

VW Embedment Strain Gauge

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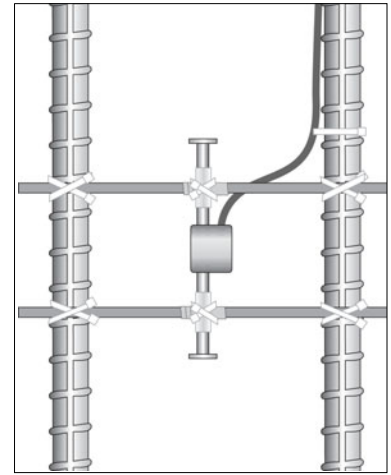
Introduction

- Applications** VW Embedment Strain Gauges are used to measure strain in reinforced concrete and mass concrete.
- Operation** The body of the strain gauge is a steel tube with flanges at either end. Inside the body, a steel wire held in tension between the two flanges. Strain in the concrete causes the flanges to move relative to one another, increasing or decreasing the tension in the wire.
- The tension in the wire is measured by plucking the wire with electromagnetic coils and measuring the frequency of the resulting vibration. Strain in the wire is calculated by squaring the frequency reading and multiplying a gauge factor and a batch calibration factor.
- Initial Testing** Test each sensor before it is installed. Use a readout and an ohm meter to conduct these tests.
- Take a reading with the VW sensor resting lightly on a surface. Set the readout to show Hz and sweep at the lowest frequency range (450-1200 Hz). A typical value is about 920 Hz. The actual reading may vary higher or lower by 20Hz, but it should be stable.
 - The RTD reading should be close to the ambient temperature.
 - Resistance between the orange/white and orange leads should be about 300 ohms.
 - Resistance between blue/white and blue leads should be about 2k ohms.

Installation

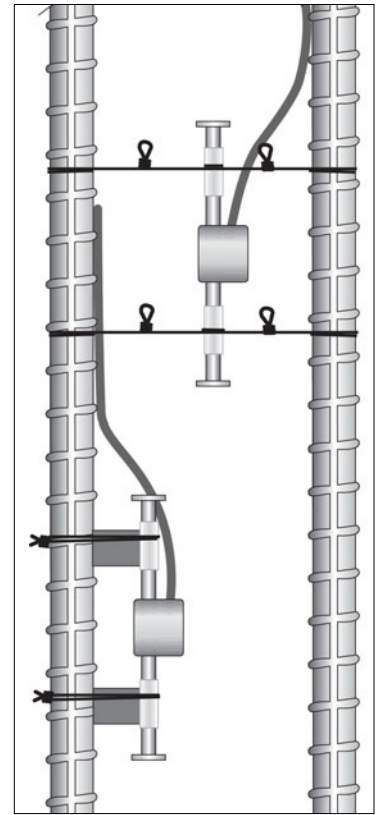
Method 1 Using Support Bars

1. Mark the location for each gauge.
2. Tie or weld support bars across the reinforcement bars. The support bars should be parallel and about 85 mm apart.
3. Wrap self-vulcanizing rubber tape around the support bars where the body of the gauge will make contact. Also wrap self-vulcanizing rubber tape around the barrel of the gauge where it will make contact with the support bars.
4. Place the gauge across the support bars, oriented parallel to the reinforcing bar. Wrap wrap a strand of tie-wire or a nylon cable tie diagonally across the barrel of the gauge to fix the gauge to the support bars. Do not over-tighten because it can affect the reading.
5. Connect a readout to the gauge to check that the reading has not changed significantly.
6. Wrap another tie wire so that an “X” is formed (see drawing). Again, do not overtighten the tie wire. Check that the reading has not changed significantly.
7. If the gauge is in a location that make it particularly vulnerable to damage from cementing, consider protecting it with some non-structural steel.
8. Run cables to the readout station as recommended in the notes below.
9. Check readings before concreting begins and also after concrete is finished.



Method 2 Using Wire Suspension

1. Mark locations for strain gauges.
2. Wrap self-vulcanizing tape around the barrel of the gauge.
3. Cut two lengths of soft-iron tie-wire, long enough to wrap twice around the gauge and twice around both reinforcing bars.
4. Wrap the middle of the wire twice around the barrel of the gauge. Do this on both sides of the sensor, as shown.
5. You should have free ends of the wire on both sides.
6. Twist two loops in the wire, about 30 mm from the gauge, as shown. These loops will be used to tighten the wire and adjust the orientation of the sensor.



7. Position the gauge between the reinforcing bars and twist the wire twice around the bars and onto itself.
8. Tighten the wire by twisting the loops.
9. Attach the readout to check that the reading has not changed significantly.
10. If the gauge is in a location that makes it particularly vulnerable to damage from cementing, consider protecting it with some non-structural steel.
11. Run cables to the readout station as recommended in the notes below.
12. Check readings before concreting begins and also after concreting is finished.

Note: The drawing also shows a variation, in which the strain gauge is held off the reinforcing bar by wood or styrofoam blocks. Thoughtful use of this method may allow the reinforcing bar itself to provide protection for the gauge and cable.

Other Installation Methods

Sometimes specifications require that the gauge be cast in a concrete briquette prior to installation.

In mass concrete applications, the gauge may be installed either before or immediately after placement of concrete. Gauges may also be installed in a rosette configuration.

Running Cable

- Start with the strain gauge that is farthest from the readout station. Tie the cable to the reinforcement bars, adding cables from other gauges on the way.
- Cables should be tied to the bar every 300 to 400 mm with nylon cable ties.
- If possible, run cables on the underside of the reinforcing bars for protection against poured concrete and vibrators.
- Always run cable along the rebar and not diagonally across the rebar. Leave some slack in the cable if there is likely to any movement in the reinforcement.
- Be sure that cables are marked several times, so that sensors can be identified after installation and after ends are trimmed.
- Protect cables where they exit the concrete with a short length of duct.

Taking Readings

Introduction

These instructions tell how to read the strain gauge with Slope Indicator's portable readouts.

Instructions for reading VW sensors with a Campbell Scientific CR10 can be found at www.slopeindicator.com. Go to Support - Tech Notes and click on the link titled "CR10-VW Sensors."

Reading with the VW Data Recorder

1. Connect signal cable to the data recorder:

Binding Posts	Wire Colors	
VW	Orange	Red
VW	White & Orange	Black
TEMP	Blue	White
TEMP	White & Blue	Green
SHIELD	Shield	Shield

2. Choose Hz + RTD or Hz + Thermistor.
3. Select the 450-1200 Hz range.
4. The recorder displays sensor reading in Hz and a temperature reading in degrees C.

Reading with the VWP Indicator

1. Connect signal cable to the VWP indicator as shown in the tables below.
2. Select the 0.45-1.2 kHz range with the Sweep key.
3. Select Hz with the Data key. Do not use microstrain settings (these are for a different model of sensor).
4. Read the RTD: Select °C with the Data key.
Note that the VWP Indicator reads RTDs only and cannot read thermistors.

Standard Jumper 52611950

Connect alligator clips as shown below:

Clips	Wire Colors		Function
Red	Orange	Red	VW
Red	White & Orange	Black	VW
Black	Blue	White	TEMP
Black	White & Blue	Green	TEMP

Universal Jumper 52611957



This cable has a universal connector and is supplied with a bare-wire adapter:

BWA	Wire Colors		Function
5	Blue	White	TEMP
6	White & Orange	Black	VW
7	White & Blue	Green	TEMP
8	Orange	Red	VW
10	Shield	Shield	Shield

Reading with the DataMate MP

The DataMate MP allows you to choose engineering units for your readings. However, for ease of data reduction, we recommend that you record readings in Hz.

Manual Mode

1. Connect signal cable as shown in the table below.
2. Switch on. Press  (Manual Mode).
3. Scroll through the list to find “Vibrating Wire Hz.”
4. Press  to excite the sensor and display a reading in Hz and a temperature reading in degrees C.

Universal Jumper and Bare-Wire Adapter

The DataMate jumper cable has a universal connector that connects directly to a universal terminal box or to signal cables that are terminated with a universal connector. A bare-wire adapter (BWA) is also supplied with the DataMate. It allows connection to wires of the signal cable as shown below:

Terminals on BWA or Terminal Box	Wire Colors		Function
5	Blue	White	TEMP
6	White & Orange	Black	VW
7	White & Blue	Green	TEMP
8	Orange	Red	VW
10	Shield	Shield	Shield

Data Reduction

Converting from Hz to microstrain

Use the following equation to convert a reading in Hz to microstrain:

$$\mu\epsilon = F^2 \times \text{Gauge-Factor} \times \text{Batch-Factor}$$

Where:

$\mu\epsilon$ = microstrain

F is a reading in Hz.

Gauge-Factor = 3.304×10^{-3}

Batch-Factor = 0.96

Calculating Change in Strain

Change in strain is calculated by subtracting the initial strain from the current strain.

$$\Delta\mu\epsilon = \mu\epsilon_{\text{current}} - \mu\epsilon_{\text{initial}}$$

or

$$\Delta\mu\epsilon = (F^2_{\text{current}} - F^2_{\text{initial}}) \times \text{Gauge-Factor} \times \text{Batch-Factor}$$

Where:

$\mu\epsilon$ = microstrain

$\Delta\mu\epsilon$ = change in microstrain

F is a reading in Hz.

Gauge-Factor = 3.304×10^{-3}

Batch-Factor = 0.96

Tension or Compression?

Using the equation above,

- a positive $\Delta\mu\epsilon$ indicates tensile strain.
- a negative $\Delta\mu\epsilon$ indicates compressive strain.

If you wish to use a different convention, reverse the sign of the $\Delta\mu\epsilon$ value.

Temperature Effects

We recommend that you always record temperature along with strain. Temperature data can help you understand changes in stress due to expansion and contraction caused by changes in temperature.

Correcting strain readings for temperature is optional. You may find that plotting temperature and strain on the same graph is more useful than trying to correct for temperature effects.

Applying a Temperature Correction

Concrete and steel have different thermal coefficients of expansion. You can calculate a correction for this difference using the equation below:

$$\text{Temperature Correction} = (TC_C - TC_S) \times (T_{\text{current}} - T_{\text{initial}})$$

Where:

TC_C is the thermal coefficient of expansion for concrete. A typical value is 10 ppm per °C.

TC_S is the thermal coefficient of expansion for the steel wire. For the strain gauge, this is 12 ppm per °C.

T is the temperature in °C.

Apply the temperature correction according to the convention that you use:

- If you assume that compressive strain is negative, subtract the temperature correction: $\Delta\mu\varepsilon - \text{Temperature Correction}$
- If you assume that compressive strain is positive, add the temperature correction: $\Delta\mu\varepsilon + \text{Temperature Correction}$.