INSTRUCTION MANUAL

EARTH PRESSURE/CONCRETE
PRESSURE CELL VIBRATING WIRE TYPE

SENSORS & MEASUREMENTS ENTERPRISES
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Earth Pressure cell

A. Introduction

The earth and concrete pressure cell is designed to measure total pressure in earth fill, mass concrete, embankment, and retaining walls, buildings, bridge abutments etc.
Proper evaluation of total stress may help in verifying the design assumptions that will promote safer and more economical design and construction of Dam, barrage, piers, foundation bearing pressures etc.
In any instrumentation scheme for geotechnical or geo structural study associated with large civil engineering structures like tall buildings, dams, underground tunnels etc. measurement of earth pressure and stress plays an important part.

1. Earth and concrete pressure cell construction.

The SME earth & concrete pressure cell basically consist of a circular flat diaphragm constructed from two stainless steel disc welded around the periphery and connected to a specially designed pressure transducer incorporating the latest vibrating wire Technology.The pressure cell has an inherently high sensitivity and it is not necessary to produce large strain on the area being monitored for the measurement of stress.
SME offers basically two type of earth pressure cell.

a) Embankment type earth pressure cell.

This type of earth pressure cells are generally installed to determined the magnitude, direction and distribution of total stress in dam, embankment, fills, under railway track, pile foundation or piers.

b) Concrete Pressure cell:

Concrete pressure cells are used for measurement of total stress against retaining wall, culverts, Piles, slurry walls, and foundation of concrete or masonry Dams.

2. Operating Principle:

The basic construction of a vibrating wire earth pressure cell is it comprises of minimum one active diaphragm welded together with minimum gap in side . The gap between the pressure pad and sensor is filled with suitable oil (generally silicon oil) up to the pinch tube. When the diaphragm deflects due to some external pressure the pre-stretched wire gets tension or compression according to its design consequently the natural frequency of wire changes accordingly. The magnet is mounted near the center of wire and when excited through SME readout unit model 2460-P provides AC pulses to magnetic coil assembly which in turn makes the wire to vibrates to its natural frequency.
The data in terms of frequency, time period or directly in engineering unit can be taken by the readout unit.

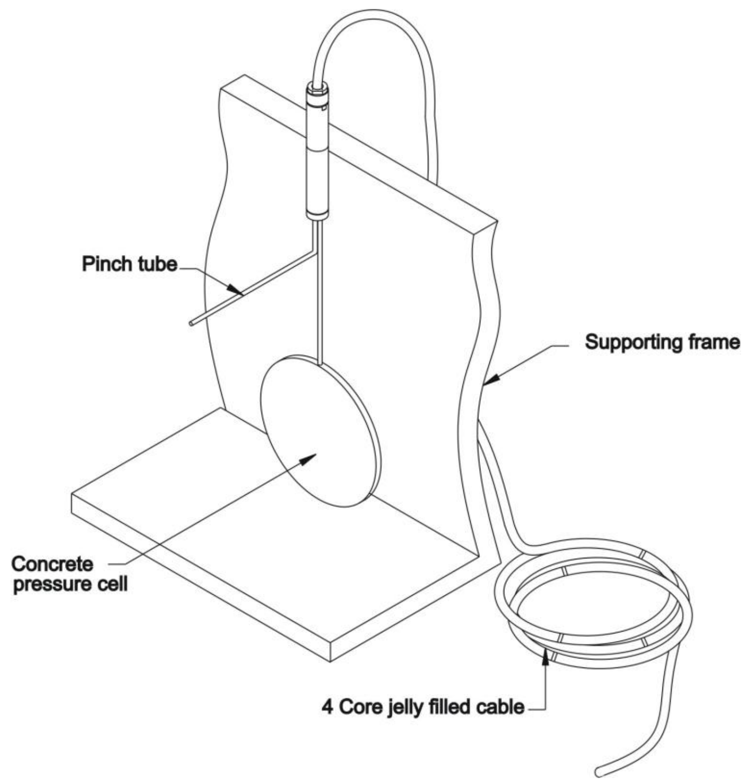
3. Installation procedure

3.1. Preparation of the sensor before installation

a.) Remove the cable joint housing from the cable end of the sensors. This gives access to the 4 core cable . Two wire marked with red and black colors are for sensor and the other two terminals are utilized in case a thermister is used for temperature measurement.
b.) Check the working of the sensors as follows,
c.) The coil resistance measured by a digital multi meter between the red and black wire, should lie between 120 – 140 Ohm. In case thermistor is used, determine resistance at the room temperature from thermister temperature chart. This resistance should be equal to that between green and white wire. For example, in case the temperature is 25°C, this resistance would be 3,000 Ohm.

d) The resistance between any lead and the protective armor should be >500 m ohms.
e) Check whether sensor is responding to changes in pressure. A crude but simple and very effective method of checking whether the sensor is responding to changes in pressure is as follows:

- Press the diaphragm with the thumb and verify that the frequency reading on the indicator decreases.
- This change in reading ensures that the deformation produced by the pressure of the thumb on the diaphragm is transmitted to the vibrating wire sensing element.



f) Cable should be marked with permanent markers every 5 m by the use of stainless steel tags tied by stainless steel wire stamped with appropriate concrete pressure cell numbers. Alternatively, plastic tabs are also available. Temporary identification can be done by writing the serial number of the sensor, 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 cable is cut or broken.

CAUTION: The single most important factor leading to loss of worthwhile data from sensors is losing track of identification of the cable ends. Proper identification and making of the cables is generally taken most casually. Care should be taken to put identification tag at the point where the cable comes out of the structure such that cable identity is not lost if the cable gets accidentally cut.

B. Installation of concrete pressure cell in concrete dam

Installing the concrete pressure cell is fairly simple operation. In case effective stress is to be determined, a pore pressure meter must be installed close by. A concrete pressure cell is normally installed with the flat surfaces horizontal to measure vertical stress. However, it can be placed at other orientations inside the fill, to measure stress in other directions i.e. a cell placed with the flat surfaces vertical will measure horizontal stress in a direction perpendicular to the diaphragms of the cell.

In a concrete dam, a number of concrete pressure cells along with other sensors are installed at selected elevations at different cross sections. For example, three pore pressure meters, five strain rosette, five no stress strain containers, five stress meters and two temperature meters are installed at elevation shown in a figure. 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 the 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.

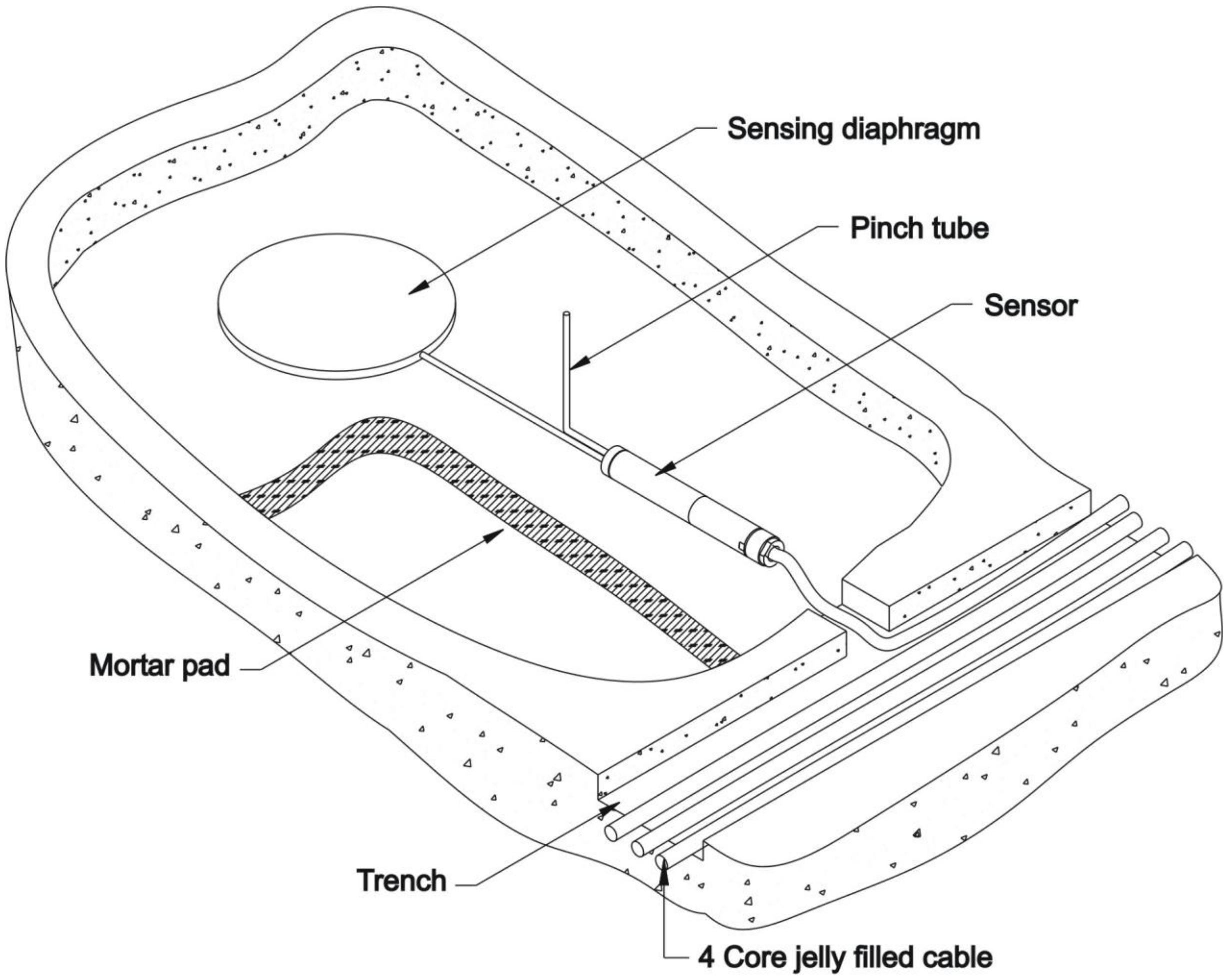


Figure 1.2

Procedure:-

a) Allow the filling of the dam to continue to an elevation of around 25 cm higher than where the sensors are to be mounted, leaving 1 m x 1 m x 25 cm deep trenches at the positions where the sensors are to be placed. Larger trenches may be left in case the concrete pressure meter is to be installed align with other sensors, specially the strain rosette and the no stress strain meter which require more space.

b) Refer to fig. 1.2 for details of the cable trench/channel for routing the cable from the sensors. The cable from the sensors should be routed through a carefully marked channel trench ending into the vertical shaft and running parallel to the line of the sensors. The depth and width of the channel trench depends upon the number of cables the trench has to carry. In case all the cables at an elevation fit in one row, the depth of the channel can be around 10 cm. If more than one row is required to lay all the cables, the depth should be increased by 10 cm per row. 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 when it is laid.

c) Prepare the concrete surface of the 1 m x 1 m sensor trench by smoothing it off and flattening it as much as possible with any available hand tool, chisel or hammer. Grout 75 mm nails around 25 mm deep into the surface of the trench to mark the periphery around the sensing diaphragm and the pressure transducer. Alternatively, little pieces of small diameter reinforced bars may be grouted in bore holes drilled adjacent to the location where the cell would be located.

d) Carefully bend the pinch tube such that when the stress meter is installed, it will protrude out from the top. It can also be wrapped in foam etc. such that it can be easily retrieved later on.

e) To accommodate irregularities in the concrete surface, it is necessary to fill the space between the surface and the cell with quick setting mortar (see fig. 1.3). Trowel a quick setting mortar pad around 30mm deep on the surface of the concrete in the trench. Press down the cell onto the pad with a little rotary motion of the hands, causing the mortar to extrude sideways thus eliminating any air bubbles or spaces between the cell and the ground. Grip the cell firmly by bending the nails or the reinforced bars on the sides of the cell. Be careful that in doing this, the cell is not damaged. This can be verified by comparing the zero reading with the initial offset.

f) Using a hand shovel, cover the concrete pressure cell with the quick setting mortar and fill the 25 cm. trench with concrete Compact with a light duty pneumatic or petrol backfill tamper, taking care that the sensor remains well protected.
A weighted tripod can be used to hold the stress cell in place until the concrete hardens. The pinch tube is arranged to protrude above the bonding layer and when the concrete has hardened it is used to pressurize the cell and ensure good contact between the cell and the surrounding concrete.

g) Once the concrete is set, the cell can be inflated using the pinch tube and a special set of pliers. Connect the cell to the readout unit and gently squeeze the pinch tube flat, using the pliers. Start squeezing around 25 mm from the capped end and proceed downwards towards the concrete layer. In case the cell diaphragm is in good contact with the concrete, the pinching will immediately cause a pressure rise in the cell. Stop the pinching immediately. However, in case the cell diaphragm expands inside any space that may exist, the pressure rise accompanying each pinch will be small. As soon as the cell starts to fill the space, the pressure rise with each pinch will become larger.

A graph of the readings should show a pronounced “knee” where contact between the cell diaphragm and concrete is made (see fig 1.4). As soon as this “knee” is passed, the squeezing of the pinch tube should be immediately stopped. Bend the pinch tube out of the way such that it lays flat on the concrete surface.

CAUTION: Do not pinch the pinch tube closer than 25 mm from the end; otherwise the seal plugging the end of the tube be damaged. As the tube is progressively squeezed flat, the fluid is forced out of the pinch tube into the cell and the pressure will rise. It is necessary to make a chart showing the relationship between the length of flattened pinch tube and the corresponding pressure reading.

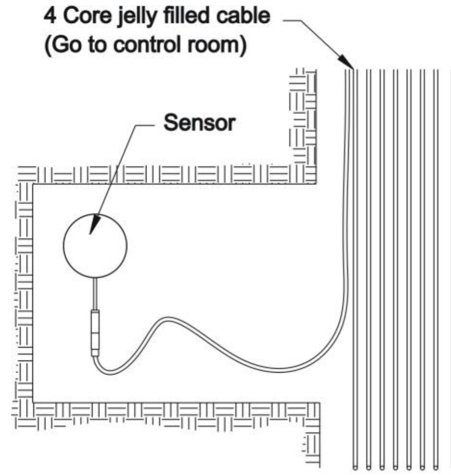
h.) Record the new initial stress reading after the cell has stabilized in the field book in the format provided.

NOTE: The first layer of material over the sensor diaphragm was around 200 mm high. Similar layers of material should be put over this and compacted properly until at least 600 mm of material has been placed. Rubber tired equipment can now cross this location, but no vibratory rollers should be permitted over the sensor until a compacted thickness of at least 1 m is laid.

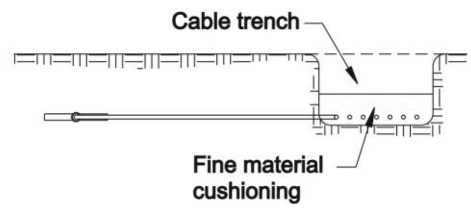
C. Cable laying

Very careful and skilled cabling is required in installation of the concrete pressure cell 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.
- The cable must be protected from damage by vibrators and compaction equipment.
- The cable must be protected from any possible stretching. Special care should be taken in case it has to be routed through different blocks.
- Cables may be spliced without affecting the sensor reading; nevertheless splicing should be avoided wherever possible. If necessary, use special cable jointing kits available from the factory.



As access galleries are available in concrete dams, the cable from the sensors is first routed to the gallery. 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 or data logger. Alternatively, if required, the signals from the junction boxes may be carried through multi core cables to any observation room outside the dam structure.



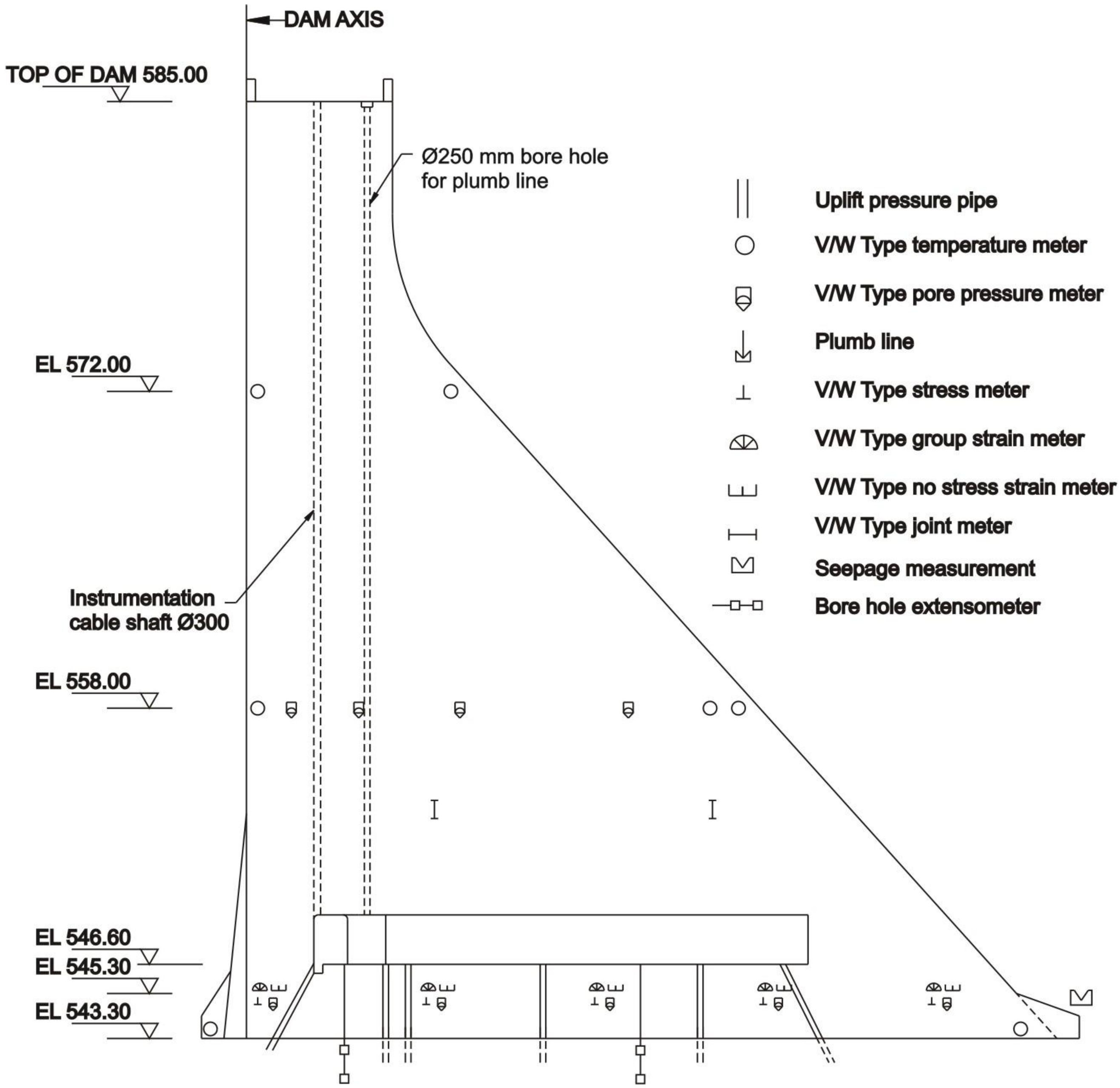
The center distance between successive cables in the cable trench should be kept at a distance of 25 mm with the help of the wooden cable spacer and cable rake provided. After laying the cable in any row, it should be covered with concrete by a hand shovel to a depth of around 10 cm and allowed to set. This is necessary to prevent any accidental damage to the cables.

Cables coming out of the sensors into the cable trench should be properly tagged. With the best possible precautions, mistakes may still occur. Tags may get lost due to the cable getting accidentally cut. SME uses the convention that looking from the end of the trench towards the sensor, the cable from the most distant sensor is always at the left hand side and the offset trenches are to the right of the cable trench. In that order, the cable from the closest sensor is at the extreme right.

CAUTION: All cables should be properly identified by tagging them every 5 m, onwards from the point from which they come out of the dam body. The tags should be of a non – corrosive material like stainless steel.

Similar precautions must be taken when the cables come out from the cable trenches into the vertical shaft.
As 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.

CAUTION: Care should be exercised when installing instruments cables to keep them as far away as possible from sources of electrical interference such as power lines, generators, motors, transformers, arc welders, etc.. Cables should never be buried or run with AC power lines. The instrument cables will pick up the 50 or 60 Hz (or other frequency) noise from the power cable and this will likely cause a problem obtaining a stable reading. Contact the factory Concerning filtering options available for use with data loggers and read out.



GENERAL ARRANGEMENT DRAWING OF INSTRUMENTS SHOWING THE LOCATION

6. Observation Sheet

Sl. No.	Date	Sensor no. Location E.L.	Sensor no. Location E.L.	Sensor no. Location E.L.	Sensor no. Location E.L.
		Stress in kg/cm²	Stress in kg/cm²	Stress in kg/cm²	Stress in kg/cm²
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. Stress readings should be taken as the concrete / masonry work progress in the vertical direction or when required in case of fills, retaining walls etc. The frequency of taking readings may be reduced as the concrete work or excavation work slow down.