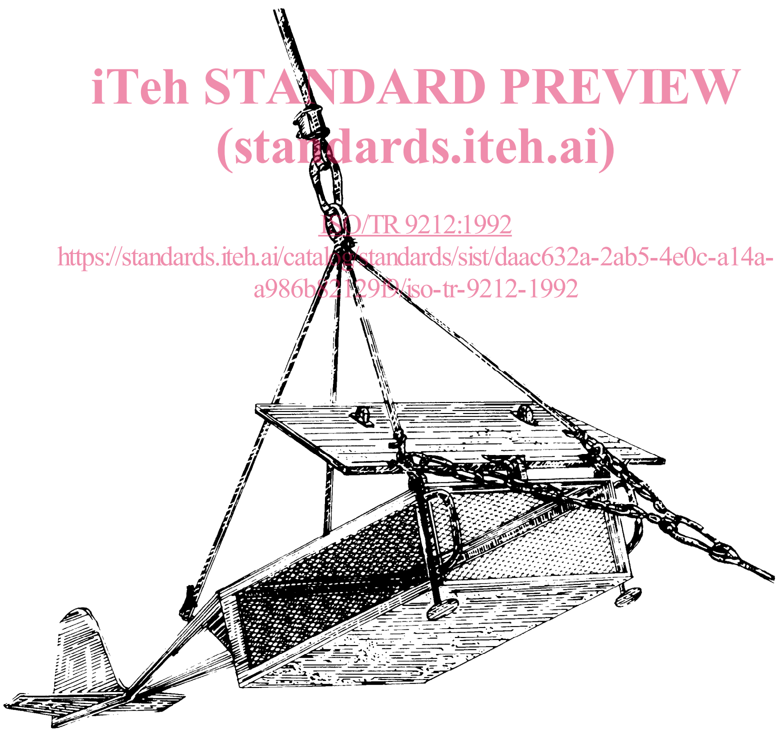
b) All other methods of measurement in which no mechanical device or bedload-sampler is used.

5.2 Principle

5.2.1 Measurements using bedload samplers

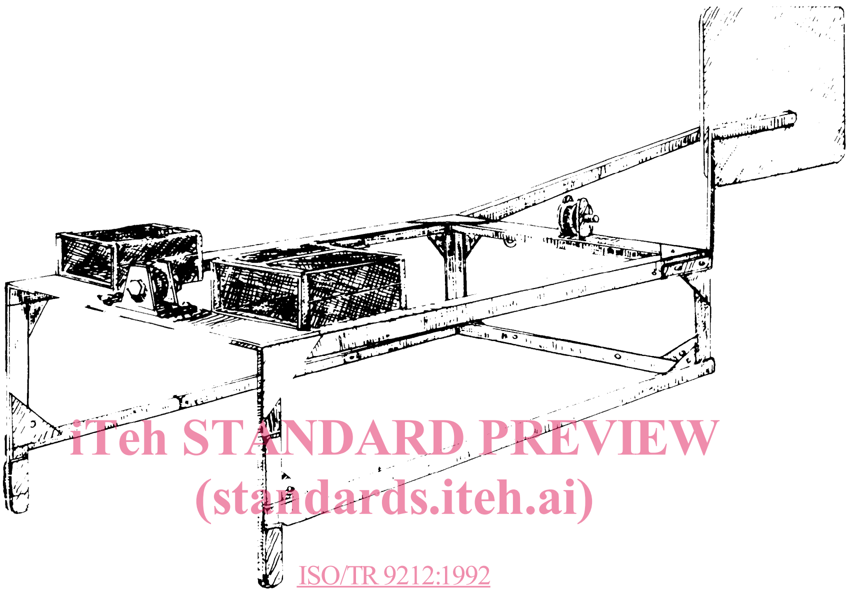
5.2.1.1 Basket sampler

This type of sampler (see figures 1 to 4) generally is composed of a frame covered with wire screen or mesh material on all sides except the front. The bottom may be solid or mesh. The sampler is placed on the channel bed, with the front perpendicular to flow, to trap bedload material for a measured time period.



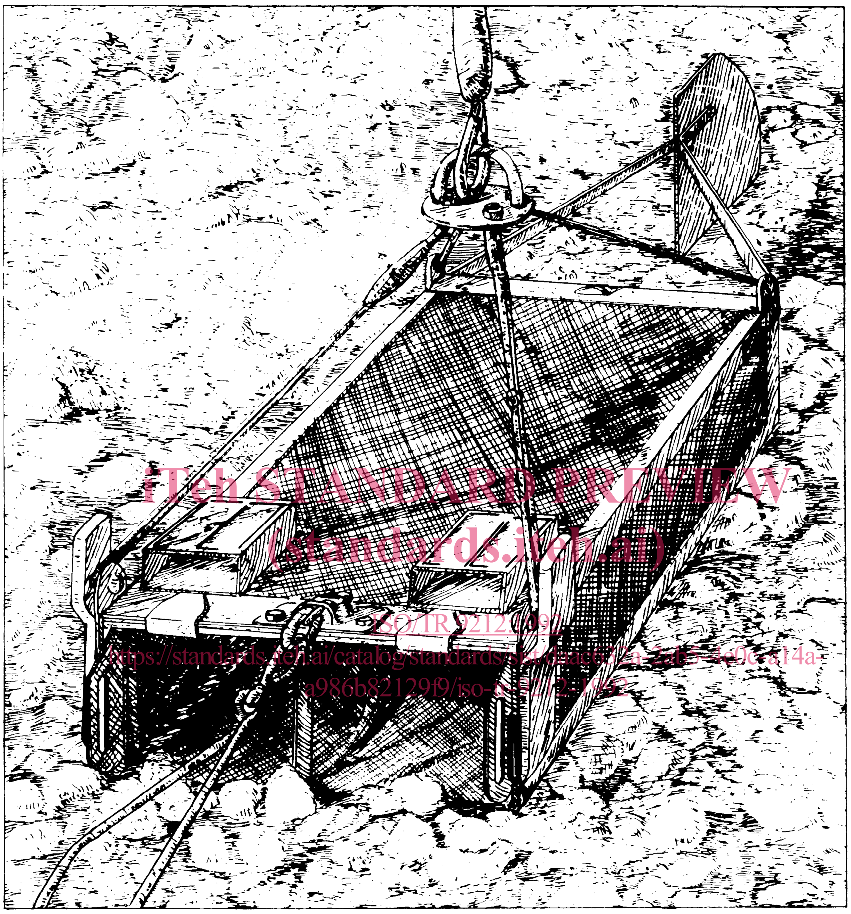
NOTE — This sampler is classed as a basket sampler with a solid bottom. No efficiency data is available.

Figure 1 — Muhlhofer sampler (1932)



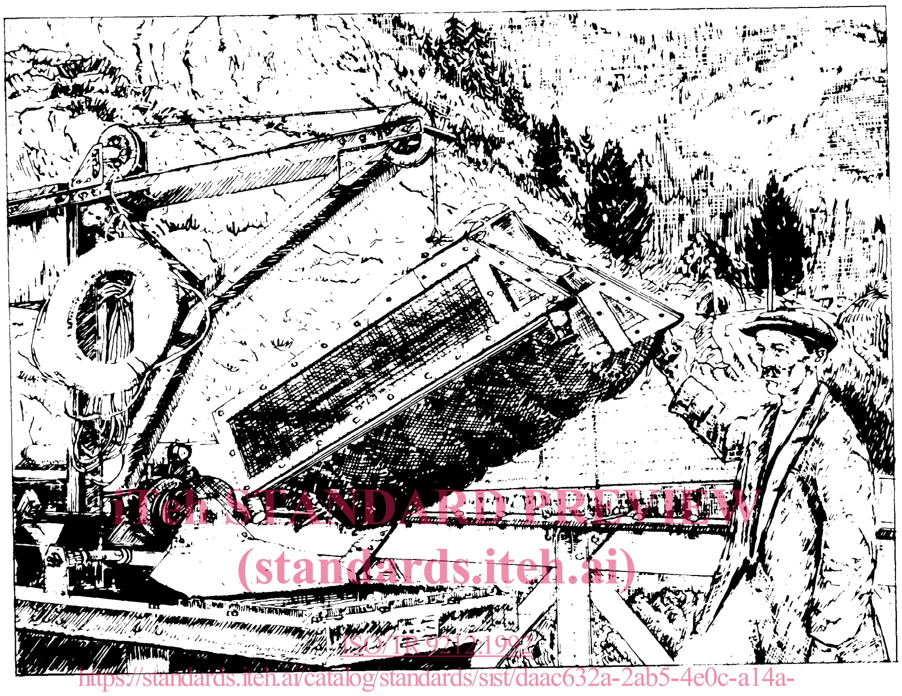
NOTE — This is a basket-type sampler designed in 1931. Similar to the Muhlhofer sampler (figure 1), 1 m long, 25 cm high and 50 cm wide with back, sides and top of 4,5 cm mesh. The bottom is of loosely woven iron rings. For bedload material 10 mm to 50 mm diameter.

Figure 2 — Ehrenberger sampler frame with mesh basket inserted into frame



NOTE — This is a basket-type sampler made of steel mesh used to sample particle sizes from 5 mm to 75 mm. Tests show efficiencies varying from 20 % to 90 %, depending upon particle size and transport rate of bedload.

Figure 3 — Nesper sampler (1937)

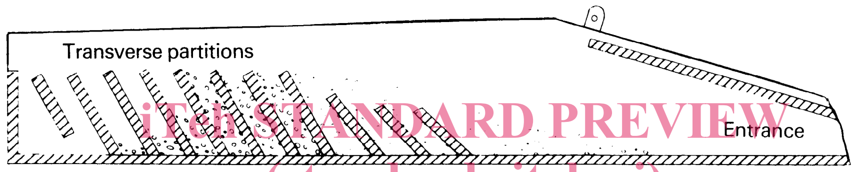


NOTE — This is a basket-type sampler using loosely-woven iron rings that conform to the shape of the bed. Efficiencies vary with sampling time and transport rate of bedload.

Figure 4 — Swiss federal authorities sampler (1939)

5.2.1.2 Pressure difference sampler

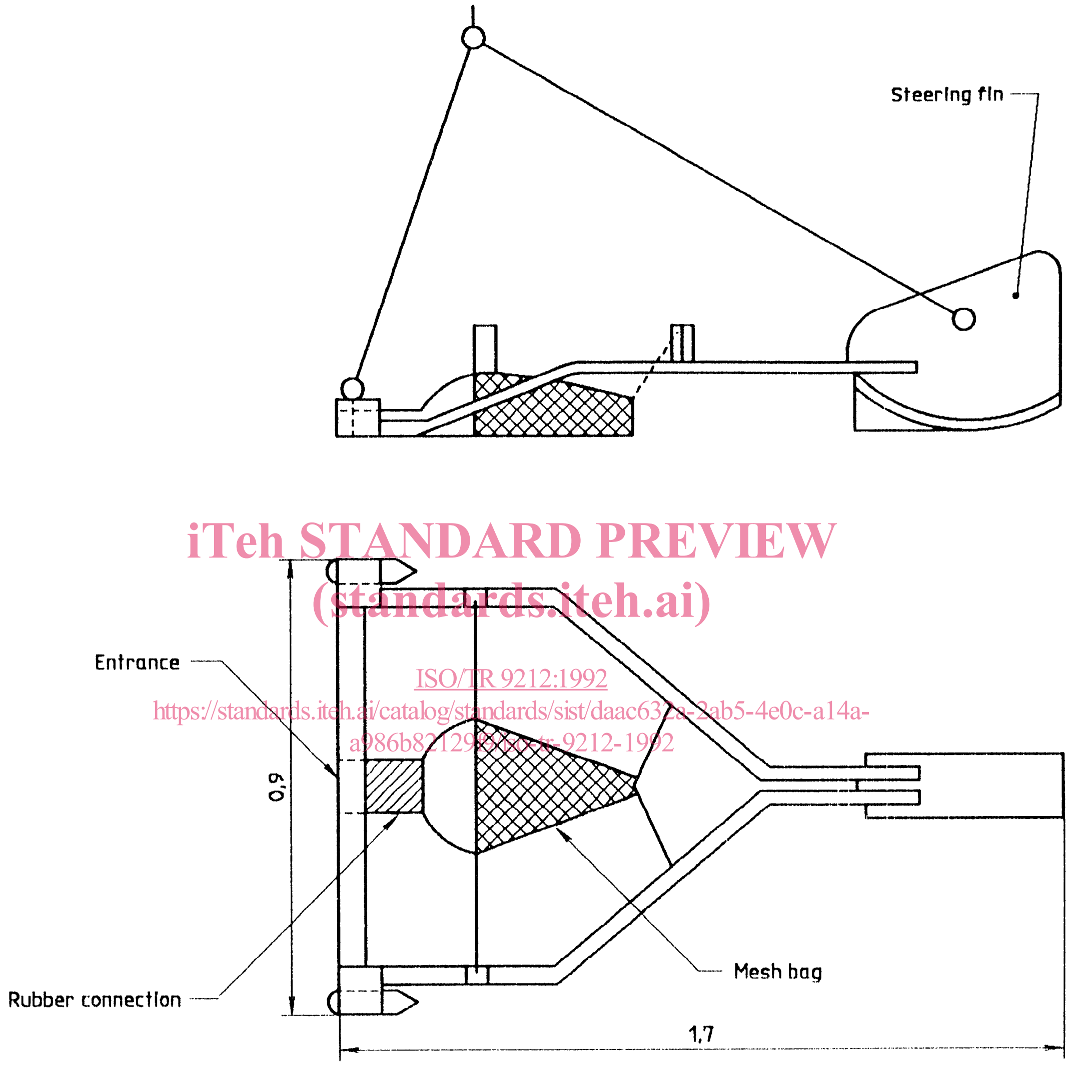
This type of sampler (see figures 5 to 11) is designed so the velocity of water entering the sampler and the stream velocity are approximately the same. Equalization of velocity is accomplished through creation of a pressure drop at the exit due to a diverging configuration between the entrance to the 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.



NOTE — This is a pressure-difference type of bedload sampler. The SRIH sampler was the first of this type to be developed. A pressure-difference sampler is designed so that the entrance velocity is about equal to ambient stream velocity. Such samplers can sample particles as small as fine sand to as large as 200 mm. Efficiencies are extremely variable.

Figure 5 — Scientific Research Institute of Hydrotechnics (SRIH) sampler

Dimensions in metres



NOTE — This is probably the best known of all pressure-difference type samplers. The Arnhem or Dutch sampler is composed 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 %.

Figure 6 — Arnhem sampler