VW Embedment Strain Gauge

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Introduction

Applications

VW embedment strain gauges are used to monitor changes in strain in reinforced concrete and mass concrete.

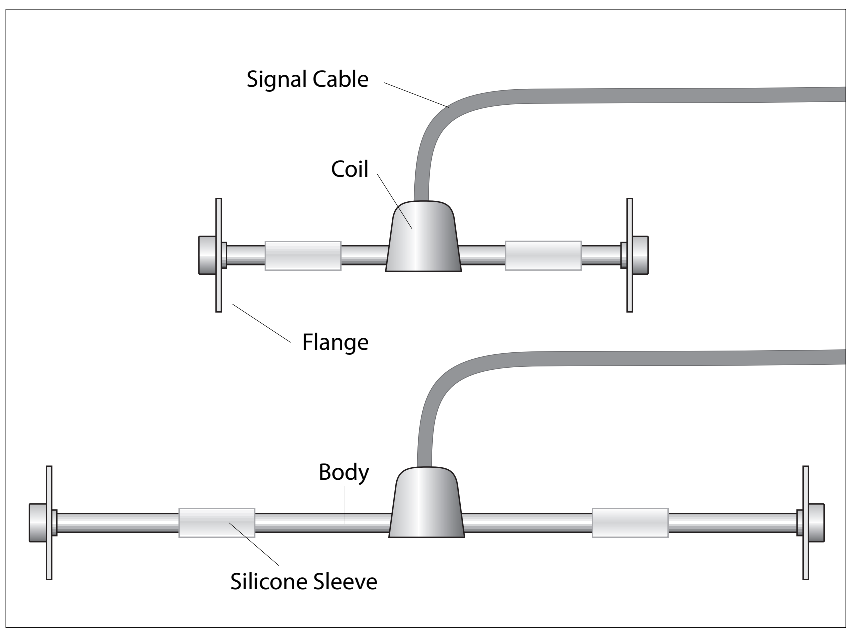
Operation

The strain gauge operates on the principle that a tensioned wire, when plucked, vibrates at its resonant frequency. The square of this frequency is proportional to the tension in the wire.

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. Deformation of the concrete causes the flanges to move relative to one another, increasing or decreasing the tension in the wire.

An electromagnetic coil is attached to the gauge body. When activated by a readout, the coil plucks the wire and transmits the resulting frequency signal back to the readout.

A change in strain is calculated by finding the difference between the initial reading and a subsequent reading and then multiplying by a gauge factor.



VW Embedment Strain Gauges are available in gauge lengths from 50 to 250 mm (2 to 10 inches).

Installation

General Notes

Here are suggestions for successful installation of strain gauges.

Sensor

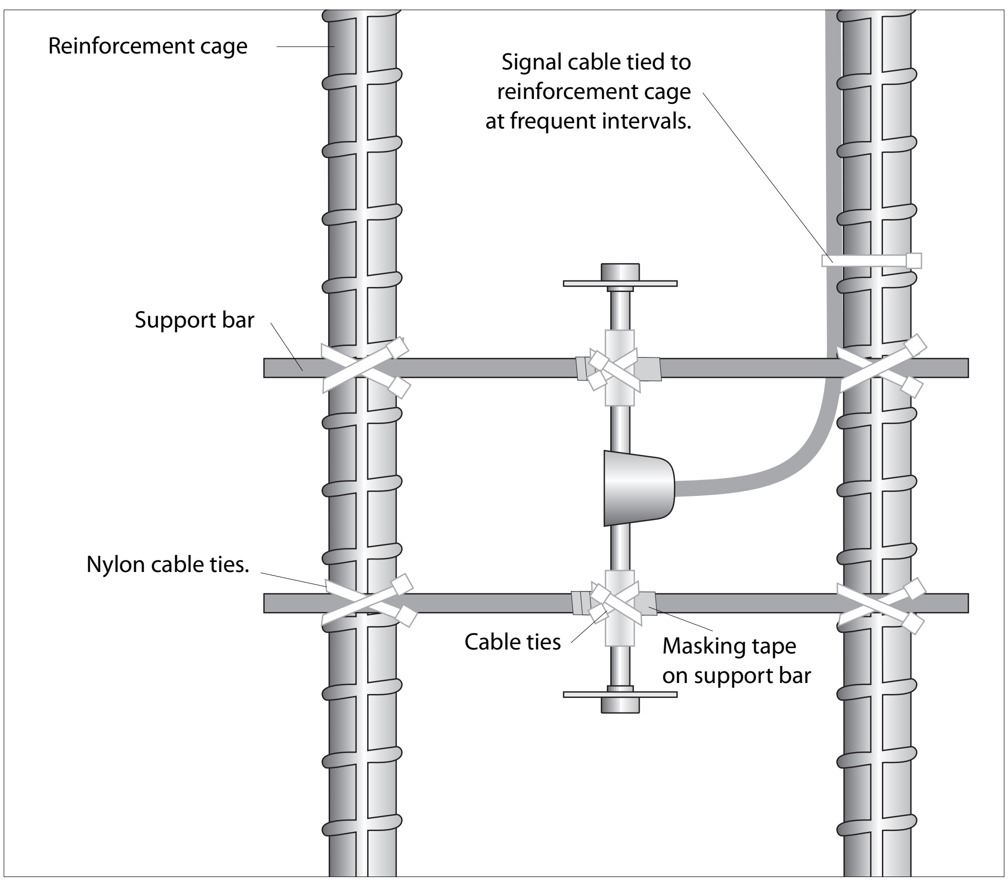
- Do not twist or pull on the end flanges of the strain gauge. This may cause non-repairable damage to the sensor.
- If the reading alters significantly when tying the gauge to the reinforcement cage, the gauge may be damaged and should be rejected.
- When a strain gauge is mounted in a particularly vulnerable position, consider spraying the area with marker paint, covering the gauge with a protective wire mesh, or placing some non-structural steel to protect the gauge. Damage is most likely to occur when the reinforcing gauge is lifted and then placed and also when the tremie pipe places the cement.
- The frequency range of the gauge is 625 to 1176 Hz. Midrange is 944 Hz. If your readout is set to show Hz^2 / 1000, the equivalent values are 391 to 1383, with midrange being 891.

Signal Cable

- Mark cables before installation so that the sensor can be identified after installation. Add extra identification marks at locations where the cable is vulnerable. This precaution may make it possible to reconnect a bundle of broken cables. Also add extra marks toward the end of the cable, where excess cable length may be cut off before being properly identified.
- Start with the sensor farthest from the reading station and run the cable along the reinforcement, picking up cables from other gauges on the way. Use nylon cable ties to strap the cables to the reinforcement at least every 300 to 400 mm.
- Run cables along the underside of the reinforcement to gain some protection from the poured concrete and the use of vibrators. Never run cables diagonally or unsupported through the reinforcement.
- Leave sufficient slack in the cables where there is likely to be any movement in the reinforcement. Check that slack cable cannot be damaged.
- Protect the cables where they exit the concrete with a short length of conduit.

Installation Method

1. Mark the reinforcement cage to show the intended position and orientation for each strain gauge. This information should be available from the engineer's drawing.
2. Tie or weld two support bars to the reinforcement. Support bars should be parallel and spaced as shown in the drawing - gauges are attached at the mid-point on either side of the coil. This is about 85mm apart for the 5.5" gauge and 150 mm apart for the 250mm gauge).
3. Wrap about 5 or 6 turns of masking tape around the support bars to pad the area where the gauge body will touch. Silicon rubber sleeves on the gauge body also provide padding. This helps prevent damage when the gauge is tied into position.
4. Remove the gauge from its packing. Orient it 90 degrees to the support bars, as shown below. Check that the flanges have plenty of clearance from any steelwork or other obstructions.
5. Fix the gauge with two nylon cable ties, one on either side. Single strands of soft iron tie wire may also be used. Tighten the ties until they just start to bite into the masking tape and sleeve.



Installation method continued

6. Connect your readout and observe the reading. Now tighten the two ties to secure the gauge. You should see little change in the reading. Add two more ties, diagonal to the first ties, and tighten them.

   If the reading changes significantly when tying, the gauge may have been damaged, and should be rejected. If your readout has a speaker, check that the tone of the gauge is pure and sustained.

7. Make a final check of the gauge reading, check that its signal cable is numbered appropriately, note its exact position.

8. Consider protection for the gauge. Protection may be as simple as spraying the installation area with marker paint. In other cases, where a tremie pipe or falling aggregate may damage the gauge, it may be necessary to protect the gauge with strategically placed, non-structural steel.

9. A set of readings should be taken immediately before and after the concrete is poured.

Other Methods of Installation

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.

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 CR10 data logger can be found at www.slopeindicator.com. Go to Support - Tech Notes. Look in the data logger section for a link titled "CR10 and VW Sensors."

VW Data Recorder

1. Connect signal cable to the data recorder.

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

2. Choose Hz^2 + RTD or Hz^2 + Thermistor, depending on which temperature device was installed.
3. Select the 450-1200 Hz range.
4. The recorder displays the sensor reading as Hz^2 /1000 and a temperature reading in degrees C.

DataMate MP

These instructions tell how to use the DataMate MP in manual mode to display readings as Hz^2/1000.

1. Connect signal cable to the bare wire adapter (BWA) as shown in the table below.

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

2. Switch on. Press (Manual Mode).
3. Scroll through the list to find "Vibrating Wire Hz^2."
4. Press to excite the sensor and display a reading in Hz^2 and a temperature reading in degrees C.

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^2 with the Data key. (Do not use microstrain settings. They are for a different model of sensor).
4. Select °C with the Data key to read an RTD. Note that the VWP Indicator cannot read a thermistor.

Standard Jumper 52611950

This cable is supplied with alligator clips:

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

Universal Jumper 52611957

This cable is supplied with a bare-wire adapter:

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

Data Reduction

Required Data

Calculating change in strain requires three values:

- A datum reading in $Hz^2/1000$ (displayed by readout).
- A subsequent reading in $Hz^2/1000$ (displayed by readout).
- A gauge factor.

Calculating Change in Strain

In the equation below, a negative value indicates compressive strain, and a positive value indicates tensile strain:

$$\Delta\mu\varepsilon = (R_1 - R_0) \times (GF)$$

Where
R_1 = current reading
R_0 = initial reading
GF = gauge factor as calculated below

If you want compressive strains represented as positive values, change the equation to:

$$\Delta\mu\varepsilon = (R_0 - R_1) \times (GF)$$

Calculating GF

The gauge factor is related to the length of the gauge. It can be calculated as follows:

$$GF = 0.1 \times L^2$$

Where L = Length of the wire in inches.

For example:

- If the wire has a length of 5.5", GF = 3.025.
- If the wire has a length of 250 mm, convert the length to inches (9.8425), then calculate. In this case, GF = 9.6875.

Temperature Effects

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

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

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

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 this strain gauge, the coefficient is 11 ppm per °C.
T is the temperature in °C.

Applying a Temperature Correction

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

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