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Hydrometry — Measurement in meandering river and in streams with unstable boundaries

Hydrométrie — Mesurage en rivières à méandres et en cours d'eau à limites instables

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Foreword

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This document was prepared by Technical Committee ISO/TC 113, *Hydrometry*, Subcommittee SC 1, *Velocity area methods*.

This second edition cancels and replaces the first edition (ISO/TR 9210:1992), which has been technically revised.

Introduction

Various methods of measurements of discharge in open channels are available, of which the velocity-area method is most extensively used. The principles of this method are published in ISO 748.

However, there are rivers and streams, in which there are no river sections with constant bed levels and constant flow conditions. This document deals specifically with measurements of flow in meandering and braided rivers, and elaborates some of the provisions in ISO 748.

Hydrometry — Measurement in meandering river and in streams with unstable boundaries

1 Scope

This document provides guidelines for discharge measurements in meandering and braided rivers, and from bridges, following the provisions of ISO 748.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, *Hydrometry — Vocabulary and symbols*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
alluvial river
river, which flows through alluvium, formed from its own deposits

Note 1 to entry: The sediment carried by an alluvial river, except for the wash load, is similar to that in the bed.

3.2
braided river
river characterized by a wide and shallow open channel, in which flow passes through a number of small-interlaced channels separated by shoals

Note 1 to entry: Frequently, there is little or no erosion of the main banks of a braided river.

Note 2 to entry: Generally, there is little or no meandering of the main channel of a braided river, but meandering in the minor channels is usual.

3.3
meandering river
channel following a sinuous path, characterized by curved flow leading to bank erosion alternating with shoaling

3.4
transition
crossover
inflection reach between two meander loops in which the main flow crosses from one side of the channel to the other

Note 1 to entry: The depth of flow in a transition is usually reduced from normal depth and is more uniform than in the curved reach.

3.5
transverse flow
flow horizontally perpendicular to the main direction of flow parallel to the axis of the open channel(s)

Note 1 to entry: Transverse (lateral) flow is frequently associated with secondary flow.

Note 2 to entry: Transverse (lateral) flow in open channels with a curved plan form causes superelevation of the water surface at the outside of the bend.

3.6
nodal point
node
inflection point
point in a transition at which the sinuous path crosses the mean axis of the meander system

Note 1 to entry: In a meandering stable channel, the nodal point migrates downstream with the meander loops. Migration can be prevented by the creation of a natural or artificial obstruction in the channel.

3.7
gauge
device installed at a gauging station for measuring the level of the surface of the liquid relative to a datum

4 Site selection in rivers

However, when the flow directions during flood and low flow seasons are very different, it is permissible to suitably adjust the orientation of gauging section during that season, taking into account the requirements in ISO 748:2007, 5.1 a) and b).

ISO 748:2007, 5.1 b) further states that the accuracy of the determination of discharge is increased if the flow directions for all points on any vertical are parallel to one another, and at right angles to the measurement section.

ISO 748:2007, 5.1 c) recommends that the bed and the margins of the channels should be stable and well-defined at all stages of flow in order to facilitate accurate measurement of the cross-section, and to ensure uniformity of conditions during and between discharge measurements.

At a measuring site, even if properly located to satisfy these requirements during flood season, the flow direction can change appreciably during low water season. As far as possible, the basic stream gauging section should not be changed. However, when the flow directions during flood and low water seasons are very different, it is permissible to suitably adjust the orientation of gauging section during the low water season, taking into account the requirements in ISO 748:2007, 5.1 a) and b).

5 Site selection in rivers with relatively stable meanders

In alluvial rivers, the course over long reaches is sometimes comprised of one meander followed by another. Then, finding a sufficiently long straight reach becomes difficult.

In a bend, transverse flow develops, and the resultant direction and velocity of flow are composed of the net effect of normal and transverse flows. The distribution of velocities and depths across the section also becomes extremely heterogeneous. In the transitions between successive meanders, the river course is relatively straight over a short reach. The cross-sections are more uniform and better defined than those in the bends are. A transition therefore provides better site conditions for a gauging station. When a straight reach over a sufficiently long distance is not available, the best alternative is therefore to select a gauging site in the transition between successive bends.

The important factors that affect the accuracy of the discharge measurement in meandering rivers are the scouring, silting and the change in flow direction at the discharge measuring section. The velocity measured at each point should be corrected for angle using a direction-measuring current meter.

6 Site selection in rivers with unstable meanders

In alluvial rivers, meanders are often unstable. If the bend curvature is small, the meander tends to progress downstream by continued erosion along the concave bank and filling along the convex bank. In this process, the river course changes its position. If the bend curvature is large, continued erosion and channel filling result in formation of a hairpin bend, ultimately forming a cut-off across the bottleneck. In this process, the meander changes its shape. Thus, depending on the bend curvature, bank recession and changes in meander position and/or shape occur, rendering the river course unstable. Requirements of site stability cannot be satisfied in such rivers.

Local strata of stiff clay or rock are sometimes encountered along the meandering course of alluvial rivers. This natural constraint obstructs free passage of the meandering river. The meanders accumulate upstream of such constraints. After some distance on the downstream side, the river course forms meanders again. But immediately downstream of the constraint, the river profile does not change appreciably. These locations are termed "nodal points" and, in view of the stability of the river bed at these points, they are ideally suited for locating gauging sites on rivers, which have an unstable course.

When natural constraints do not occur, sometimes-artificial constraints in the form of a bridge with a constricted waterway may exist. The effect of such an artificial constraint is to produce nodal points. The river reach immediately downstream of such structures where the river course remains locally stable, can be utilized for locating gauging sites.

At such measurement locations on rivers with unstable meanders, it is useful if two different water level gauges are installed at two consecutive nodal points. If moving gravel bars make the exact measuring of the water level in a measuring profile impossible or inaccurate, the existing of a second level measurement at a less detracted profile could be very useful for the measuring of the water levels and the determination of the corresponding discharges.

7 Discharge measurement in braided rivers

The discharge measurements in braided rivers with sandy beds are difficult to carry out due to the instability of the river bed. The flow in some rivers at meanders can reverse on the inside of the curve in the form of a gyre. In the discharge measurement, the negative flow should be subtracted to get the net flow.

Due to different bed forms, the parts of a cross-section can have varying roughness and depths. All these factors can bring about appreciable variation in water level, even with the same discharge. Are there such quick and noticeable changes, lots of discharge measurements are necessary to define the continuing shifting of the rating curves.

Under these conditions, in addition to the mean stage-discharge curve, rating-curves at the extremes of depth must be established. Upper levels and freeboards of engineering structures have to be designed with respect to upper stage curves, whereas foundation levels have to be designed with respect to the depth of flow recording to the lower stage envelope curves.

When several major channels are required to be gauged along the measuring line, it may become necessary to employ two or more measuring boats and crews to work simultaneously in order to complete one discharge measurement at a single time.

Braided rivers in sub-mountainous regions are often subject to sedimentation, with a tendency towards shifting channels. Discharge measurements therefore should be made as quickly as possible to keep the change in stage to a minimum. This can be achieved by using a single-point or a two-point method for the velocity measurement instead of multiple-point method and by reducing the number of the observation verticals.

At such measurement conditions in braided rivers with a great instability of the river bed and frequent changes of the islands (which separate the river channels), it would be useful to install two different water level gauges at neighbouring locations. This results in additional information for better decisions, basics for the shifting of the rating curves.