RST INSTRUMENTS LTD.

VW Rebar Strain Meter

Instruction Manual

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VW Rebar Strain Meter Instruction Manual

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Table of Contents

1 INTRODUCTION 1

2 INSTALLATION 2

2.1 GAUGE INSTALLATION 2
2.2 CABLE PROTECTION 2

3 TAKING READINGS 2

3.1 MEASURING TEMPERATURES 2

4 DATA REDUCTION 3

4.1 CALCULATION OF STRAIN 3
4.2 TEMPERATURE CORRECTIONS 3

5 TROUBLESHOOTING 5

Appendices

Appendix A - THERMISTOR TEMPERATURE DERIVATION 6

Tables

Table 1: C-1 Thermistor Resistance versus Temperature 6

Equations

Equation 1: Change in Strain 3
Equation 2: Thermally Corrected Strain Calculation 3

Figures

Figure 1: Rebar Strain Meter General Arrangement 1
Figure 2: Sister Bar General Arrangement 1
Figure 3: Sample Calibration Record 4

1 INTRODUCTION

The RST Rebar Strain Meter is designed for direct burial in concrete structures, requiring reinforcing bars, for the purpose of measuring strain as a result of externally applied loads. Typical installations include, but are not exclusive to; foundations, piles, bridges, dams, containment vessels, tunnel liners, etc. The instrument is comprised of two lengths of rebar, separated by a Temperature compensated Gauge Section, and a customer specified length of cable. The Gauge Section is designed to match the strain in the rebar, and is protected by debonding sleeves so that the strain measured, is free from local effects that may act on the Gauge Section. Various Rebar/gauge sizes and cable lengths are available upon request.

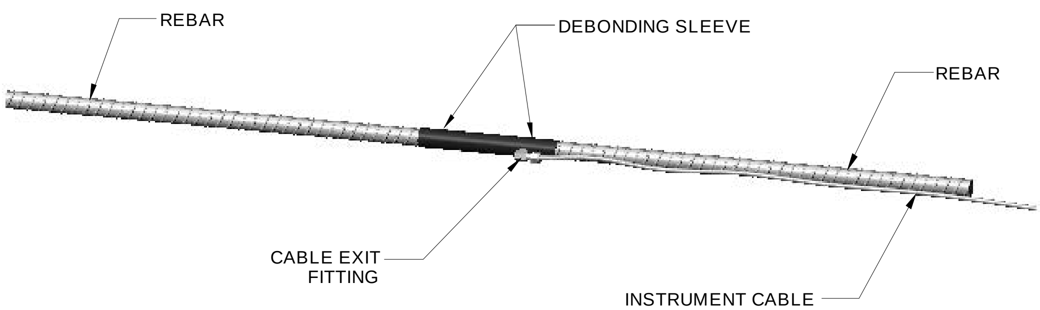

Figure 1: Rebar Strain Meter General Arrangement

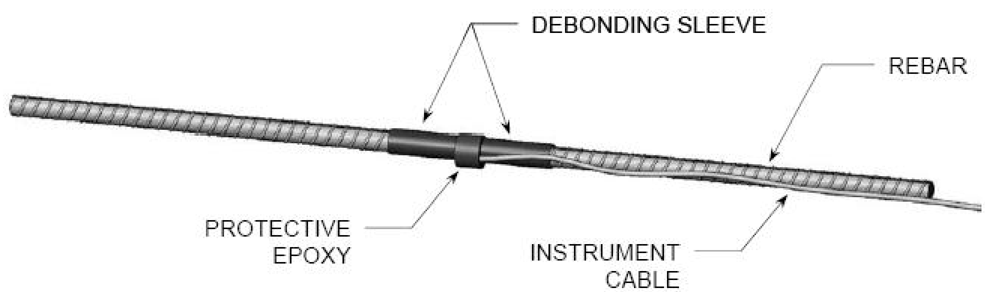

Figure 2: Sister Bar General Arrangement

It is highly recommended to install a pair of Rebar Strain Gauges on either side of the neutral axis, (ex. 180 degrees apart on a circular rebar cage) so that bending moments can be separated from axial loads.

2 INSTALLATION

It is recommended upon receiving the instrument, to verify the unit is functioning properly. This is achieved by comparing the current reading with the reading indicated on the calibration sheet (no applied load).

2.1 GAUGE INSTALLATION

The Rebar Strain Gauge is secured to the existing reinforcement rebar system, in a predetermined location, by bolting, welding or tying it in place. Only secure the Rebar Sections of the Rebar Strain gauge, not the Gauge Section. Keep in mind, the purpose for securing the Strain Gauge is to secure the instrument in place when pouring the concrete.

2.2 CABLE PROTECTION

Since the Rebar Strain Meters use a frequency based Vibrating Wire Sensing Element, the length of cable used is not a concern.

When laying the cable, take care to select a route that will provide the best protection from pouring the concrete.

3 TAKING READINGS

Readings can be taken by connecting the instrument to a VW2102 or VW2104 readout (B scale), or a RST supplied datalogger (with a frequency sweep 1200-3200Hz) refer to each units Operating Manual for more detail.

3.1 MEASURING TEMPERATURES

The RST Rebar Strain gauge is equipped with a thermistor for reading temperature. The thermistor gives a varying resistance output as the temperature changes.

1. Connect an ohmmeter to the two Thermistor leads coming from the strain gauge (Since the resistance changes with temperature are large, the effect of cable resistance is usually insignificant).

2. Lookup the temperature for the measured resistance in Table C-1, Alternately the temperature could be calculated using Equation C-1.

Note: The VW2104 readout box will read the Thermistor and display temperature in ^{o}C.

4 DATA REDUCTION

4.1 CALCULATION OF STRAIN

Once a reading has been taken, it can be inserted in the equation below to calculate Strain ($\mu\varepsilon$) units;

$$\mu\varepsilon = G.F. * (B_c - B_i)$$

Equation 1: Change in Strain

Where:

$\mu\varepsilon$	= Change in Strain
G.F.	= Gauge Factor (refer to Calibration Sheet)
B_c	= Current Reading
B_i	= Initial Reading (no load or initial load)

4.2 TEMPERATURE CORRECTIONS

Temperature variations of considerable magnitude are not uncommon, particularly during concrete curing; therefore it is always advisable to measure temperature along with every measurement of strain.

If the concrete expanded by exactly the same amount as the wire, then the wire tension would remain constant and no correction would be necessary. However since the coefficient of expansion of concrete, is approximately 10.4 microstrain/ºC and 12.2 microstrain/ºC for steel, a temperature correction is required:

Corrected strain in concrete is given by

$$\mu\varepsilon_{corrected} = \mu\varepsilon + (T_c - T_i)K$$

Equation 2: Thermally Corrected Strain Calculation

Where K= 12.2 microstrain/ºC - 10.4 microstrain/ºC = **1.8 microstrain/ºC**

Note: *Users should use their own values for the Temperature Coefficient of concrete if known.*

Calibration Record

200 - 2050 Hartley Ave., Coquitlam, British Columbia, Canada V3K 6W5
Tel: 604.540.1100 • Fax: 604.540.1005 • Toll Free: 1.800.665.5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Rebar Strainmeter

Customer:		RST
Model:		VW5000 - 15
Serial Number:		**SR0000**
Rebar Size:		15 Metric
Date of Calibration:		9-Jul-09
Temperature:		24.2 °C
W.O. Number:		Q000000
Cable Length:		15 meters
Cable Colour Code:	Red / Black (Coil)	Green / White (Thermistor)
Cable Type:		EL380004
Thermistor Type:		3 kohms

Applied Load (kN)	First Reading (B units)	Second Reading (B units)	Average Readings (B units)	Calculated Linear (kN)	Linearity F.S. Error (%)
4.0	6631	6628	6629.5	4.0	0.09
10.0	7163	7159	7161.0	10.0	0.08
16.0	7696	7700	7698.0	16.0	0.02
22.0	8235	8227	8231.0	22.0	0.13
28.0	8774	8772	8773.0	28.0	0.13
4.0	6628	6627	6627.5	4.0	0.01
				Max. Error (%):	0.13

B Unit = Freq^2 x 10-3
Bc = Current Reading
Bi = No Load or Initial Reading

Load Calibration Factor:	F =	0.01120	kN/B unit
Regression Zero:	At Calibration =	6270.2	B unit
Calculated Load (kN) = F x (Bc - Bi)			

Gauge Factor:	GF =	0.2800	µE / B unit

Calculated Strain = GF x (Bc - Bi)

	B Unit	Temp °C
Shipped Zero Reading:	6290	23.0
Calibration Zero Reading:	6293	24.2

Technician: J. Chu Date: 9-Jul-09

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Document Number.: ELL0203B

Figure 3: Sample Calibration Record

5 TROUBLESHOOTING

Maintenance and troubleshooting of the Rebar Strain Gauges are confined to periodic checks of cable connections and maintenance of terminals. Once installed, the gauges are usually inaccessible and remedial action is limited.

Consult the following list of problems and possible solutions should difficulties arise. Consult the factory for additional troubleshooting help.

Symptom: Strain Gauge Readings are Unstable

- ✓ Is the readout box position set correctly? If using a datalogger to record readings automatically are the swept frequency excitation settings correct?
- ✓ Is the strain reading outside the specified range (either compressive or tensile) of the instrument? Gauge may have become too slack or too tight; inspection of the data might indicate that this is a possibility.
- ✓ Is there a source of electrical noise nearby? Most probable sources of electrical noise are motors, generators and antennas. Move the equipment away from the installation or install electronic filtering. Make sure the shield drain wire is connected to ground whether using a portable readout or datalogger.
- ✓ Does the readout work with another gauge? If not, the readout may have a low battery or be malfunctioning.

Symptom: Strain Gauge Fails to Read

- ✓ Is the cable cut or crushed? This can be checked with an ohmmeter. Nominal resistance between the two gauge leads for the VWSG-S (usually red and black leads) is 45Ω ± 5Ω. Remember to add cable resistance when checking (22 AWG stranded copper leads are approximately 14.7Ω/1000' or 48.5Ω/km, multiply by 2 for both directions). If the resistance reads infinite or very high (megohms), a cut wire must be suspected. If the resistance reads very low (<100Ω) a short in the cable is likely. Splicing kits and instructions are available from the factory to repair broken or shorted cables. Consult the factory for additional information.
- ✓ Does the readout or datalogger work with another strain gauge? If not, the readout or datalogger may be malfunctioning.

Appendix A - THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale 41C3001-B3, Alpha #13A3001-B3
Resistance to Temperature Equation:

$$T = \frac{1}{A+B(LnR)+C(LnR)^3} - 273.2$$

Equation C-1 Convert Thermistor Resistance to Temperature

where:

T	=	Temperature in °C.
LnR	=	Natural Log of Thermistor Resistance
A	=	1.4051×10^{-3} (coefficient calculated over the -50 to +150°C. span)
B	=	2.369×10^{-4}
C	=	$1.019 \text{ X } 10^{-7}$

Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp	Ohms	Temp
201.1K	-50	16.60K	-10	2417	+30	525.4	+70	153.2	+110
187.3K	-49	15.72K	-9	2317	31	507.8	71	149.0	111
174.5K	-48	14.90K	-8	2221	32	490.9	72	145.0	112
162.7K	-47	14.12K	-7	2130	33	474.7	73	141.11	113
151.7K	-46	13.39K	-6	2042	34	459.0	74	137.2	114
141.6K	-45	12.70K	-5	1959	35	444.0	75	133.6	115
132.2K	-44	12.05K	-4	1880	36	429.5	76	130.0	116
123.5K	-43	11.44K	-3	1805	37	415.6	77	126.5	117
115.4K	-42	10.86K	-2	1733	38	402.2	78	123.2	118
107.9K	-41	10.31K	-1	1664	39	389.3	79	119.9	119
101.0K	-40	9796	0	1598	40	376.9	80	116.8	120
94.48K	-39	9310	+1	1535	41	364.9	81	113.8	121
88.46K	-38	8851	2	1475	42	353.4	82	110.8	122
82.87K	-37	8417	3	1418	43	342..2	83	107.9	123
77.99K	-36	8006	4	1363	44	331.5	84	105.2	124
72.81K	-35	7618	5	1310	45	321.2	85	102.5	125
68.30K	-35	7252	6	1260	46	311.3	86	99.9	126
64.09K	-33	6905	7	1212	47	301.7	87	97.3	127
60.17K	-32	6576	8	1167	48	282.4	88	94.9	128
56.51K	-31	6265	9	1123	49	283.5	89	92.5	129
53.10K	-30	5971	10	1081	50	274.9	90	90.2	130
49.91K	-29	56.92	11	1040	51	266.6	91	87.9	131
46.94K	-28	5427	12	1002	52	258.6	92	85.7	132
44.16K	-27	5177	13	965.	53	250.9	93	83.6	134
39.13K	-25	4714	15	895.8	55	236.2	95	79.6	135
36.86K	-24	4500	16	863.3	56	229.3	96	77.6	136
34.73K	-23	4297	17	832.2	57	222.6	97	75.8	137
32.74K	-22	4105	18	802.3	58	216.1	98	73.9	138
30.87K	-21	3922	19	773.7	59	209.8	99	72.2	139
29.13K	-20	3748	20	746.3	60	203.8	100	70.4	140
27.49K	-19	3583	21	719.9	61	197.9	101	68.8	141
25.95K	-18	3426	22	694.7	62	192.2	102	67.1	142
24.51K	-17	3277	23	670.4	63	186.8	103	65.5	143
23.16K	-16	3135	24	647.1	64	181.5	104	64.0	144
21.89K	-15	3000	25	624.7	65	176.4	105	62.5	145
20.70K	-14	2872	26	603.3	66	171.4	106	61.1	146
19.58K	-13	2750	27	582.6	67	166.7	107	59.6	147
18.52K	-12	2633	28	562.8	68	162.0	108	58.3	148
17.53K	-11	2523	29	543.7	69	157.6	109	56.8	149
								55.6	150

Table 1: C-1 Thermistor Resistance versus Temperature