भारतीय मानक

कंक्रीट और चिनाई वाले बाँधों में विरूपण मापन युक्तियों के संस्थापन, रख-रखाव और प्रेक्षण की मार्गदर्शिका

भाग 2 कम्पन तार किस्म के संयुक्त मीटर

Indian Standard

GUIDELINES FOR INSTALLATION, MAINTENANCE AND OBSERVATION OF DEFORMATION MEASURING DEVICES IN CONCRETE AND MASONRY DAMS

PART 2 VIBRATING WIRE TYPE JOINTMETER

ICS 93.160; 91.220

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Price Group 2

FOREWORD

This Indian Standard (Part 2) was adopted by the Bureau of Indian Standards, after the draft finalized by the Hydraulic Structures Instrumentation Sectional Committee had been approved by the River Valley Division Council.

To minimize cracking, large straight gravity and arch gravity dams are made in blocks, separated from each other by transverse and longitudinal contraction joints. To restore the dam to its monolithic state for integrated behaviour, contraction joints are grouted with cement grout. Grouting of joints is done when the joints have opened to their maximum. Measurement of joints movement during grouting operation will indicate the quantity of grout to be pumped into the joints.

Measurement of joint movements subsequent to the completion of the grouting of contraction joints, provides information regarding the behaviour of the grouted joint.

Surface measurement of joint movements are useful for observing movement of joints. These measurements can be made with mechanical strain gauges . However, surface measurements cannot be fully relied upon, as all joints do not open to the same extent. Internal joint movements may, therefore, also need to be measured. Jointmeters are used for measurements of internal movements of joints.

This standard has been prepared in two parts : IS 10434 (Part 1) : 1982 'Guidelines for installation, maintenance and observation of deformation measuring devices in concrete and masonry dams : Part 1 Resistance type jointmeters' covers the resistance type jointmeters, and Part 2 covers the vibrating wire type jointmeters.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GUIDELINES FOR INSTALLATION, MAINTENANCE AND OBSERVATION OF DEFORMATION MEASURING DEVICES IN CONCRETE AND MASONRY DAMS

PART 2 VIBRATING WIRE TYPE JOINTMETER

1 SCOPE

This standard (Part 2) covers the details of installation, maintenance and observations of vibrating wire type jointmeters of the embedded type for measurement of joint movements at the surface and in the interior of concrete and masonry dam.

2 REFERENCE

The Indian Standard IS 6524:1972 'Code of practice for installation and observation of instruments for temperature measurement inside dams — Resistance type thermometers', is a necessary adjunct to this standard.

3 MEASUREMENTS OF JOINT MOVEMENTS AT THE SURFACE BY DETACHABLE GAUGES

3.1 Principle and Construction

Measurements of joint movements at surface or at the locations accessible from galleries are made by detachable gauges.

The vibrating wire type jointmeters can also be used for mounting on surface by providing suitable mounting fixtures with the gauge.

3.2 Number, Location and Layout

The mounting studs should be installed on the surface at points corresponding to the locations of jointmeters inside the dam. These should also be fixed inside galleries across accessible joints at points which correspond to the jointmeter locations.

3.2.1 Mounting studs should be fixed across cracks that are considered dangerous to the integrity of structure. The behaviour of these cracks should be observed under imposed loading.

3.2.2 The arrangement for fixing the mounting studs across the joint is shown in Fig. 1. The difference in the readings derived from the relevant formula gives the value of increase/decrease in the joint opening.

4 MEASUREMENT OF INTERNAL JOINT MOVEMENTS BY JOINTMETERS

4.1 Jointmeters

Two kinds of jointmeters for internal joint movement measurements are in use:

a) Resistance type [*see* IS 10434 (Part 1) : 1982], and

b) Vibrating wire type

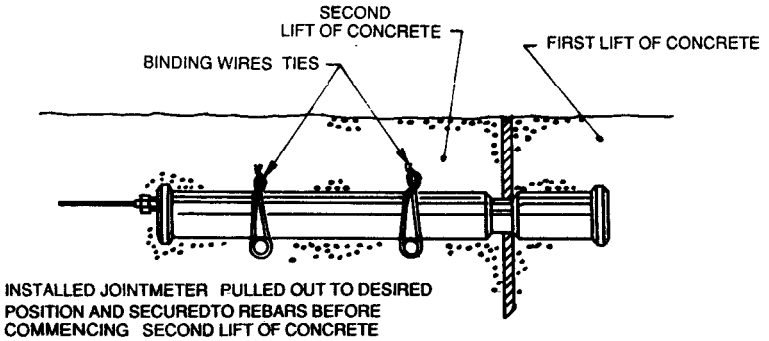

FIG. 1 JOINTMETER INSTALLATION

4.1.1 *Vibrating Wire Type Jointmeter*

4.1.1.1 *Operating principles*

The basic principle of Vibrating Wire Type Jointmeter is that change in natural frequency of a stretched wire depends on the change of the tension in the wire. In this instrument one end of the wire is attached to the moveable head of the jointmeter by a steel spring and the other end to a fixed point. Any displacement is thus transformed to a variation in tension of the spring and vibrating wire. The frequency of the wire is a measure of displacement between joints. A difference of square of frequencies is proportional to the displacement. The frequency readings are read by the vibrating wire readout which is connected to the gauge by cables.

4.1.1.2 *Construction*

The jointmeter is constructed in two parts, the moveable part and the fixed part. Normally both the parts have a flange at each end of the instrument. The moveable part is attached to a spring which in turn is connected to the vibrating wire. With the movement of joint the moveable part of the jointmeter moves thereby changing the resonant frequency of the vibrating wire.

4.1.1.3 *Advantages*

The vibrating wire type jointmeter works on the principle of observing frequency and the main advantages are:

1) Easy to read by simple instrument;

2) Effects of signal cable resistance, contact resistance, leakage to ground or length of signal cable are negligible; and

3) Frequency signal permits data transmission over long distance and thus suitable for centralized observation.

4.2 Number and Location

4.2.1 Number of jointmeters required to be provided in any dam will depend upon the dimension, block layout, provision of transverse and longitudinal joints or transverse joints only, configuration of the foundation profile, presence of specially-treated foundation features under the dam and the extent to which measurements of joint behaviour would prove adequate in representing the joint movements for the entire structure.

4.2.2 In the case of a dam built in V-shaped canyon; jointmeters should be installed in at least three blocks, namely, one central block representing the deepest and maximum section of the dam and a block each in the abutment portions representing blocks built on steeply sloping section.

Jointmeters should also be installed in one of the non-overflow blocks or any other block which is representative of these blocks. In each of the blocks, jointmeters should be placed in the centre of the portion, encirled between the grouting joints.

4.3 Signal Cable

This cable connects the transducer to the readout unit. It should be selected to withstand the environment in which it is required to be laid.

In normal cases, cables with two core annealed copper conductors and with copper shield, heavy PVC coating should be used. When used in adverse environment, steel armoured petroleum jelly-filled and polyethylene-insulated cables should be used. Heavily armoured cables with 10, 20 or more pairs of conductors should be used to connect different junction boxes to the instrument house.

4.3.1 The calculated length of cable should be increased by 10 percent or 1.5 m, whichever is more, to allow for possible variation in the selected route.

4.3.2 Each meter length of cable should be identified by a letter prefix. The normal prefix for jointmeter is JM-1, JM-2 etc. After splicing, a copper band duly stamped or punched with instrument identification number is crimped to the cable about one metre away from the free end. In addition a few more labels consisting of the identification number marked on white tape should be placed around the cable near the read-out end.

4.3.3 Provisions contained in **4.3** of IS 6524 : 1972 should also apply to the jointmeter installation.

4.4 Terminal Boards

Cables should be terminated in suitable terminal boxes. Jointmeter numbers should be indicated in the terminal boxes also as described in **4.3.2**. If the terminal boxes are to be placed in the inspection gallery, they should be mounted in niche, preferably on the downstream side. The terminal boxes should be moisture-proof.

4.5 Readout/Data Logger

A simple, portable, battery-operated readout unit with 4-digit LCD display should be used. Calibration data for each transducer should be provided for converting the frequency readings to relevant engineering units when a simple readout unit is used to read frequency.

5 CALIBRATION

5.1 Each transducer should be calibrated separately on a suitable calibration system in the laboratory prior to taking the instrument to field for installation. It is very often not possible to recalibrate a sensor after installation. This means that good long term stability of the sensor is very important to obtain reliable results. The sensors should be capable of overloading to 1.5 times the rated capacity. While calibrating the sensors, the transducers are to be overloaded to 10 percent more than the rated capacity for at least 10 times for stabilizing the calibrated readings. Each transducer should be provided with a separate calibration certificate.

Usually the gauge wire and the body of the transducer are made of materials having similar coefficient of thermal expansion and the temperature variation, if any, thus will only influence the readings to a very limited degree. The transducers are to be calibrated at different temperatures within its working range and the thermal coefficient should be recorded in calibration certificate.

5.2 Method of Installation

5.2.1 *Vibrating Wire Type Jointmeters*

5.2.1.1 Prior to embedment of jointmeter, each instrument should be checked physically and also functionally by moving the movable part of the jointmeter and observing the change in the readings on the readout.

5.2.1.2 The jointmeter is installed in two parts, the movable part and the fixed part. During the first lift of concrete, the socket is fixed to the framework with the installation plug and bolt. When the concrete has cured, the framework is withdrawn leaving the exposed end of installed socket ready to accept the main body (fixed part) of the jointmeter.

Before the second lift of concrete is cast, the jointmeter is screwed into the installed socket, extended sufficiently to allow for expected joint movement, tied securely on rebar supports. When both the lifts of concrete are complete, the jointmeter is firmly anchored into each lift to measure opening or closing the joint. The sensing transducer is usually smaller than the protective body of the jointmeter. A small degree of shear motion of the concrete is accommodated by universal joint of the unit.

5.3 Observation

5.3.1 Observations of the resonant frequency of the jointmeter should be made by connecting the leads from the jointmeter to the Readout Unit. The leads from the jointmeter are brought out to the Terminal Boxes fixed in the galleries. To ensure correct and reliable measurement the identification marks on the leads must be checked.

5.3.2 The following reading schedule may be adopted:

a) Immediately after embedment;

b) Every 3 h for the next 30 h;

c) Every 12 h for the next four days;

d) Once a day till the concrete temperature rises to a maximum (usually about two weeks);

e) Bi-weekly for the next month;

f) Weekly afterwards until the completion of contraction, joint grouting, and

g) Fortnightly thereafter.

5.4 Forms of Record

Observations should be recorded on the field reading form shown in Annex A. These forms should be got printed sufficiently in advance and kept ready. Duplicate copy of observations should be prepared simultaneously. The original should be sent to design office, or to the office entrusted with the analysis of the data and the duplicate retained in the field record office for future reference.

Alternatively, if a Central Data Acquisition System is used, the data is automatically collected and presented in the formats as required in the method of analysis used.

5.5 Readings

The readings of resonant frequency change are taken with the help of readout unit.

The value of calibration factor K, the value of zero frequency f_o, coefficient of temperature C and the value of constant A should be provided by the instrument manufacturer after calibrating the instruments in the factory.

The following formula is used to calculate the displacement:

$$D = K\,[(f^2 - f_o^2) + C\,(t - t_o)] + A$$

where

K = calibration factor (mm/H_z^2),

f_o = zero frequency (H_z) at t °C,

f = frequency (H_z) at t °C,

C = coefficient of temperature (H_z^2/°C),

D = displacement (mm) at t °C,

A = zero offset (mm),

t = temperature of the instrument at the time of observation in °C, and

t_0 = temperature of instrument at the time of calibration in °C.

NOTE — If joint is closing, then f_0 is larger than f and value of D is negative, and if joint is opening, then f is greater than f_0, and value of D is positive.

ANNEX A
(*Clause* 5.4)

PROFORMA FOR RECORD OF OBSERVATIONS OF VIBRATING WIRE TYPE JOINTMETERS

Project :

a) Instrument Name :

b) Instrument Manufacturer :

Location :

Initial Frequency f_0 : Calibration Temp (t_0) :

Calibration Factor (K) : Temperature Coefficent (C) :

Zero Offsets (A) :

Displacement $D = K [(f^2 - f_0^2) + C (t - t_0)] + A$

Date	R. W. L. in m	Temperature of Location of Jointmeter t °C	Observed Frequency (f) H_z	Difference of Squared Frequencies ($f^2 - f_0^2$) H_z	Displacement (D) mm	Remarks

Observer's Signature:

Date:

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Handbook' and 'Standards : Monthly Additions'.

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