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Instruction Manual
Model 3900
Embedment Strain Gage

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1. INTRODUCTION

The Model 3900 Embedment Strain Gage is designed for the measurement of dynamic strains in concrete structures, asphalt roadways and soils. It comprises a full-bridge strain gage proving ring element coupled in series with a tension spring which is stretched between two end flanges. An outer PVC tube sealed with O-rings provides a waterproof housing. The end flanges are embedded and move in accordance with the surrounding material. The voltage signals from the strain gage are transmitted via cable to the readout location.



Figure1 The Model 3900 Embedment Strain Gage.

The strain gage can be read out by means of the Geokon Model 501 Readout Box or by applying a 2 to 12 Volt excitation to the input leads, and reading the corresponding millivolt output.. The output at full range is approximately 3mV/V. The standard wiring for use with the GK501 readout box is configured to compensate for the use of long cables by the remote sensing of the input voltage at the sensor. A Thermistor is included inside the sensor to measure temperatures This requires a cable with 4 shielded pairs of conductors.

2. INSTALLATION

The embedment gage is delivered with the sensor set at an approximately mid-range position ready for installment. The standard range is +/- 2500 microstrain. (Other ranges are available). An initial test can be conducted by connecting the strain gage to the GK 501 Readout Box or to a regulated voltage supply. Movement of the end flanges should produce a corresponding change in the gage output. At no time should the end flanges be twisted or pulled beyond the range of the sensor as this could permanently damage the gage.

The gage should be installed directly in the concrete or asphalt by hand. Large aggregate should be removed from the area immediately surrounding the sensor. The use of vibrators immediately next to the gage should be avoided. The standard cable has a thick PVC jacket and can be placed directly in the concrete. In hot asphalt a Teflon cable is required.

3. TAKING READINGS

Connect the ten pin connector to the GK501 readout box or connect the bare wires to a voltage supply and millivoltmeter as follows:

3.1 Input Connections

Bendix Pin	Circuit Label	Description	Geokon Purple Cable
A	S-	Bridge Output -	White's Black
B	P+	Bridge Excitation +	Red
C	P-	Bridge Excitation -	Red's Black
D	S+	Bridge Output +	White
E	NC	No Connection	NC
F	G	Ground for shield	Shield
G	T	Thermistor	Blue
H	T	Thermistor	Blue's Black
J	RS+	Remote Sense +	Green
K	RS-	Remote Sense -	Green's Black

Figure 2 Input Connections

Notes:

¹ Blue and Blue's Black (thermistor) wires can be connected to an ohmmeter to measure temperature.

² Non-remote sense is optional and must be specified at the time of ordering.

3.2 Circuit Diagram

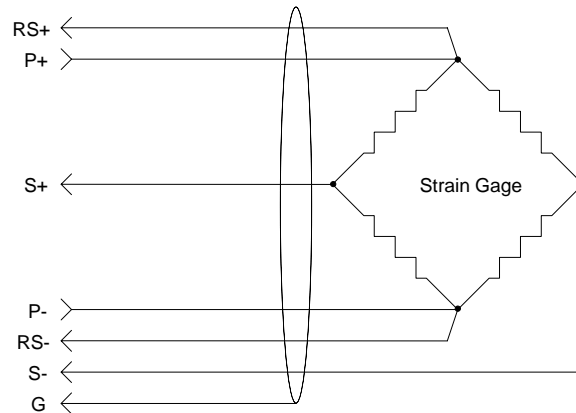


Figure 3 Circuit Diagram

3.3. Using the Geokon GK-501 Readout Box

The user is referred to the GK-501 Instruction Manual for additional information on the following instructions:

1. Connect the embedment gage to the readout box by means of the 10 pin input connector.
2. Switch the power switch to the "ON" position.
3. Switch the selector switch to the "x1" position.
4. Read the display and record.
5. See the GK-501 Instruction Manual for further instructions.

4. DATA REDUCTION

4.1. Displacement Calculation

The basic units utilized by Geokon for measurement and reduction of data from Model 3900 Embedment Strain Gages are mV/V

If a GK501 readout box is in use $\text{mV/V} = \text{Digits} / 4000$

Where **Digits** is the reading on the GK501 readout box

The displacement **D** is given by the equation

$$D = (R_1 - R_0) / 4000 \times C$$

Where; **D** is the displacement in the units given on the calibration sheet.
R₀ is the initial GK501 reading in digits.
R₁ is the current GK 501 reading in digits.
C is the **millimeters(or inches)/mV/V** calibration factor as supplied on the Cal Sheet (Figure 3).

If a regulated power supply and a millivoltmeter is used then calculate the displacement by deviding the measured millivolt output by the voltage input measured at the sensor.

4.2. Strain Calculation

To calculate the **strain ε**, divide the measured displacement **D** by the gage length **L**. The standard length for **L** is 203mm (8inches)

Example: Using a GK501 $R_0 = -2841$ and $R_1 = -2225$, $K=0.05193\text{inches/mV/V}$.
 Strain $\epsilon = (-2225 - (-2841)) / 4000 \times 0.05193 / 8 = +1000$ **microstrain (tension)**

Note that an increasing reading denotes a tensile strain.

4.3. Temperature Correction Factor

Tests have shown that the temperature effect is such that the embedment gage reading goes down (compression) as the temperature goes up. The required temperature correction factor is +6 microstrain/°C

So, for a standard 8 inch long gage, where **C** is given in inches/mV/V, the calculation for strain **S**, corrected for temperature change (**T₁ - T₀**) measured in degrees Centigrade, is :

$$S = 0.002(R_1 - R_0) \times C + 6(T_1 - T_0) \text{ microstrain}$$

Where **C** is given in metric units the equivalent equation is

$$S = 0.05075(R_1 - R_0) \times C + 6(T_1 - T_0) \text{ microstrain}$$



48 Spencer St. Lebanon, N.H. 03766 USA

Resistance Strain Gage

Model Number: 3900Range: 5000 micro-strainSerial Number: 07-5116Temperature: 23.1 °CCal. Std. Cntrl #(s): 463, 187, 249, 146, 529Date of Calibration: March 12, 2007

Technician: _____

	Displacement (volts)	Displacement (inches)	Gage Reading (mV/V)	Change	Linearity % FS
First Cycle	0.0000	0.00000	-1.0188		-0.03
	0.4006	0.00801	-0.8640	0.01548	0.00
	0.8002	0.01600	-0.7103	0.01538	0.03
	1.2002	0.02400	-0.5563	0.01540	0.02
	1.6004	0.03201	-0.4020	0.01543	0.01
	2.0001	0.04000	-0.2485	0.01535	-0.03
Second Cycle	0.0000	0.00000	-1.0190		-0.03
	0.4001	0.00800	-0.8648	0.01543	0.02
	0.8005	0.01601	-0.7103	0.01545	0.01
	1.2001	0.02400	-0.5563	0.01540	0.03
	1.6001	0.03200	-0.4025	0.01538	0.02
	2.0001	0.04000	-0.2488	0.01538	-0.03

Calibration Factor (C): 0.05193 (inches/ mV/ Volt)

Function Test at Shipment

-0.6275 (mV/ V)

Temperature: 21.7 °CDate: March 12, 2007

The above instrument was found to be In Tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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Figure 4 Typical Calibration Sheet

APPENDIX A - SPECIFICATIONS

A.1. Model 3900 Embedment Strain Gage Specifications

Standard Range¹:	5000microstrain
Accuracy:	+/- 0.1%FS
Linearity:	<0.5% FSR
Resolution:	+/- 0.025% FSR
Repeatability:	0.1% FSR
Temperature Effect:	0.12% FSR/°C
Temperature Range:	-20 to +80° C 0 to 110° F
Active Gage Length²	203mm
Input Resistance:	350Ω
Output Resistance:	350 Ω
Excitation Voltage:	2 to 15 V DC
Maximum Excitation Voltage:	30 V
Cable Type³:	4 twisted pair (8 conductor) 22 AWG Foil shield, PVC jacket, nominal OD=9.5 mm (0.375")

Notes

¹ Other ranges available on request.

² Other gage lengths available on request.

³ Teflon cables need for asphalt.

APPENDIX B - THERMISTOR TEMPERATURE DERIVATION

Thermistor Type: YSI 44005, Dale #1C3001-B3, Alpha #13A3001-B3

Resistance to Temperature Equation:

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

Equation B-1 Convert Thermistor Resistance to Temperature

where: T = Temperature in °C.

LnR = Natural Log of Thermistor Resistance

A = 1.4051×10^{-3} (coefficients calculated over the -50 to +150° C. span)

B = 2.369×10^{-4}

C = 1.019×10^{-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	141.1	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
77.66K	-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	-34	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	292.4	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	5692	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	965.0	53	250.9	93	83.6	133
41.56K	-26	4939	14	929.6	54	243.4	94	81.6	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 B-1 Thermistor Resistance versus Temperature