INSTRUCTION MANUAL

VIBRATING WIRE TYPE
JOINT METER

SENSORS & MEASUREMENTS ENTERPRISES
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Vibrating wire joint meter

1. Introduction

The SME vibrating wire joint meter is designed to measure the displacement/ movement across joints such as the joint opening between two concrete/ masonry blocks in a dam. It is also used for the monitoring of cracks and for displacement in concrete structures, rocks, bridges and pavement slabs etc.

In mass concrete, much of the temperature rise caused by the heat of hydration of the cement takes place at a time when the concrete is relatively weak and easily deformed. Thus for a block of concrete placed between two older blocks, any tendency towards expansion at early age is largely observed by creep in the concrete. When the temperature drops, contraction joints open almost immediately. It is often important to measure the opening of the contraction joints at some distance from an available surface in order to judge accurately when joints should be grouted, how much grout should be pumped into the joints, and to explain unusual occurrences which accompany the building of the dam. These measurements at inaccessible points are made with electronic joint meters.

Surface joint measurements can be made either on the surface or at locations accessible from galleries. The measurements are made by fixing two reference points, one on either side of the joint and accurately measuring the distance between the two points mechanically or electronically at certain intervals. Full reliance should not be placed on surface measurements. It should be recognized that all pars of a joint do not open at the same time, nor even the same amount. Thus, most information on joint opening is gained from internally located joint meters. In some cases, where knowledge of shearing movement is desired, surface measurement can be made to advantage where joints are accessible in galleries.

NOTE: Surface measurements should be made at locations corresponding to embedded joint meters so that results can be compared.

The SME joint meter is in the general form of a cylinder. The central portion of the cylinder comprises of a metallic housing which permits expansion. One end of the cylinder is provided with threads which screw the joint meter through a threaded socket which is anchored and buried perpendicular to the contraction joint in a block of concrete. The other end of the cylinder comprises of an end socket, cable joint housing and rubber bellows which are embedded on the concrete block on the other side. Thus the joint meter is embedded across a joint, half on each side so as to be stretched when the joint opens. To prevent cement milk from filling up the extensible socket of the meter is protected inside the steel tube. The space between the joint meter and the steel tube is filled with grease and a rubber end cap snapped over the steel socket. The rubber end cap has a central hole to slide over the straight portion of the joint meter.

2. Vibrating wire joint meter

2.1. Operating principle.

The vibrating wire joint meter basically consists of a magnetic, high tensile strength stretched wire, one end of which is anchored and the other end fixed to an element with a extendable when required. A spring which deflects in proportion to the displacement is attached to the other side of the element. Any change in displacement, deflects the element proportionally and this in turn affects the tension in the stretched wire.

The wire is plucked by a coil magnet. Proportionate to the tension in the wire, it resonates at a frequency f.

The resonant frequency, with which the wire vibrates, induces an alternating current in the coil magnet. This is ready by the read out unit.

Summarizing, any variation in joint operating, causes the element to deflect. This change in tension in the wire, thus affecting the frequency of vibration. The displacement is proportional to the square of the frequency and the read out unit is able to display this directly in engineering units.

2.2. General description

The joint meter is manufactured in various capacities. The transducer is provided with a thermistor for monitoring the temperature (on demand). Normally, no stress correction due to temperature induced frequency changes is required. However, if it is necessary to make these corrections, refer to the data on zero shift due to temperature changes provided in the test report.

a.) Stainless steel body

The vibrating wire and coil magnet assembly is enclosed in a stainless steel body with a expendable body to take care of the expansion. The sensor is hermetically sealed. This resulting in it becoming immune to the effect of any ingress of water. It will always remain in the closed position, unless stretched or pulled mechanically.

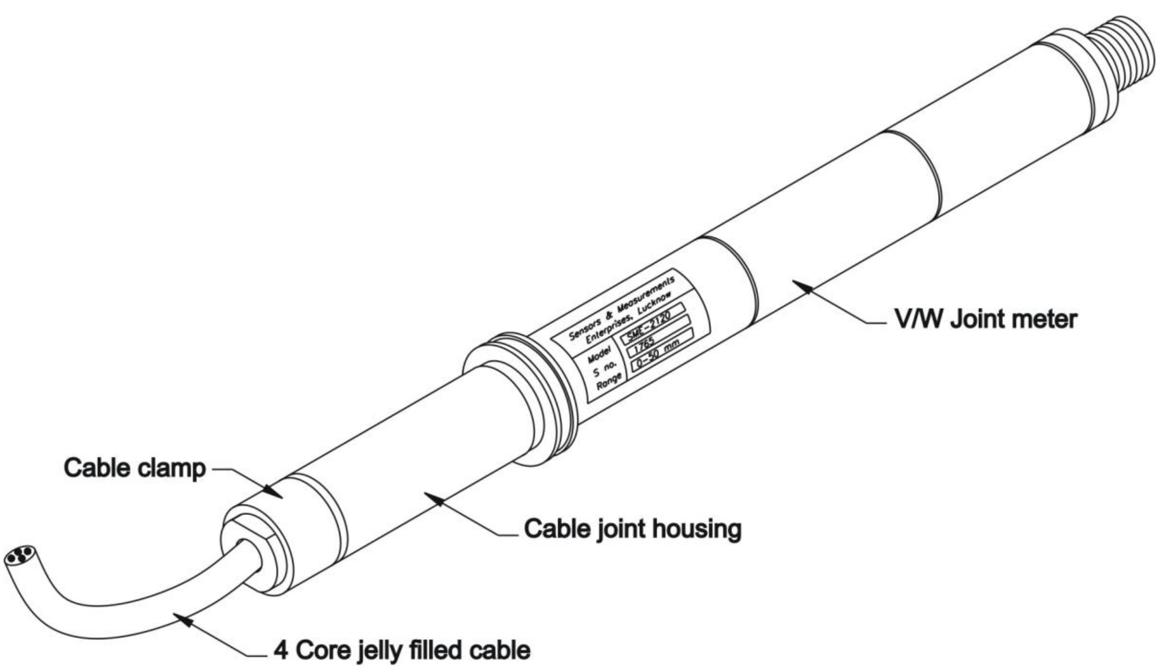
b.) Cable connection

The leads from the coil magnet are brought to the cable joint housing The four core cable with two core marked red and black are connected to the coil magnet. The other two wire marked green and white are connected to the thermistor (if thermister is connected). A cable joint housing and cable gland is provided for the cable connection.

Proper cable jointing should be ensured.

c.) Socket assembly

The socket assembly consists of a steel socket , which serves to act as a hold fast in the concrete and a protective rubber cap. It has a central threaded hole to which the joint meter end can be screwed directly. The detail of joint meter assembly is shown in the following figure.



CAUTION: Make sure that the threads of the joint meters are not damaged in transport or storage. They should match with the threads in the joint meter and the socket assembly.

2.3. Taking readings with the vibrating wire indicator

The model SME 2460-P vibrating wire indicator is a microprocessor based read-out unit for use with vibrating wire transducers. It can display the measured frequency in terms of time period, frequency squared or the value of the measured parameter directly in proper engineering units.

The SME 2460-P indicator can store calibration coefficients of up to 100 vibrating wire transducers so that the value of the measured parameter from these transducers can be shown directly in proper engineering units.

The indicator has an internal non-volatile memory with sufficient capacity to store about 700 readings from any of the 100 programmed transducers in any combination.

The calibration coefficients are given in the individual test report provided with each transducer. The gage factor, unit and sign can directly be taken from the test certificate for programming the readout unit. For transducers with a built in interchangeable thermistor, it can also display the temperature of the transducer directly in degree Centigrade.

The stored readings can either be uploaded to a host computer using the serial interface or can be printed out on any text printer equipped with a RS-232C serial communications interface.

An internal 12V. rechargeable Eveready cell are used to provide power to the indicator. A fully charged new battery provides nearly 20 hours of operation on a single charge. A separate

battery charger is provided with the indicator to charge the internal battery from 230 V AC mains.

The readout unit is housed in a aluminum enclosure and the readout unit is provided with suitable lather case for easy transportation and taking the data.

3. Tools and accessories required for Installation

The following tools and accessories are required for proper cable jointing and installation of the joint meter:

3.1. Soldering iron 25 watt
3.2. Rosin solder wire, 30 swg
3.3. Cable jointing compound
3.4. Acetone (commercial)
3.5. Spanner adjustable.
3.6. Cable jointing housing
3.7. Collar plug (to seal end socket assembly before concreting)
3.8. Hacksaw with 150 mm blade
3.9. Cable cutter
3.10. Surgical blade with holder
3.11. Wire stripper
3.12. Pliers 160mm
3.13. Stainless steel rod 5 mm Φ 150 mm length
3.14. Rotary tin cutter
3.15. Wooden fixture for jointing the joint meters
3.16. Cloth for cleaning
3.17. Petroleum jelly/grease
3.18. Spirit level
3.19. Multimeter

3.20. Model 2460-P portable readout unit

4. Installation procedure & trouble shooting

The embedment procedure of the joint meter is completed in two stages. During the first stage, the steel socket assembly, which serves to simplify the installation procedure as well as protect the joint meter, is embedded in one block of concrete (high block). The joint meter is not embedded at this stage. In the second stage, the joint meter is carefully screwed in into the steel socket and elongated to the desired opening. The cavity in the steel socket is filled with grease and covered with the protective rubber collar plug. The outside end of the joint meter is then anchored in concrete by raising the level of the second block of concrete (low block). The cables are carefully laid and guided to the observation room.

4.1. Embedment of the steel socket in the high block

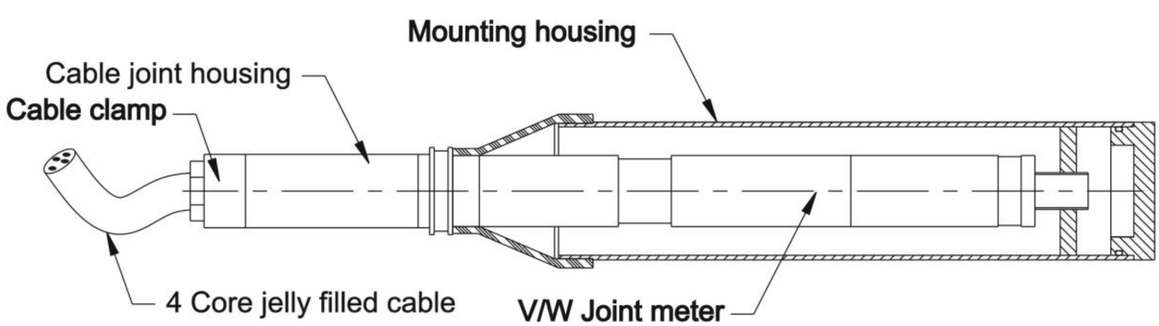
The steel socket comprises of a cylinder (socket) with a round steel bar at the end, which serves to act as a hold fast in the concrete. It is important that the steel socket is placed in a manner such that its axis is perpendicular to the contraction / expansion joint in the high block. After

determining the location of the joint meter the following steps are suggested for easy installation of the socket:

- **a.)** Mark the position where the joint meter is to be fixed. It should be around 15 cm below the top of the lift. Raise the lift in the high block to the top leaving a gap of around 1m x 1m x 20cm deep at the location where the joint meter is to be fixed, The steel socket with its stay rod is to be mounted in this location.
- **b.)** Position the steel socket in the trough securing it in place to adjacent steel bars or shuttering. The face of the steel socket should be flush with the joint face of the high block and its axis perpendicular to the joint face.
- **c.)** Thoroughly clean the steel socket bore and the rim face. Remove any traces of concrete with a wet cloth. Take a piece of clean cloth, smear it liberally with petroleum jelly or grease and push it into the steel socket assembly.
- **d.)** Check the final alignment of the steel socket face. It should be flush with the joint face with the axis perpendicular to the joint face. Make suitable adjustments, if necessary. A spirit level should be used on the surface of the steel socket to check that its axis is in a horizontal plane.
- **e.)** Pour in concrete around the socket assembly and stay rods and complete the high block lift.
- **f.)** Provide a suitable marker for easily locating the embedded socket face.

4.2. Preparation of the joint meter

A required length of cable has to be joined to the joint meter at site according to the general procedures for cable splicing and joining. The joint meter with the requisite amount of cable required should be prepared in advance in a separate room or office close to the site.



a.) Remove the cable joint housing from the cable end of the sensor. This gives access to a four cable. Two of the wires red and black colors are connected to the coil of the vibrating wire sensor. The other two wires green and yellow connect to a thermistor used for temperature measurement.

b.) Check the working of the sensor as follows:

- The coil resistance measured by the digital multi meter should be between 110-130 Ohm. Determine resistance at the room temperature from thermistor temperature resistance. This resistance should be equal to that between wire green and white. For example, in case the room temperature is 25°C, this resistance would be 3,000 Ohm.
- The resistance between any lead and the protective armour should be > 500 m Ohm.
- Connect the sensor to the SME model 2640-P readout unit and switch it on. Press the frequency button the display will show frequency between 1800 and 2,100 Hz. This initial reading on the readout unit should be stable.
- At check whether the joint meter is responding to changes in displacement, extend the joint meter by about 5 mm by hand. The change in frequency ensures that the deformation produced by the displacement is transmitted to the vibrating wire sensing element.

c.) Connect the required length of the cable to the sensor as suggested in the operating manual of cable jointing.

d.) Check the working of the sensor again following the procedure described above.

CAUTION: The joint meter is a delicate and sensitive instrument. It should be handled with care. Twisting it or applying too much force on it may result in a zero shift or even permanent damage.

e.) Cable should be marked with permanent markers every 5 m by the use of stainless steel tags stamped with appropriate joint meter numbers tied by stainless steel wire. Temporary identification can be done by writing the serial number of the joint meter,its code number and the location at which it is installed, on a strip of paper, placing the strip on the cable and covering it with a transparent plastic cello tape. Permanent identification is necessary to prevent errors in making proper connections in the junction box and to insure correct splicing if the cable is cut or broken.

4.3. Installing the joint meter

Installing joint meter in a concrete dam has to be done with perfection. Great care has to be taken. The steps involved in the placement of the joint meter assembly and its installation are as follows:

a.) Proceed with the concreting of the low block until the top of the lift is approximately 20 cm from the meters elevation.

b.) Bring the joint meter-cable assembly to the site.

c.) Carefully remove if any concrete around the socket face. Demarcate an area of about 1m x 1m around the joint meter location on the low block and clean it up. Lay a clean plastic sheet in this area. Exercise care that no dirt enters the steel socket. Pull out the greased cloth.

d.) Smear the joint meter liberally with petroleum jelly or grease and insert it into the steel socket. Gently screw the joint meter clockwise inside the steel socket and tighten it. Do not use force. Use of spanner or application of excessive torque will damage the joint meter. It is suggested that after insertion of the joint meter into the socket but before screwing it into the steel socket, the meter be rotated approximately 8 times anti-clockwise and then screwed in. This procedure will ensure that the cable does not remain twisted after the meter has been screwed in.

CAUTION: Great care should be taken while tightening the joint meter into the steel Socket. Application of force while screwing the joint meter into the steel socket will permanently damage it, it may also shear, crack or perforate the bellows.

e.) Support the screwed joint meter at the cable joint housing end with concrete mortar and using tie wires align it axially with the steel socket. Pull the joint meter to the extent as specified in the design and using tie wires retain it in this position. Fill the space between the steel socket and the joint meter with petroleum jelly. Push the protective rubber cap over the steel socket and clamp it. Seal it with the protective waterproof tape.

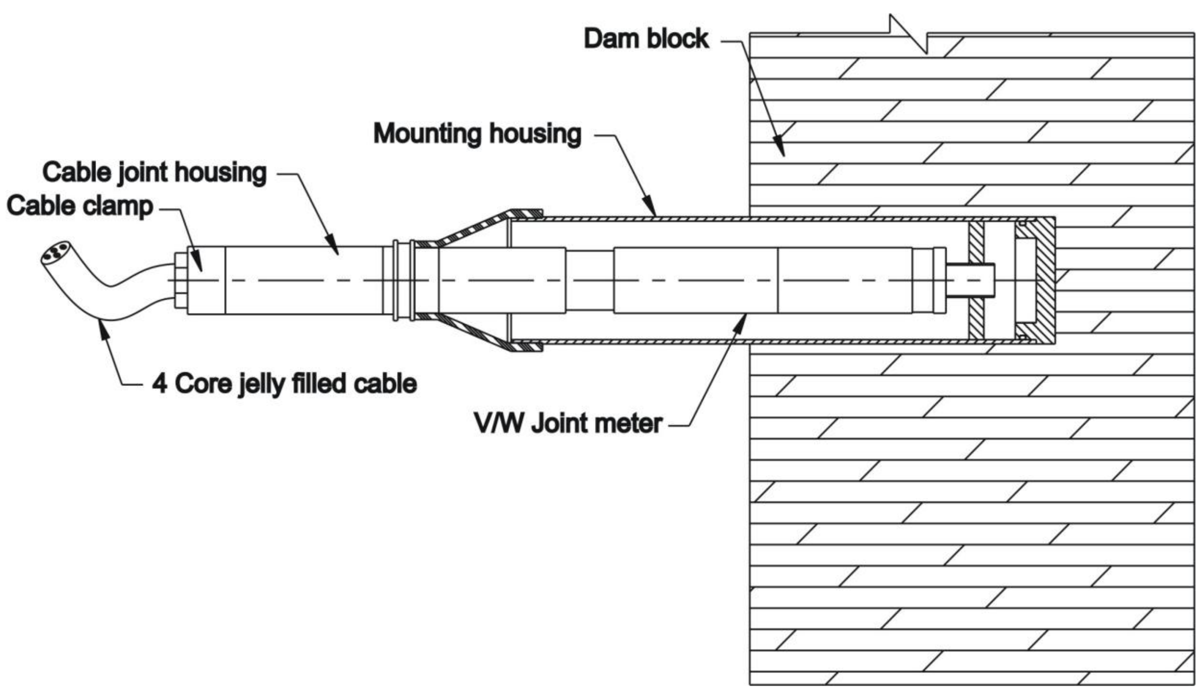
NOTE: Consult project authorities in case amount of initial offset to be given to the joint meter is not specified. The joint meter must always be mounted somewhat extended to take care of any contraction which may take place.

f.) Remove plastic sheet from the base of the low block.

g.) Lay the cable as described. Check the joint meter reading with the digital indicator. The reading should be equal to the initial offset at which the joint meter is set.

h.) Proceed with the concreting of the joint meter to the top of the lift and allow concrete to set in for at least 24 hours. The concrete over the joint meter and the cable should be hand shoveled and mildly vibrated using a hand vibrator. Take care that the joint meter does not get damaged by use of the hand vibrator.

i.) After concreting and at end of 24 hours, again check if the displacement reading is all right.



4.4 Laying of cable in a concrete dam

Very careful and skilled cabling is required in the installation of the joint meter as the sensor/cable joint and a large part of the cable is permanently embedded and no future access is available for any maintenance and corrective action.

The procedure for laying of cables differs with individual installations. In general, however, all installations have the following common requirement:

- The cable must be protected from damage by angular and sharp particles of the material in which the cable is embedded.

As access galleries are provided in a concrete dam, the cable from the joint meter is first routed to the gallery through a vertical shaft meant for routing the cables. These cables may be terminated in junction boxes inside the gallery. The data from the various sensors can then be taken or logged from the junction boxes with the help of a read out unit. Alternatively, if required, the signals from the junction boxes may be carried through multi core cables to any observation room outside the dam structure.

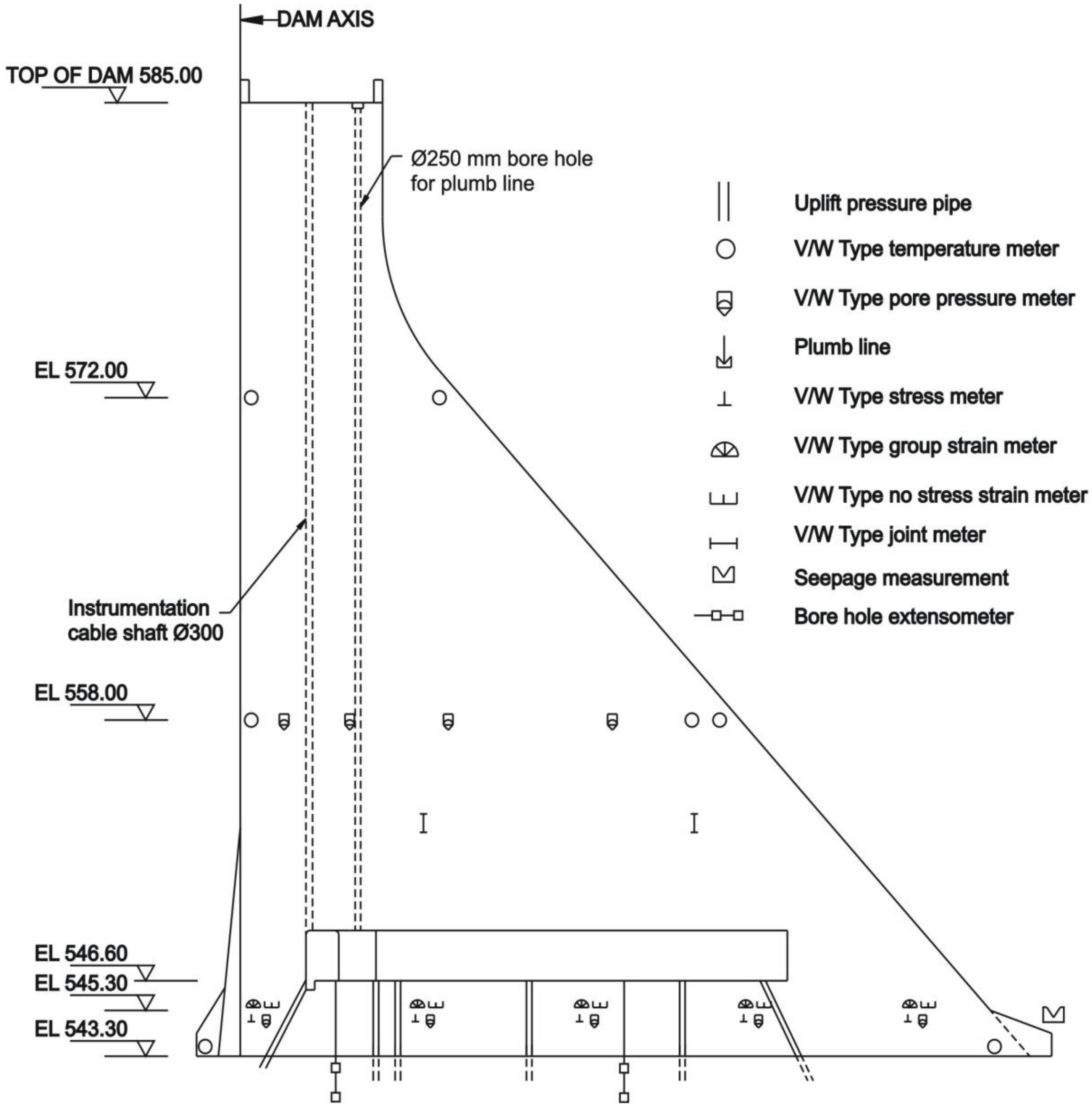
NOTE: As a matter of practice, the steel socket should not be mounted in the block where the cable has to be terminated. The other block not having the instrument gallery, should always be raised first. This helps in preventing the cable from crossing the joint opening between two blocks. In case due to some reason this becomes necessary, take the precaution of passing the cable through a flexible plastic pipe when being routed over the joint between the two blocks.

In a concrete dam, a number of joint meters along other sensors are installed at selected elevations at different cross sections. For example, four joint meter, ten temperature meters and five pore pressure meters are installed at elevation 322 m. Cables from these sensors have to be taken to junction boxes to be mounted inside one of the cross galleries. The gallery may be above or below the elevation at which the sensors are to be installed. As a general practice, all the cables from sensors at any particular elevation are routed to a vertical shaft on the upstream side of the dam. The cables are then lowered or lifted through the vertical shaft to the gallery. As most of the sensors are installed in one line in any plane, the cables from these sensors are run in cable trenches running parallel to the line of the sensors. However, as only one joint meter is mounted at any location between two blocks, the cable has to be individually routed from the joint meter to the cable shaft.

The cable from the joint meter should be routed through a carefully marked 10 cm deep x 20cm wide channel trench running from the sensor to the vertical shaft. The channel trench should be properly cleaned and leveled. Any sharp rocks or objects should be removed to prevent the cable from accidentally getting damaged. To take care of settlement effects and temperature effects during concrete setting, the cable may be slightly zig zagged. After laying the cable, it should be covered with concrete by a hand shovel and allowed to set. This is necessary to prevent any accidental damage to the cable.

CAUTION: To take care of any settlement and/or contraction of concrete due to temperature effects, the cable should be zig-zagged by providing a uniformly distributed slack of around 0.5 m in a 15 m length of each cable. Precaution must be taken that the cables are properly tagged, onward from the point from which they come out of the dam into the vertical shaft.

As an SME convention, again, the cable from the most distant sensor at any elevation should be connected to the extreme left socket in the junction box. Succeeding cables from the sensors are connected progressively towards the right in the junction box.



NOTE: IS: 7436 (Part II) states – " In the case of large dams built in V-shape canyon, joint meters should be provided in at least three blocks, namely, deepest central block and a block each in the abutment portion representing blocks built on steeply sloping abutments. In plan of a given elevation the joint meters in each of these blocks should be installed on the center of the longitudinal joints and at the center of the transverse dimensions of the monoliths in the block, spaced about 15 m

vertically for the entire height of the longitudinal and transverse joints. This spacing may be modified in the top portion of the joint if joint height does not permit of 15 m spacing for the entire height.

4.4. Trouble shooting

Joint meter is installed during construction of the structure. Once installed, the cell is usually inaccessible and remedial action is limited. Maintenance and trouble shooting is consequently confined to periodic checks of cable connection and functioning of the read-out unit. Refer to the following list of problems and possible solutions should problem arise. For additional help, consult the factory.

a.) Symptom: Joint meter reading unstable

- Check the insulation resistance. The resistance between any lead and the protective armour should be > 500 m Ohm. If not, cut a meter or so from the end of the cable and check again.

- Does the read-out work with another joint meter? If not, the read-out may have a low battery or be malfunctioning. Consult the manual of the readout unit for charging or trouble shooting instructions.
- Use another read-out unit to take the reading.
- Check if there a source of electrical noise nearby? General sources of electrical noise are motors, generators, transformers, arc welders and antennas. If so the problem could be reduced by shielding from the electrical noise.

b.) Symptom: Joint meter fails to read

- The cable may be cut or crushed? Check the nominal resistance between the two gage leads using an Ohm meter. It should be within 120-140 Ohm. The correct value is given in the joint meter test certificate. Please add the cable resistance when checking. For the model -10/11 cable, the resistance is 26 Ohm/km and for the model 12-15 cable, the resistance is 84 Ohm/km. (multiply by 2 for both leads). In case any other cable is used, make the necessary addition in the resistance value. If the resistance reads infinite or a very high value, a cut in the cable is suspected. If the resistance reads very low (<100 Ohm), a short in the cable is likely.
- Does the read-out work with another joint meter? If not, the read-out may have a low battery or be malfunctioning. Consult the manual of the readout unit for charging or trouble shooting instructions.
- Use another read-out unit to take the reading.

6. Observation Sheet

Model SME 2460-P Readout Unit

Sl. #	Date	Sensor no. Location E.L.	Sensor no. Location E.L.	Sensor no. Location E.L.	Sensor no. Location E.L.
		Temperature °C	Temperature °C	Temperature °C	Temperature °C
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					

6.1. Frequency of observation

There is no fixed rule on frequency of taking readings. Joint meter readings should be taken every day at the time of pouring of concrete. There after readings may be taken at every 15 days interval during construction and at monthly intervals thereafter. The frequency of taking readings may be reduced as the joint meter data stabilizes.

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