



# ENCARDIO RITE

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USERS' MANUAL

## HYDRAULIC OVERFLOW SETTLEMENT GAGE

MODEL EHOS-35



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## 1 INTRODUCTION

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The hydraulic overflow settlement gage is suitable for measurement of settlement in an embankment of a dam or in fills where the settlement cell (sensor) and the terminal structure or observation room can be nearly at the same elevation.

### 1.1 Conventions used in this manual

**WARNING!** Warning messages call attention to a procedure or practice, that if not properly followed could possibly cause personal injury.

**CAUTION:** Caution messages call attention to a procedure or practice, that if not properly followed may result in loss of data or damage to equipment.

**NOTE:** Note contains important information and is set off from regular text to draw the users' attention.

### 1.2 How to use this manual

This users' manual is intended to provide you with sufficient information for installing and making optimum use of the hydraulic overflow settlement gage. It covers the description of the gage and installation & operation procedures.

To make this manual more useful, we invite your valuable comments and suggestions regarding any additions or enhancements. We also request you to please let us know of any errors that you may find while going through this manual.

**NOTE:** The installation personnel must have a background of good installation practices and knowledge of the fundamentals of geotechnics. Novices may find it very difficult to carry on installation work. The intricacies involved in installation are such that even if a single essential but an apparently minor requirement is ignored or overlooked, the most reliable of instruments will be rendered useless.

A lot of effort has been made in preparing this instruction manual. However, even the best instruction manuals cannot provide for each and every condition in the field that may affect the performance of the sensor. Also, blindly following the instruction manual will not guarantee success. Sometimes, depending upon field conditions, installation personnel will have to consciously depart from the written text and use their knowledge and common sense to find the solution to a particular problem.

The manual is divided into a number of sections. Each section contains a specific type of information. The list given below tells you where to look for in this manual if you need some specific information.

*For the principle of operation of the hydraulic overflow settlement gage: See § 2.1 'Operating principle'.*

*For detailed description: See § 2.2 'General description'.*

*For installation procedures: See § 3 'Installation procedure'.*

*For taking readings: See § 4 'Operation sequence'.*

## 2 HYDRAULIC OVERFLOW SETTLEMENT GAGE

### 2.1 Operating principle

The hydraulic overflow settlement gage works on the 'U' tube principle. The system consists of a sealed settlement cell connected to a level indicator through an overflow tube. The settlement cell is securely cast into a concrete block in the structure at the location where settlement is to be monitored. The level indicator tube with an adjoining measuring scale is fixed on an aluminium channel (housing beam in figure 5) in the terminal house. The terminal house is normally built on stable ground. If not, a surveying method must be used to monitor its elevation at the time of taking a reading. Any settlement or heave in the settlement cell can be measured on the mm scale of the housing beam. The gage is normally read by pumping in some water through the overflow pipe inside the settlement cell and letting level in the visible level indicator tube stabilise at the same elevation as in the overflow pipe. A drain tube allows surplus water from the overflow pipe to flow out from the cell. An air vent tube maintains the inside of the settlement cell at atmospheric pressure.

It is recommended that before taking a reading, the system should be flushed with the de-aired fluid of volume equal to at least that in the overflow pipe and the connecting overflow tube.

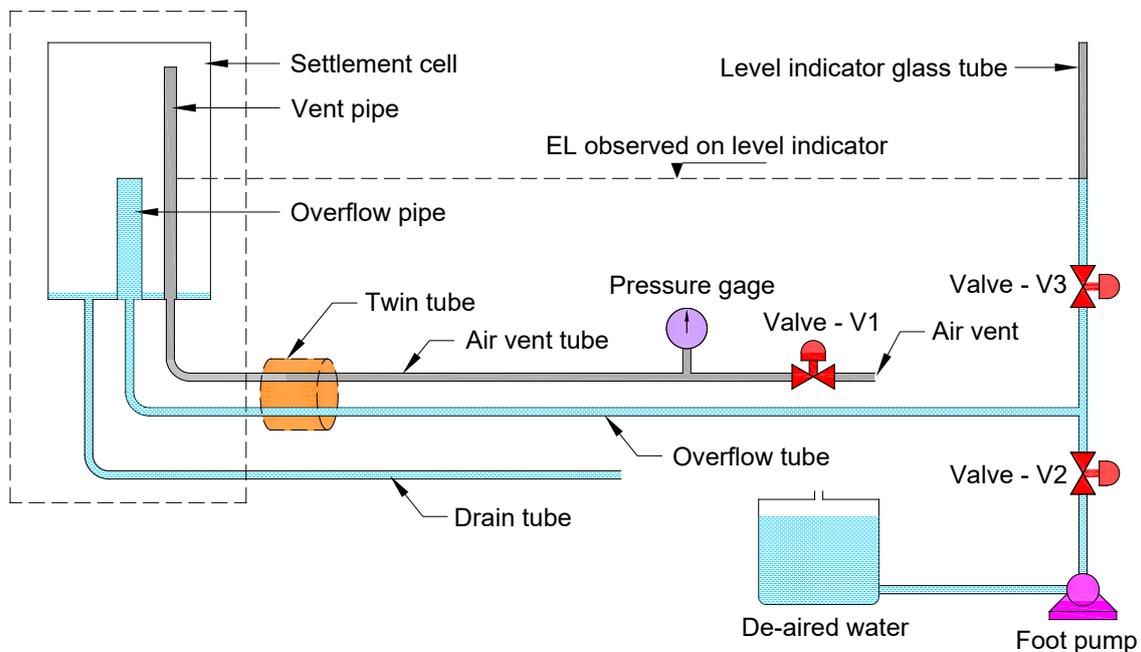


Figure 1- Settlement overflow settlement gage schematic

### 2.2 Advantages

- The settlement gage does not require any electronic instruments.
- It has a long service life, measurement stability, and reliability.
- The installation of the level indicator can be located at the same elevation of the settlement cell.
- The system is not prone to fluctuations in temperature or atmospheric pressure.
- It is possible to measure beneath concrete and earth structures that are not accessible to other instruments.

### 2.3 General description

The system consists of the following:

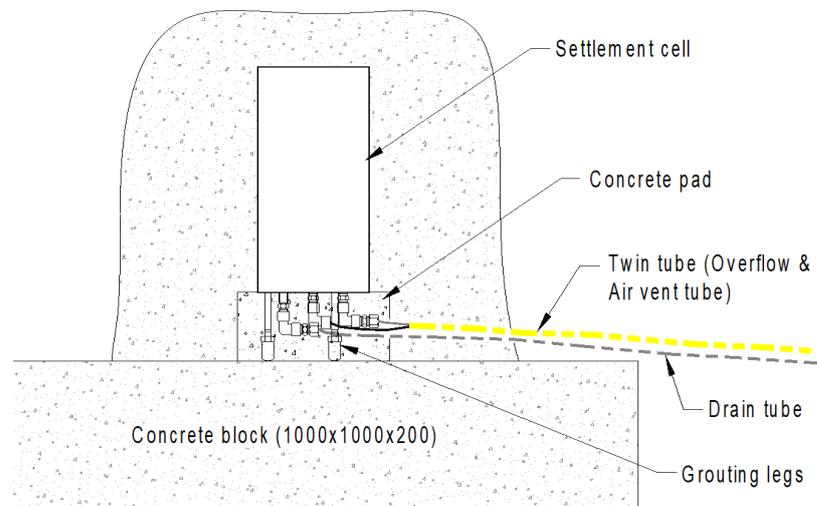
- Settlement cell with connections (quick fittings) for an overflow pipe (OF), air vent (V) and drain

tube (D) (figure 2 (a) & 2 (b)).

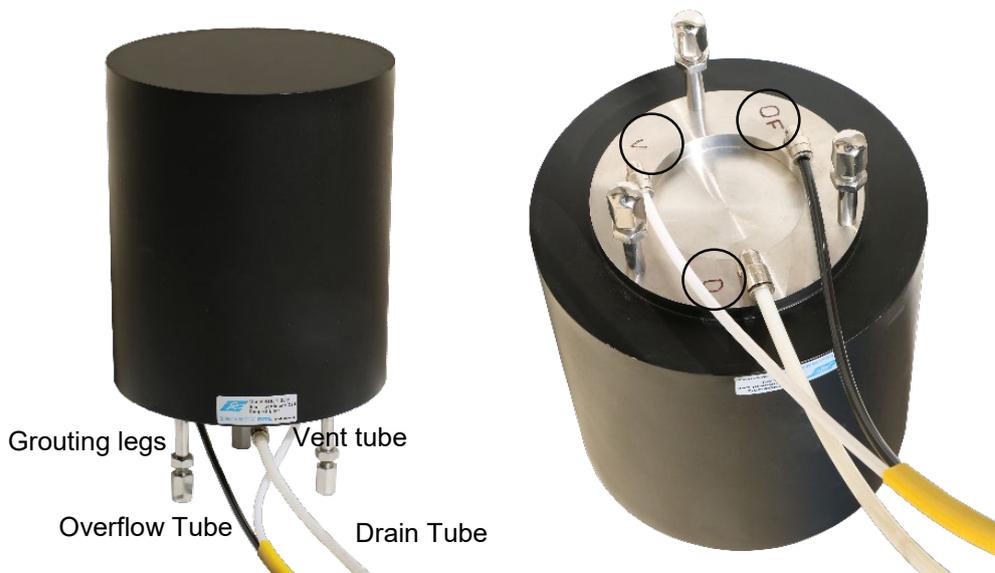
- Polythene sheathed twin nylon tubing. The black tube is for overflow pipe and white tube for air vent (figure 2 (a) & 2 (b)).
- Nylon tube for draining of overflow water. This tube is of a larger diameter than that of the overflow or air vent tubes (figure 2 (a) & 2 (b)).
- The level indicator unit (figure 5) mounted inside a terminal structure. A water pump (figure 4) is required for circulating water through the system.

### 2.3.1 Overflow settlement cell

The cell comprises of sealed rigid stainless-steel container with an internal water overflow pipe, air vent tube, and three quick fittings to connect to water, vent and drain tubes as illustrated below:



**Figure 2 (a) - Settlement cell - mounting**



**Figure 2 (b) – Settlement cell - tube details**

**2.3.2 Tubing**

- Twin-tube - two nylon tubes, one black and one white of uniform cross-section are enclosed in an outer polythene sheathing (yellow). The tubes are connected to the housing beam in the following manner (figure 3):
  - The black nylon tube is connected to the quick fitting marked 'From Overflow Tube'
  - The white nylon tube is connected to the quick fitting marked 'From Vent Tube'
- White nylon tube – this is of larger diameter than the other two nylon tubes is connected to the quick fitting marked 'From Drain Tube'

Diameter (i.d. /o.d.) (mm)	Colour	Connection
4 / 6	Black	From Overflow Tube
4 / 6	White	From Vent Tube
6 / 8	White	From Drain Tube



**Figure 3 Details of tubing**

**2.3.3 Level indicator unit**

The level indicator measurement unit (figure 5) for the hydraulic overflow settlement gage comprises a transparent level indicator (glass tube) with a suitable measuring scale to monitor settlement.

Three shut off valves V1, V2 & V3 are provided to facilitate settlement monitoring through unions that connect to the glass tube level indicator, the nylon tubes, and the water pump.

A pressure gage is provided in the vent line to monitor air pressure build-up during filling/flushing of settlement cells.

A spare glass tube is packed inside the channel section of the aluminium beam.

Details along with dimensions of the aluminium beam are as follows:

Parameter	Dimension
Length	Settlement range (2000 mm) + 500 mm
Width	180 mm
Thickness	80 mm

**2.3.4 Water pump**

A hand-operated water pump is required for circulating water through the system (figure 4). An electrical water pump is also available optionally. It is a mono-block 0.25 HP centrifugal pump with operating voltage 220 V, 50 Hz AC, single-phase unless otherwise specified. A sufficient length of flexible connecting tubing is provided with the pump.



**Figure 4 – Water pump**

### **2.3.5 De-aired fluid**

A mixture containing 50% ethylene glycol and 50% de-aired water is recommended for the hydraulic overflow settlement gage. The mixture has a relative density of around 1.06 at 4°C. Ethylene glycol is a good wetting agent and also an antifreeze. The system responds better if the tubes are free of air bubbles.

### **2.3.6 Terminal structure**

A terminal structure for installing the hydraulic overflow settlement gage is to be constructed on the stable ground near the downstream face of the dam at a suitable location. The terminal structure can house several settlement gages. The terminal structure can be around 3 m x 3 m x 3.5 m high. It should have a suitable entry duct for the entry of the nylon tubes from the settlement cells.

It is good practice to provide a settlement marker at the terminal structure and note down its co-ordinates using a suitable surveying method

## **2.4 Tools & accessories required for installation**

Following tools and accessories are recommended for proper installation of the hydraulic overflow settlement gage:

- 1 Spanner (6/7, 14/15, 16/17)
- 2 Adjustable spanner 150 mm
- 3 Screwdriver 150 mm
- 4 Pliers 150 mm
- 5 Tube cutter
- 6 Hack saw with 15 cm blade
- 7 Electric drill with drill bits
- 8 3 m steel measuring tape
- 9 Marker pen
- 10 Plumb bob with 5 m cord
- 11 Soft cotton cloth

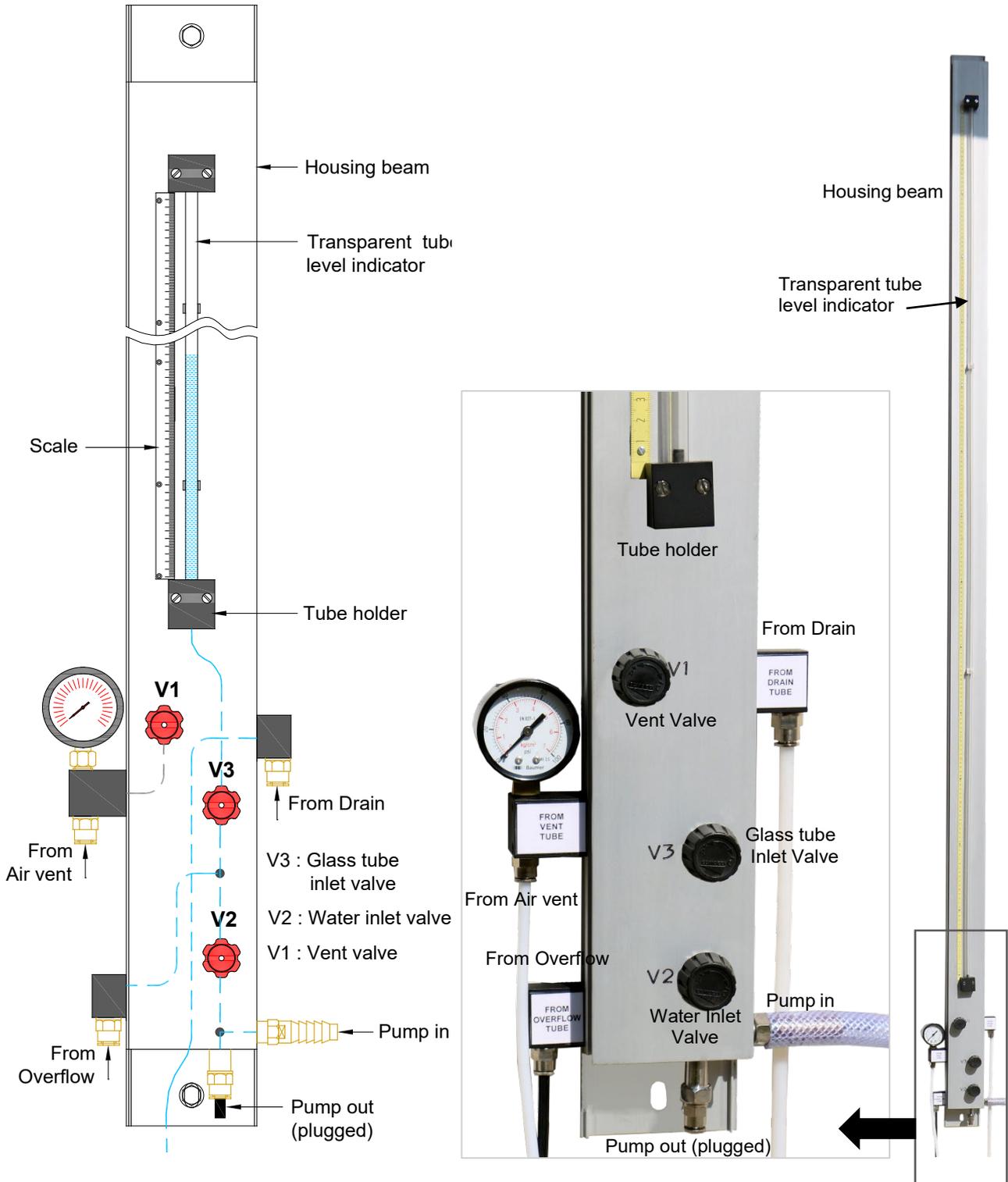


Figure 5 - Hydraulic Settlement Level Indicator Unit

### 3 INSTALLATION PROCEDURE

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- 3.1 Construct a terminal structure with an entry duct at a specified location on the downstream side on the stable ground at the same level as the anticipated settlement point. Install a survey marker pin at the roof of the terminal structure.

**NOTE:** Settlement is measured with respect to the terminal structure. The terminal structure may itself be subjected to lateral and vertical shift. A survey marker pin should be provided at a suitable location on the terminal structure, preferably on the rooftop.

The survey marker pin position (northing, easting, and elevation) should be determined just after installation and from then on checked periodically. This will enable the settlement measurement to be corrected to get absolute values.

**NOTE:** It is recommended that the hydraulic overflow settlement gage be installed only after the construction of the terminal structure.

- 3.2 Fasten the level indicator unit vertically to the concrete wall of the terminal structure using expandable fasteners (Hilti HST M8 x 75) (figure 6). Use a plumb bob/spirit level for vertical alignment.



**Figure 6 - Hilti Fasteners**

If required, several level indicator units can be installed parallel to each other on the wall.

- 3.3 Make a gradually sloped 500 mm wide x 300 mm deep trench from the terminal structure to point where settlement is to be monitored. The slope of the trench should be determined depending upon the expected settlement/heave. In case only settlement is expected, the slope of the trench should be such that the middle of the settlement cell should be at an elevation of around 200 mm below the top of the glass tube level indicator when the installation is completed. A gradual slope assists proper drainage and also helps in avoiding the formation of air pockets in the tubing. However, at no point the tubing should be at a higher elevation than that of the readout location.
- 3.4 Properly prepare and roller compact surface where nylon tubing is to be installed. To protect the tubing from mechanical damage, backfill the trench with around 100 mm of sand. Contact of any sharp or angular objects with the nylon tubing must be avoided.
- 3.5 Pass the ends of the nylon tubes through the entry duct in the terminal structure and connects them to their respective quick fitting on the level indicator unit (figure 3 and § 2.3.2).
- 3.6 Route the nylon tubes from the terminal structure to the location of the settlement cell. Care should be taken to avoid kinks or sudden bends in the tubing. Route the tubing in the trench to allow for ground movement.
- NOTE:** Nylon tubing should be laid in the trench by rolling the cable reel on its periphery. Under no circumstances should the tubing be unwound from any one side of the reel. This can happen, for example, when the reel is kept on its side and the tubing is taken out without rolling it.
- 3.7 Place a layer of 100 mm of sand over the nylon tubes. Backfill trench with sieved excavated material. Compact the backfill. Do not move any construction equipment over installation until a further 1 m is backfilled.

**NOTE:** To prevent migration of water along the trench, bentonite plugs can be constructed at intervals. In case of an earth dam, before packing the trench with backfill, a plug approximately 100 mm thick, made of a mixture of 5% bentonite (by volume) exhibiting a free swell factor of approximately 600%, and 95% sand should be placed in the trench at intervals of approximately 10 m.

- 3.8 Construct a concrete block of 1m x 1m x 200 mm height at the location where the settlement cell is to be installed. Connect the nylon tubes to their respective quick fitting on the settlement cell marked:
- OF for overflow tube
  - V for the air vent tube
  - D for the drain tube

Locate the settlement cell vertically in the middle of the concrete block on three no. grouting legs provided at the bottom of the cell.

- 3.9 Follow the procedure described in § 4 'Operation sequence'. Note the level in the glass tube level indicator. Maintain the level and verticality of the settlement cell by adjusting the height the groutable legs with the help of a spanner. Set the height of the cell such that the water level in the glass tube level indicator is as per the design requirement. Carefully fill in concrete under the base of the settlement cell to form a concrete pad. Enclose the cell in concrete to form a block. Be careful with the fill material around the installation such that settlement cell and connecting tubing are not damaged.

## 4 OPERATING SEQUENCE

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- 4.1 Determine northing, easting, and elevation of the survey pin on the terminal structure.
- 4.2 Pump de-aired water into settlement cell and the connected water tube as described below (figure 5):
  - 4.2.1 Connect the outlet pipe of the pump to the inlet fitting of the settlement unit.
  - 4.2.2 Open system water inlet valve V2.
  - 4.2.3 Close valves V1 (air vent) and V3 (glass tube inlet).
  - 4.2.4 Pump de-aired water into the settlement cell till air-bubble free water starts flowing out from the drain tube. Observe pressure gage during the process. The pressure should not exceed  $1 \text{ kg/cm}^2$  (100 kPa). In case pressure increase beyond this limit, stop pumping and wait till the pressure falls to around zero value. Resume pumping if the flushing is incomplete.

**NOTE:** Pump gently, for e.g. after one or two slow strokes, stop for a while, and check the pressure. Pumping vigorously may shoot up the water level and water may overflow from the opening at the top when the valve V3 is opened up.

- 4.2.5 Open the glass tube inlet valve of the level indicator tube V3 slightly so that water slowly rises up to its maximum level in the glass tube.
  - 4.2.6 Close valve V3.
  - 4.2.7 Close the system water inlet valve V2.
  - 4.2.8 Open valve V1 and V3 when water stops coming out from the drain tube. The outlet pipe of the pump can be disconnected and the pump removed if required elsewhere.
  - 4.2.9 Allow the water level in the level indicator glass tube to stabilize. Check by taking water level reading every 5 minutes (It would take around 30 minutes to stabilize).
- 4.3 As soon as the water level stabilizes, note down the reading. Take the reading on the scale, check the lowest point of the concave meniscus of the water column. Avoid any parallax error by keeping an eye at the meniscus level.
- 4.4 Based upon the terminal structure survey co-ordinates, apply the following correction factor to the data.
  - In case, the terminal structure building settles down, subtract the elevation difference of the terminal structure from the observed readings of the settlement cells.
  - In case, the terminal structure building appears to come up/heave, add the elevation difference of the terminal structure to the observed readings of the settlement cells.

**NOTE:** Monitor readings of the settlement cells once in a month or as directed by the Engineer-in-Charge.