Vibrating Wire Triaxial Jointmeter
User Manual

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Section 1 : Foreword

It is essential that the equipment covered by this manual is both installed and operated by competent and suitably qualified personnel. They must both **READ AND UNDERSTAND** the procedures outlined in this manual before attempting installation or operation of the equipment on site.

All systems are designed to operate consistently under normal field conditions but although their components are relatively robust for such sensitivity they will not survive mishandling or neglect. Treat all items with respect and handle with CARE.

Obviously these techniques can only serve as a general guide and will require modification to suit particular circumstances on site. If difficulties are encountered time will usually be saved by contacting Soil Instruments at the earliest opportunity.

Section 2 : Introduction

The Vibrating Wire Triaxial Jointmeter measures relative displacement of two points either side of a construction joint. The Jointmeter comprises three displacement transducers, installed in such a way that displacement is measured in 3 planes at 90° to each other.

The anchor legs of the Jointmeter are grouted into drilled holes either side of the joint to be studied.

The Jointmeter can be installed in any orientation but the method of Installation will vary according to whether the anchor legs are to be installed into holes drilled upwards, downwards or horizontally.

Displacement transducer range is 30mm, other ranges can be supplied on request.

Vibrating Wire Triaxial Jointmeters can be manufactured not only to measure the movement of “flat” joints but of joints between walls or sections of a structure at any angle to each other. Our engineers will be glad to discuss your requirements with you.

2.01 Preliminary Tests

Upon receipt of the instrument on site, the following checks should be carried out immediately:

The Jointmeter arms should be inspected for transit damage and a check made that the clamp bushes and locking nuts are firmly held in position.

The transducers should be checked using the Vibrating Wire Readout/Logger.

The audio signal from the transducers should be sharp and consistent and the period reading should not vary by more than ± 1 period unit.

A “range check” can be carried out on each transducer by programming the Vibrating Wire Readout/Logger with the gauge factor for the transducer and a “zero” period reading taken when the piston is fully extended.

By fully compressing the piston, the reading from the logger should change by slightly more than the quoted range of the transducer.

(This is because all transducers are manufactured with a slight “overrange”.)

Section 3 : Installation

3.01 Mounting Arm Installation

Jointmeters are installed across construction joints using two specially designed mounting arms. One arm has a three-sided anvil; the other has three holes with collets to accept the displacement transducers.

Holes are drilled either side of the construction joint to accept the anchor legs of the Jointmeter.
Each hole should be drilled to 100mm depth with minimum 25mm diameter.
The legs will be fixed in position using grout or epoxy resin. If the drilled holes are not vertically downwards, the Jointmeter will have to be temporarily supported in position while the grout or resin sets.

The mounting arms of the Jointmeter are aligned using an installation jig.
The size of the installation jig also determines the initial setting for the displacement transducers.
Once the grout or resin has set sufficiently, the installation jig is removed.

3.02 Transducer Installation and Base Reading

Once it has been verified that the Jointmeter arms are firmly fixed in position, installation of the displacement transducers can begin.

The Vibrating Wire Readout/Logger should now be used to record a "base" period reading for all three transducers with their pistons fully extended.

The transducers are now inserted into the locating holes in the Jointmeter arm such that their pistons come to rest on the anvil.

The reading of each transducer should now be checked to ensure they are at the required initial setting. The following numerical example should make the procedure clear:

Example

Gauge Constant K : -80.1028
Base Period Reading N_0 : 4166.4
Period Reading after transducer installation N_1 : 5028.2

Position of piston rod at initial setting

$$= -80.1028 \left(\frac{10^7}{4166.4^2} - \frac{10^7}{5028.2^2} \right)$$

$$= -\underline{14.46\ \text{mm}}$$

The Jointmeter transducer is set at 14.46 mm or -0.54mm away from the mid point of its 0-30mm range. This method can be used to check the initial setting of each transducer.

The only adjustment available is by unscrewing the transducer in the arm.
Once initial setting is satisfactory, lock the transducer by tightening the locking grub screw.

Once all the three transducers have been installed, the serial numbers of the x, y and z transducers should be recorded along with their initial readings.

The transducers should now be connected to the remote reading location using either an individual cable for each transducer or by using a single multiconductor cable connected to the transducers by a small junction box.

Any covers should be fitted as soon as possible after cable connection.

3.03 Routing Cables

Cable should be protected to avoid damage during and after the Installation.

The cables from the instrument can be spliced onto armoured, direct burial cable which can be safely routed through concrete without protection. Ensure that sharp kinks and bends are avoided and that no rodding or vibrating pokers are allowed close to the cable.

3.04 Splicing

Because vibrating wire transducers output frequency or period, a direct derivative of frequency, rather than current or voltage, slight variations in cable resistance have no effect on Jointmeter readings. Consequently, splicing has no effect on instrument performance allowing cables to be spliced and routed to junction boxes and then connected to multiconductor cables for transmission to a central location.

Splicing should be carried out using an epoxy spicing kit and in accordance with the instructions included in the kit.

3.05 Initial Data

Once the Jointmeter has been installed and the transducer setting has been achieved, a 'Base' or 'Initial' Reading must be recorded. This value should be recorded in Period x 10^7 units and since it will be used in the calculation of all subsequent readings, it is good practice to take a number of readings and use the average value.

Section 4 : Monitoring and Data Interpretation

Each Soil Instruments Vibrating Wire transducer is calibrated and is supplied with a standard Calibration Certificate giving the Gauge constant and information on atmospheric conditions at the time of calibration.

Calibration is carried out by pulling out the connecting rod to full range while it is coupled to a micrometer. Readings are taken at full range displacement/extension, a number of intermediate points and at zero extension, the gauge factor is then calculated.

Because vibrating wire Triaxial Jointmeters measure the movement of construction joints in three dimensions it is essential after installation that a record is made of precisely which direction of movement each transducer is recording. It must be recorded what type of movement is indicated by a positive or negative increase in displacement reading.

For example, if the joint opens, the piston on the relevant transducer will be pushed inwards. A higher "period" reading will therefore occur. The transducers are supplied with negative gauge factors which (when used in the vibrating wire equation given below) means a negative increase in displacement is measured.

A similar note must be made for both other transducers in the Jointmeter. One transducer is measuring transverse shear and the other longitudinal shear of the joint.

Following the installation instructions the reference reading is noted which indicates zero movement. Subsequent data obtained from the Jointmeter can be reduced to linear movement in millimetres by using the gauge constant in the equation given in the Calibration Certificate. An example of data reduction is as follows;

Gauge Constant: K mm: -120.4254

Reference Reading No: 6320
(Zero measurement)

Example 1: Subsequent Reading N_1: 4820

Equivalent Linear Movement (Extension): $\Delta L = K \times \left(\frac{10^7}{N_o^2} - \frac{10^7}{N_1^2} \right)$

ΔL = 21.685mm

Example 2: Subsequent Reading N_2: 6740

Equivalent Linear Movement (Extension): $-120.4254 \left(\frac{10^7}{\{6320\}^2} - \frac{10^7}{\{6740\}^2} \right)$

ΔL = -3.6404mm

The jointmeter working elements are made primarily of steel and stainless steel and are affected by changing temperature to a certain predictable degree. In case of large temperature changes application of temperature correction will improve the accuracy of the measurements. The approximate temperature effect on the gauge is -0.02mm per degree Celsius.

Hence for a temperature increase of 10º C Jointmeter will indicate (-0.02 x 10) -0.2mm reduction in linear measurement. Correction is applied by adding 0.2mm to the result indicated by the Jointmeter reading. A fall in temperature will result in a positive change in linear measurement which can be corrected accordingly.

Physical dimensional changes due to temperature in the Jointmeter and the structure on which it is mounted are of the order of 10^{-6}m/m/°C and can be neglected.

Barometric pressure changes do not affect the Jointmeter reading.

4.01 Environmental Factors

Since the purpose of the Jointmeter installation is to monitor site conditions, factors which may affect these conditions should always be observed and recorded. Seemingly minor effects may have a real influence on the behaviour of the structure being monitored and may give an early indication of potential problems. Such factors include but are not limited to: blasting, rainfall, tidal levels, excavation and fill levels and sequences, site traffic, temperature and barometric changes, changes in personnel reading the instruments, nearby construction activities and seasonal changes.

Section 5 : Troubleshooting

If a failure of any Vibrating Wire transducer or the electrical cable is suspected, the following steps can be followed. The transducers themselves are sealed and cannot be opened for inspection. The "Troubleshooting Flowchart" should also be followed if any instrument failures are suspected.

The steps below and the Troubleshooting Flowchart are applicable generally to any vibrating wire instrument.

STEP 1

Before any of the following steps are followed, the readout unit should be used to verify the stability of the reading and the audio signal from the portable logger should be heard. An unstable (wildly fluctuating) reading from a transducer, or an unsteady audio signal are both indications of possible problems with instruments or their related electrical cables.

If a portable data logger is giving faulty readings or audio signals from all transducers, a faulty readout unit must be suspected. Another readout unit should be used to check the readings from the transducers and Soil Instruments Ltd. should be consulted about the faulty readout unit.

STEP 2

The resistance across the two conductors of the electrical cable should be checked. This can be done using a multimeter device across the two exposed conductors if the cable has not been connected to a terminal cabinet, or can be done just as easily across the two conductors if the instrument has been connected to such a terminal (or datalogger).

The resistance across the two conductors should be approximately of the order of 120° to 180°. The majority of this resistance will come from the transducer (say approximately 130°).

Before proceeding to Steps 3 and 4, the continuity should be checked between conductors and earthing screen of the electrical cable. If continuity exists, a damaged cable is confirmed.

STEP 3

If the resistance across the two conductors is much higher than the values quoted in "STEP 1" (or is infinite), a severed cable must be suspected.

STEP 4

If the resistance cross the two conductors is much lower than the values quoted in "STEP 1" (say 80 ○ or less) it is likely that cable damage has occurred causing a short in the circuit.

STEP 5

If the resistance is within the values quoted in "STEP 1" (i.e. 120° to 180°), AND no continuity exists between conductor and earth screen and on checking the reading from the transducer, it proves to be still unstable or wildly fluctuating, it must be assumed that the integrity of the circuit is good. A faulty transducer could be suspected if neighbouring construction activities do not account for the anomaly Soil Instruments Ltd. should be consulted.

If the point at which the cable is damaged is found, the cable can then be spliced in accordance with recommended procedures.

Appendix A. Trouble Shooting Flowchart