1988/26. Unidata installation at S. Pickett's house, Windermere Road, Windermere.

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Abstract

A badly cracked house on the eastern shore of the River Tamar at Windermere has previously been investigated to determine the nature and cause of cracking. The most severe cracking occurs on the east wall of the house, where wide gaps are present in the brickwork and the concrete patio has moved away from the house. This cracking has extended into a retaining wall on the north side of the downstairs garage.

To monitor the extent of movement and cracking a Unidata logger was installed with displacement and water level transducers. This logger constantly monitors movement, which allows correlation with possible causes.

INTRODUCTION

A badly cracked house on the eastern shore of the River Tamar at Windermere has been investigated by W. R. Moore (Moore, 1986) to determine the nature and cause of cracking. The house is a split-level, white brick building, with a concrete wall perimeter base and pile foundations. The most severe cracking occurs on the east wall of the house, where wide gaps are present in the brickwork and the concrete patio has moved away from the house. This cracking has extended into a retaining wall on the north side of the downstairs garage.

It was suggested that a monitor could be installed at this house to measure movement of the house and/or cracks in the house, and to determine at what magnitude and regularity the movement occured. It was also suggested that a rain gauge and water level gauge be installed to see if any correlation between rainfall and movement occured.

The most favourable method of monitoring these parameters was to use a UNIDATA logger with appropiate transducers. The UNIDATA logger can measure up to eight data channels of analog information and two channels of digital information, so it was possible to connect existing transducers to the system with great ease. The points taken for measuring movement were the north retaining wall in the garage and the external north wall.

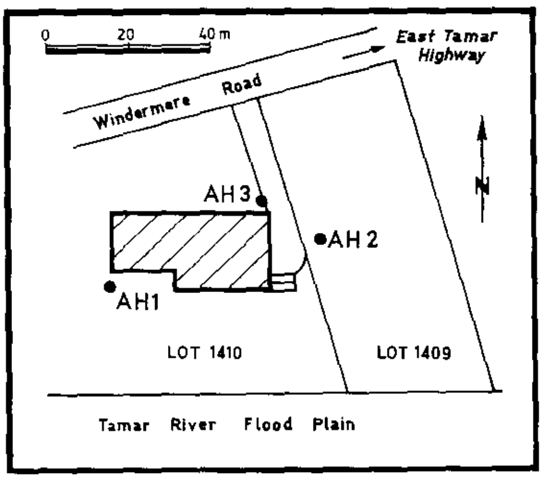


Figure 1. *Location of drill holes.*

5 cm

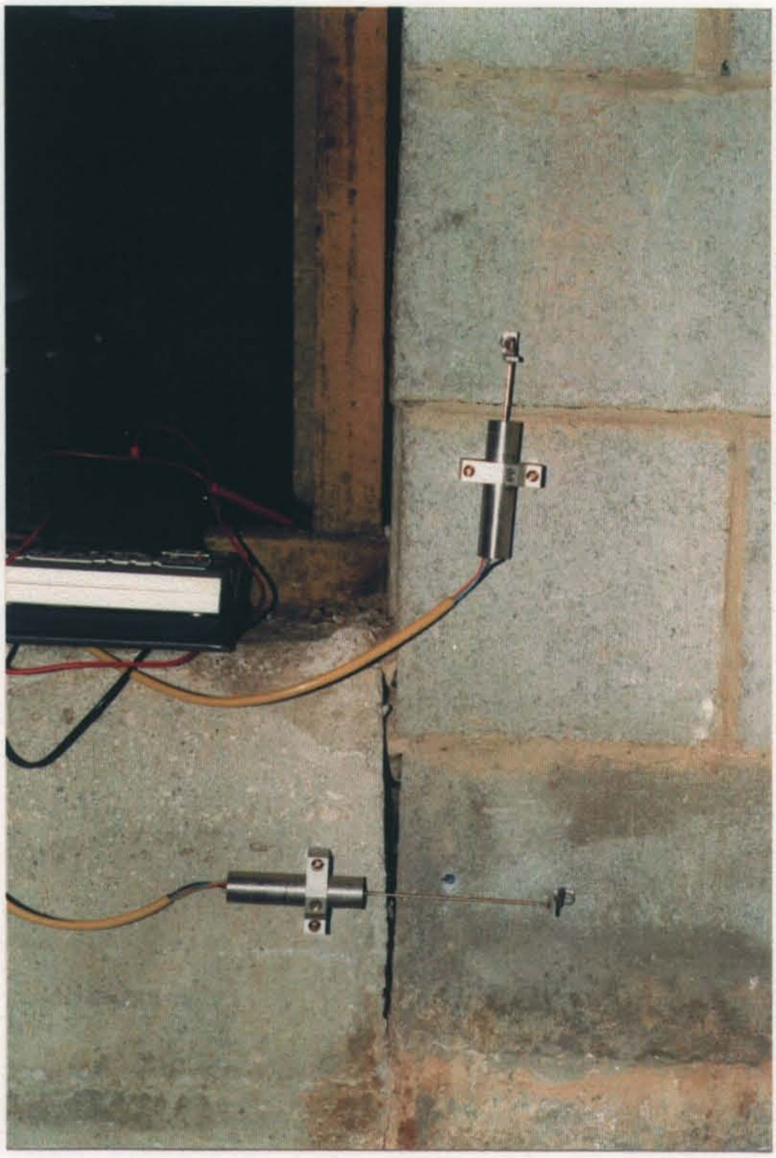


Figure 2. *Linear voltage displacement transducer.*

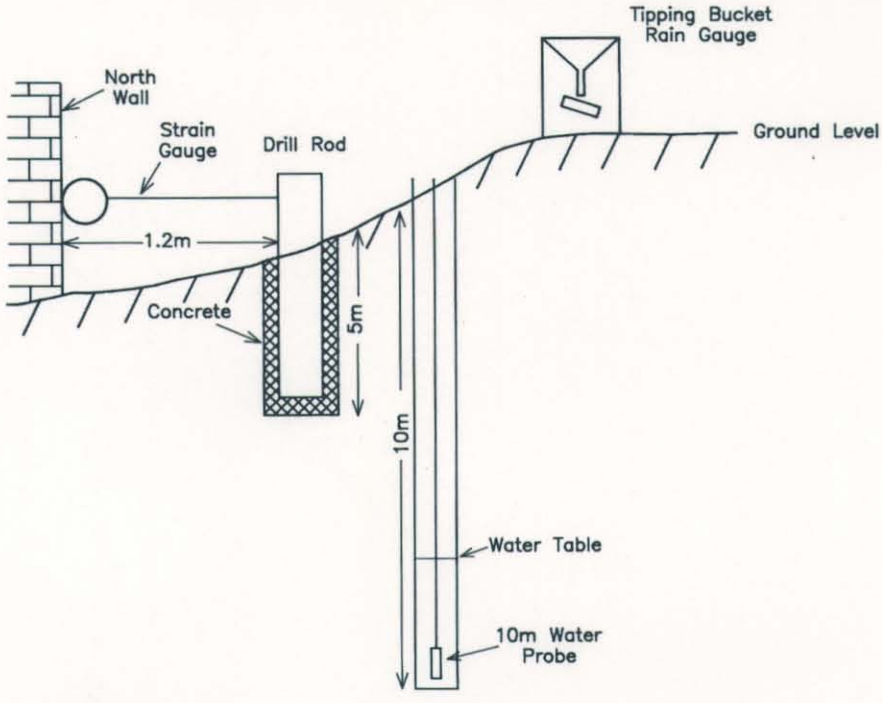


Figure 3. *Instrumentation at Pickett's house, Windermere.*

The internal wall was fitted with two Linear Voltage Displacement Transducers (LVDT) (see Appendix 1), one in the vertical plane and one in the horizontal plane, across two cracks (see fig. 2). On the external wall a strain gauge (see Appendix 2) was mounted attached to a drill rod concreted to a depth of five metres (see fig. 3). To measure rainfall a tipping bucket rain gauge (see Appendix 3) was installed beside the driveway three metres from the north side of the house. An observation bore hole of 50 mm diameter was drilled next to the rain gauge (AH3, fig. 1). The depth of the hole was ten metres, and a ten metre water probe was installed (see Appendix 4).

INTERNAL MEASUREMENT

The internal measurements were taken to see if the already existing cracks were moving, and possibly by how much. Two suitable cracks were used (one in a horizontal plane and one in a vertical plane) as this would give some indication of the direction and magnitude of movement. It must be stressed that the measurements taken are only of relative movements of one brick to another, and cannot give an absolute indication of movement. In other words we were just measuring the size of the cracks. The two LVDT's were anchored to the wall and set to mid-range on their scales to allow for movement in any direction (see fig. 2).

EXTERNAL MEASUREMENT

A five metre long drill rod was concreted into the ground to a depth of about 4.5 metres. This rod was positioned as close to the north wall of the house as possible (about 1.2 m; fig. 3). A strain gauge was then anchored to the house, with a threaded rod connecting the strain gauge and the drill rod. At the drill rod end of the connecting rod was a small turnbuckle; this allowed the strain gauge to be set or reset by adjusting the length of the connecting rod (see fig. 4).

Figure 4. *Reset turnbuckle on strain gauge.*

To obtain a qualitative result the rod has to be securely anchored into the bedrock below so that any surface movement will not affect the position of the anchor (drill rod) position. This is virtually impossible in low cost investigations, so the results have to be treated as one movement relative to the other. However the drill rod was surveyed in and is checked at regular intervals to ascertain if the drill rod is actually moving as well. The movement observed by the surveyor can be used as a correction factor by the data processor if the need should arise.

The strain gauge measures movement in terms of the distance between the house and the drill rod, so if the movement of the house is up or down this can also be interpreted as a downslope movement. Care must be taken when interpreting the results, and it is suggested that the interpreter consult the surveyor when processing the data.

INSTALLATION

The UNIDATA recorder is situated in the garage inside a grey enclosure with UNIDATA printed on the lid. A special triangular key is required to open the lid to service the unit (explained in Sedgman and Weldon, 1988). Power to the unit is supplied via a power point next to the installation; this power point is taped over so that the power cannot be switched off. Recording of the power by the data logger is required to show whether sudden changes of movement are real or due to a power failure. The power supply to the strain gauge is separate from the main supply, and is located behind the north wall under the house. This unit also has the strain gauge amplifer, calibration and offset adjustments (these should never have to altered). Power for the water probe comes directly from the data logger, and will not be affected by power failures.

Data for all channels is recorded at three hour intervals. All strain, water, and LVDT measurements are averaged over this period, with the rain gauge being a total accumalation over the period. A detailed description of the program which controls the data logger is given in Appendix 6.

MAINTENANCE

The installation should be serviced by the Toshiba laptop computer at least once every six weeks or so, as the memory within the data logger can be filled very shortly after this period of time (Sedgman and Weldon, 1988).

To carry out any electrical or mechanical maintenance you require a multimeter, screw drivers, and a pair of shifting spanners. Remove the lid of the enclosure and connect the negative lead of the multimeter to pin 41. To measure the output for the transducers the following pins are used (see Appendix 5 for circuit connections):

a:	pin 39	LVDT1
b:	pin 36	LVDT2
c:	pin 33	Voltmeter
d:	pin 30	Strain gauge
e:	pin 27	Water depth

Maintenance requirements are as follows:

1: *Effect* - Readings on LVDT go off scale .

Remedy - Loosen the retaining screw on the LVDT so that it moves freely, move the body until a reading of 1.25 volts appears on the multimeter.

2: *Effect* - Strain gauge readings go off scale.

Remedy - Adjust the turnbuckle on the drill rod assembly until the reading is 1.25 volts on the multimeter.

3: *Effect* - Erratic readings on the water probe.

Remedy - Replace probe.

REFERENCES

MOORE, W. R. 1986. Investigation of cracking of S. Pickett's house, Windermere Road, Windermere. *Unpub. Rep. Dep. Mines Tasm.* 1986/83.

SEDGMAN, R. J.; WELDON, B. D. 1988. Field manual for the Toshiba laptop computer. *Unpub. Rep. Dep. Mines Tasm.* 1988/22.

[14 September 1988]

APPENDIX 1

Linear Voltage Displacement Transducer (LVDT)

The LVDT is operated from a 5 volt power supply and indicates the position of linear motion. It has two fixed pionts, one being a transformer and the other a rod positioned in the centre of the transformer. When the rod moves in and out of the transformer a variable voltage is given on the output of the transformer, this being proportional to the rod's position. The output varies ± 5 volts, but in a Unidata logger application only the positive output is used in the range 0 to 2.55 volts (this range gives an extremely linear output).

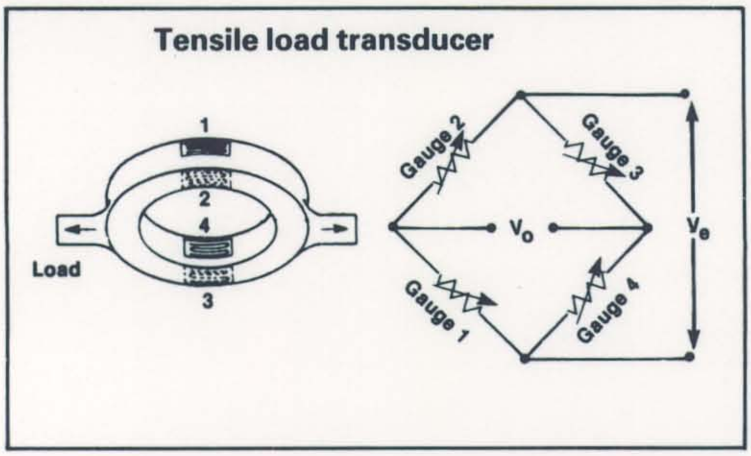
To give results as numerical value of displacement the readings taken must be scaled by 1.6 to 1 in the data logger output. This gives an indication of movement in millimetres, and not just a voltage reading.

APPENDIX 2

Strain gauge

To measure strain it was decided to use what is called a proving ring. This consists of four strain gauges mounted on an aluminium ring (two on opposite external sides and two on opposite internal sides) (see fig. 5). An amplifier is required to give an output which is suitable for measuring with the Unidata loggers, which have an output of 0 to 2.55 volts. The amplifier chosen was the Radio Spares type 308-815 (see fig. 6 for construction details).

Figure 5.



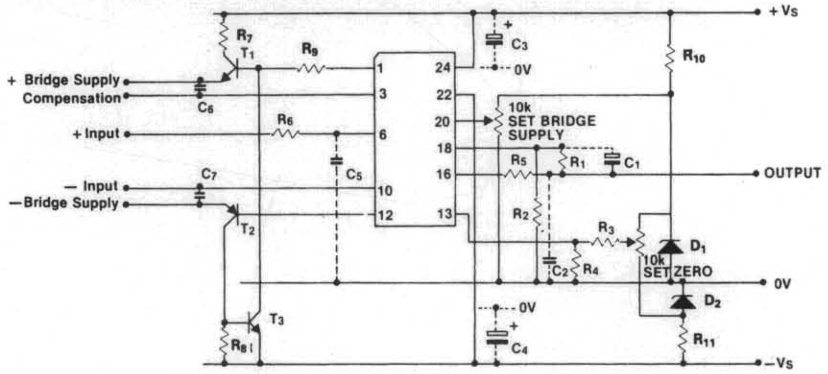
6604

Specification

(At 25°C ambient and ±12V supply unless otherwise stated.)

Supply voltage	±2 to ±20V dc
Input offset voltage	1 mV max
Input offset voltage/temperature	1 μV/°C max
Input offset voltage/supply	5μV/V max
Input offset voltage/time	1μV/month max
Input impedance	>2.5MΩ min
Input noise voltage	1μV p.p max
Band width (unity gain)	400kHz
Output current	5mA
Output voltage span	±(V_s-3)V
Closed loop gain (adjustable)	5 to 10,000
Open loop gain	>100dB
Common mode rejection ratio	>100dB
Bridge supply voltage/temperature	20μV/°C
Maximum bridge supply current	12mA
Power dissipation	0.5W
Warm up time	5mins
Operating temperature range	–25°C to +85°C

Basic circuit for printed circuit board 435-692 (gain approx. 1000).



Component values

R_1 100k	R_7 47R	C_2, C_5 10n (typ.)
R_2 100R	R_8 10R	C_3, C_4 10μ(tant.)
R_3 100k*	R_9 1k0	T_1 BD 135
R_4 68R*	R_{10} 680R	T_2 BD 136
R_5 10R	R_{11} 680R	T_3 BC 108
R_6 100R(typ.)	C_1, C_6, C_7 100n (typ.)	D_1, D_2 1N827

A glass fibre printed circuit board, stock number 435-692, is available for the basic circuit as given in Figure 7.

The board is 46 x 98mm in size and is complete with screen printed component identification and a solder mask.

Only typical values are given for certain components, as adjustment of these values may be necessary in specific applications to obtain optimum noise reduction (see Minimisation of Noise, page 5).

*R_3 and R_4 values may be adjusted to alter the zero adjustment range when compensating for bridge imbalance.

Notes:

Gain is defined as $1 + \frac{R_1}{R_2}$

Zero adjustment range $\pm 6.2 \times \frac{R_4}{R_3 + R_4}$ Volts

Total bridge supply = 2 × bridge ref input (pin 20)

C_5 may be omitted for input lead lengths of less than 10 metres.

T_1 and T_2 provide bridge currents up to 60mA and should be kept away from the amplifier.

T_3 and R_5 provide current limit of approx 60mA.

Where high stability power supplies are being used zero and bridge supply reference may be taken direct from the power rails.

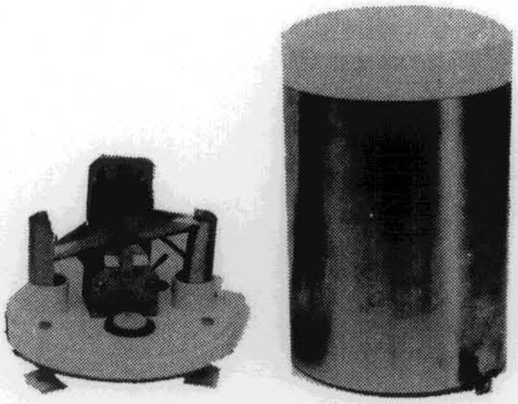
The high output of some semiconductor strain

Figure 6.

APPENDIX 3

Rain Gauge

The tipping bucket rain gauge is a commercially available rain gauge which measures to resolution of 0.2 mm. With every 0.2 mm of rain which falls, the bucket tips over and a pulse is sent to the data logger.



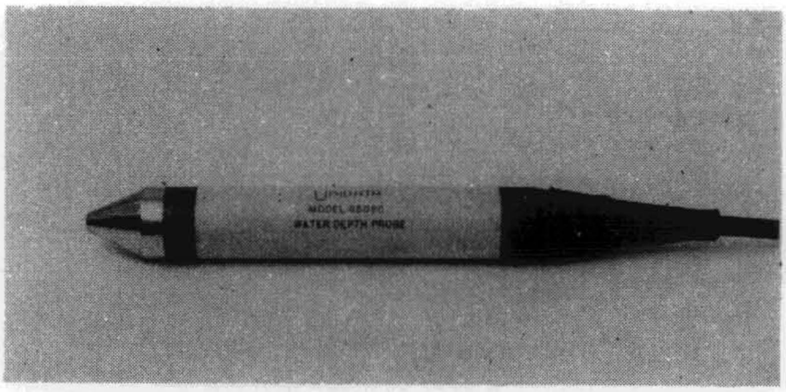
Model 6506A/B – Tipping Bucket Rainfall Gauges

Material:	Painted and polished stainless steel, cast alloy base
Signal Element:	Sealed reed switch
Cable:	PVC 2 wire, shielded, 5 metres
Weight:	3 kgs
Bucket Capacity:	Adjustable from 0.1mm to 0.5mm **Model 6506A** — 0.2mm **Model 6506B** — 0.5mm

APPENDIX 4

Water probe 10 m

The water probe is a low cost solid-state probe designed to measure hydrostatic pressure of water. In conjuction with the data logger it has a resolution of ± 40 millimetres.



Model 6508A/B/C/D – Water Depth Probes

Low cost, solid state probe designed to measure the hydrostatic pressure of water. Ideal for drainage, bore hole and river height recording projects. Sealed and factory calibrated to standard ranges, these probes are interchangeable. As many as eight Water Depth Probes may be connected to the Data Logger.

Sensor:	Semi-conductor strain gauge element
Electronics:	Integrated amplifier and correction circuitry
Power:	5 VDC, 4ma (4% of battery life)
Construction:	Sealed PVC (UV resistant)
Cable:	3 core vented cable with shield. 50m maximum
Resolution:	0.5% of range (-1 to 40 deg C)
Size:	25mm diameter, 180mm long
Weight:	200 grams (excl cable).
Range:	**Model 6508A** 0 to 1 metre of water **Model 6508C** 0 to 5 metres of water **Model 6508D** 0 to 10 metres of water **Model 6508E** 0 to 20 metres of water

APPENDIX 5

Circuit connections

Transducer	*Termination strip Number*
LVDT 1	signal 39, power external (40)
LVDT 2	" 36, " " (37)
Volt meter	" 33, " " (34)
Strain gauge	" 30, " " (31)
Water probe	" 27, " internal (15)
Rain gauge	" 9, " " (15)

APPENDIX 6

Scheme definition

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Scheme WRMDS2, Title: Windermere, water level, rainfall, displacement. RJS.
Communication port 1
Access form: Direct
Logger size 8K
Logger cycle rate 5 seconds
Log interval 180 minutes
Instrument 2222 measuring displacement
Log a0 as AV disp, being linear displacement transducer
Instrument 2222 measuring displacement
Log a1 as AV disp, being linear displacement transducer
Instrument 2223 measuring volt meter
Log a2 as AV v. meter, being voltage measurement
   Log a3 as AV strain, being strain
Instrument 6508d measuring Water depth 10 m
Log a4 as AV Depth, being Depth 10 m
Instrument 6506a measuring Rainfall Gauge 0.2 mm
Log c0 as Tot Rain, being Rainfall 0.2 mm
Total 6 entries, 6 bytes logged, 1109 log entries
giving a max logging time of 138 days, 15 hours
BASIC readable file generated
Detailed print-out to lpt1:
Plot 2
Plot 3
Plot 4
Plot 5
Plot 6
Plot 7
Plot 6 and 7
Plot 2 and 3 and 5
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