# 1984/42. House damage at 'The Grange' Kempton

*R.C. Donaldson*

*Abstract*

House damage at 'The Grange' Kempton is not due to an active geological fault, but to a variable thickness of expansive clay soils which had been subject to localised wetting.

## INTRODUCTION

Mr H. Oldmeadow, architect, asked the Department to investigate the possibility that the extensive structural damage at 'The Grange' Kempton [EN179918] was associated with an active geological fault.

The geological map of the area shows no such fault, either known or inferred, at this location. This was confirmed during the initial site visit. The severe cracking and distortion of both external and internal structural walls was, however, considered to be related to expansive soils, despite continued movement since substantial underpinning less than two years ago.

## DRILLING

A series of shallow auger holes was recommended to identify the nature of the soils beneath the foundations. Three holes were drilled; detailed descriptions of material encountered are contained in Appendix 1 and their locations are shown in Figure 1.

Results of drilling show that the house is underlain by Triassic sandstone and its weathering products rather than Jurassic dolerite which crops out on the hill immediately behind the house. However, some dolerite rock fragments were noted in the upper section of Hole 2 and probably represent a veneer of transported material from further upslope. The depth to bedrock is variable over the site, ranging from about 1.0 m in Hole 1, to approximately 2.5 m and 3.5 m in Holes 2 and 3 respectively. As may be expected, the areas of severe cracking are associated with the thicker soil profiles overlying bedrock.

## LABORATORY TESTING

Laboratory testing, involving X-ray diffraction, Atterberg Limit and soil suction tests were carried out on selected soil samples to determine some physical characteristics and identify the presence of expansive clay minerals (table 1).

The high plasticity index (LL-PL) and linear shrinkage figures are both indicative of a highly expansive clay soil. The mineralogy of the clay fraction (using XRD techniques) showed a predominance of montmorillonite; a well known expansive clay mineral with the potential for large volume changes. Soil suction profiles showed very little variation in pF values (4.1-4.4) over the total depth for each hole. This indicates that the soil is extremely dry and near the wilt point for most plants.

## DISCUSSION

The results of the investigation indicate that the major cause of the house damage is due to the presence of expansive clay beneath the foundations. Clay soils such as these increase in volume upon wetting and decrease

*Table 1. SOIL PROPERTIES - THE GRANGE, KEMPTON*

| Hole no. | Depth (m) | M.C.%[1] | pF[2] | L.L.[3] | P.L.[4] | L.S.[5] | X.R.D.[6] |
|---|---|---|---|---|---|---|---|
| 1 | 0 -0.9 | 19.3 | 4.11 | | | | Mont.(D). Musc. Quartz |
| | 0.9-1.8 | 9.2 | 4.45 | | | | |
| | 1.8-2.0 | 8.2 | 4.40 | | | | |
| 2 | 0 -0.9 | 18.5 | 4.32 | | | | |
| | 0.9-1.8 | 17.4 | 4.35 | 84 | 21 | 22 | Mont.(D). Kaolin, Quartz |
| | 1.8-2.7 | 18.0 | 4.25 | | | | |
| | 2.7-3.4 | 14.3 | 4.28 | 67 | 21 | 19 | Mont.(D). Quartz |
| 3 | 0 -0.9 | 27.3 | 4.31 | | | | |
| | 0.9-1.8 | 18.4 | 4.40 | | | | |
| | 1.8-2.7 | 25.5 | 4.27 | 85 | 22 | 21 | Mont.(D). Quartz |
| | 2.7-3.6 | 20.6 | 4.28 | | | | |
| | 3.6-4.5 | 18.6 | 4.19 | 86 | 23 | 22 | Mont.(D). Quartz |

*NOTES:*

(1) Moisture content - oven dried at 105-110°C.

(2) Measured with Wescor Pyschrometer using C52 chamber and Dew Point Method.

(3) Liquid Limit.

(4) Plastic Limit.

(5) Linear Shrinkage.

(6) Mont.(D) - Montmorillonite (dominant)
Musc. - Muscovite.

in volume when dried out. These soils can, therefore, be expected to swell and shrink to varying degrees following changes in their seasonal moisture content. However, cyclic or seasonal movement alone is insufficient to account for the extensive damage considering the age of the structure. The damage at 'The Grange' has most likely resulted from a change in moisture conditions from a localised source. It is my opinion that a long term leak from a broken service pipe associated with the septic tank system progressively wetted up the subsoil beneath the foundations. This fault was reportedly rectified about two years ago and the damage is the result of subsequent soil shrinkage (drying out) as the soil moisture profile returns to equilibrium.

The continued movement of the foundations since underpinning is not surprising. The clay soil was reportedly saturated during the underpinning process, with free water issuing from the dug trenches. This meant that the soil was in a state of heave at the time and thus shrinkage was inevitable as the soil dried out. In hindsight, the depth of underpinning was probably insufficient as there is between 2.5 and 3.5 m of expansive clay, all of which presumably was saturated and subject to volume changes.

RECOMMENDATIONS

Remedial measures involving the repair of the extensive cracking of the house is an engineering decision. However, having established the probable cause for the damage, one can predict that movement will continue until the soil moisture profile beneath the foundations is in equilibrium with the surrounding ground; this can take up to 5-6 years. With pF values of 4.1-4.4, the shrinkage phase is probably almost complete.

Movement should be carefully monitored and repairs carried out when it is minimal or has ceased.

Deliberate wetting up of the soil will cause heave and tilt the foundations again, but this remedy could well cause additional differential movement due to the inhomogeneity of the clays. The most important aspect of any remedial work is to ensure there are minimal changes in the soil moisture profile on completion of repairs. The structurally sound condition of the house for the many years prior to the recent cracking, suggests that seasonal heave is not a problem and this should be considered when deciding on remedial measures. Cosmetic repair work may be all that is eventually required once the soil moisture profile is in equilibrium.

[14 June 1984]

APPENDIX 1 - LOGS OF HOLES

TASMANIA DEPARTMENT OF MINES

# ENGINEERING LOG – BOREHOLE

borehole no. 1

sheet 1 of 1

project: House damage "The Grange" | location: Kempton

co-ordinates | R.L. | inclination | bearing

drill type: Triefus | drill method: Auger | drill fluid:

hole commenced: 30.3.1984 | hole completed: 30.3.1984 | drilled by: M. Triffett | logged by: R.C. Donaldson | checked by:

| penetration 1 2 3 | support | water | notes samples, tests | metres R.L. | depth | graphic log | classification symbol | material soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency density index | hand penetrometer kPa 25 50 100 200 400 | structure, geology |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NONE | NOT ENCOUNTERED | | | | | SM | Sandy SILT: moderate dilatency, grey sand fine | D | Fr | | Topsoil |
| | | | | | | | Cl | Sandy CLAY: high plasticity, brown/ black sand fine to medium | M < PL | H | | Residual clay horizon. |
| | | | | | | | | Similar to above, gradational colour change to yellow brown | | | | |
| | | | XRD | | 1 | | SC | Clayey SAND: fine to medium, yellow brown clay, medium to high plasticity | D | Fr | | Extremely weathered sandstone/ mudstone bedrock |
| | | | | | 2 | | | DRILL REFUSED AT 1.9 m IN CLAYEY SAND | | | | Extremely weathered bedrock |



5 cm

5/8

TASMANIA DEPARTMENT OF MINES

# ENGINEERING LOG – BOREHOLE

borehole no. 2

sheet 1 of 1

project: House damage "The Grange"  location: Kempton

co-ordinates:  
R.L.:  
inclination:  
bearing:  
drill type: Triefus  
drill method: Auger  
drill fluid:  
hole commenced: 30.3.1984  
hole completed: 30.3.1984  
drilled by: M. Triffett  
logged by: R.C. Donaldson  
checked by:

| penetration 1 2 3 | support | water | notes samples, tests | R.L. | depth (metres) | graphic log | classification symbol | material (soil type: plasticity or particle characteristics, colour, secondary and minor components) | moisture condition | consistency density index | hand penetrometer kPa (25 50 100 200 400) | structure, geology |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NONE NOT ENCOUNTERED | | | | | CH | Sandy CLAY: high plasticity, brown, sand fine to medium. Some roots, root fibres, trace gravel (brick and dolerite rock fragments). | M < PL | H | | Fill? |
| | | | ATTERBERG XRD | | 1 | | | Similar to above, mottled brown and yellow brown. | | | | |
| | | | | | 2 | | | Similar to above, mottled yellow brown and red, some coarse sand and gravel (ferruginous sandstone fragments). | | | | Residual clay horizon |
| | | | | | | | | — GRADATIONAL BOUNDARY — | | | | |
| | | | ATTERBERG XRD | | 3 | | SC | Clayey SAND: fine to medium, mottled yellow brown and grey, clay high plasticity. | M < PL | | | Extremely weathered sandstone/ mudstone bedrock |
| | | | | | 4 | | | DRILL REFUSED AT 3.4 m IN CLAYEY SAND | | | | Extremely weathered bedrock |



5 cm

6/8

TASMANIA DEPARTMENT OF MINES

# ENGINEERING LOG – BOREHOLE

borehole no. 3
sheet 1 of 1

project House damage "The Grange" location Kempton

co-ordinates
R.L.
inclination
bearing

drill type Triefus
drill method Auger
drill fluid

hole commenced 30.3.1984
hole completed 30.3.1984
drilled by M. Triffett
logged by R.C. Donaldson
checked by

| penetration 1 2 3 | support | water | notes samples, tests | metres R.L. | depth | graphic log | classification symbol | material soil type: plasticity or particle characteristics, colour, secondary and minor components. | moisture condition | consistency density index | hand penetrometer kPa 25 50 100 200 400 | structure, geology |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NONE / NOT ENCOUNTERED | | | 0 | | CH | CLAY: high plasticity, brown, some fine to medium sand, some roots and root fibres. | M < PL | H | | |
| | | | | | 1 | | CH | Sandy CLAY: high plasticity, mottled brown and yellow brown, sand fine to medium, some coarse, trace gravel (ferruginous sandstone fragments) | M < PL | H | | Residual clay horizon |
| | | | ATTERBERG XRD | | 2 | | CH | CLAY: high plasticity, brown and green grey, some fine to medium sand, trace gravel (ironstone nodules). | M ≃ | V.St | | |
| | | | | | 3 | | | Similar to above, yellow brown | | | | |
| | | | | | | | | GRADATIONAL BOUNDARY | | | | |
| | | | ATTERBERG XRD | | 4 | | CH | Sandy CLAY: high plasticity, mottled yellow brown and grey, sand fine to medium | M ≃> PL | St | | Extremely weathered bedrock |
| | | | | | 5 | | | HOLE TERMINATED AT 4.5 m IN SANDY CLAY | | | | Extremely weathered bedrock |



5 cm

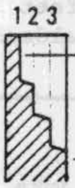
TASMANIA DEPARTMENT OF MINES

# EXPLANATION SHEET FOR ENGINEERING LOGS

## Borehole and excavation log

### Penetration

1 2 3



No resistance

ranging to

refusal

### Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

### Notes - samples and tests

| | |
|---|---|
| U50 | Undisturbed sample 50mm diameter. |
| D | Disturbed sample. |
| N | Standard penetrometer blow count for 300mm. |
| N * | SPT + sample. |

### Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

### Moisture content

| | |
|---|---|
| D | Dry, looks and feel dry. |
| M | Moist, no free water on hand when remoulding. |
| W | Wet, free water on hand when remoulding. |
| LL | Liquid limit. |
| PL | Plastic limit. |
| PI | Plasticity Index. |

eg. M > PL - Moist, moisture content greater than the plastic limit.

### Consistency

| | | hand penetrometer (kPa) |
|---|---|---|
| VS | Very soft. | < 25 |
| S | Soft. | 25 - 50 |
| F | Firm. | 50 - 100 |
| St | Stiff. | 100 - 200 |
| VSt | Very stiff. | 200 - 400 |
| H | Hard. | > 400 |
| Fb | Friable. | |

Notes: X on log is test result

▬ is range of results.

### Density index

| | | % |
|---|---|---|
| VL | Very loose. | 0 - 15 |
| L | Loose. | 15 - 35 |
| MD | Medium dense. | 35 - 65 |
| D | Dense. | 65 - 85 |
| VD | Very Dense | 85 - 100 |

## Cored borehole log

### Case - lift

Casing used.

Barrel withdrawn.

### Fluid loss

No loss

50% loss

100% loss.

### Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of $1 \times 10^{-4}$ mm/sec.

### Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

### Weathering

| | |
|---|---|
| Fr | Fresh. |
| SW | Slightly weathered. |
| HW | Highly weathered. |
| EW | Extremely weathered. |

### Strength

| | | point load strength index $I_{s(50)}$ (MPa) |
|---|---|---|
| EL | Extremely low. | < 0·03 |
| VL | Very low. | 0·03 - 0·1 |
| L | Low. | 0·1 - 0·3 |
| M | Medium. | 0·3 - 1 |
| H | High | 1 - 3 |
| VH | Very high. | 3 - 10 |
| EH | Extremely high. | > 10 |

Note: X on log is test result.

### Significant defects

Significant defects shown graphically.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

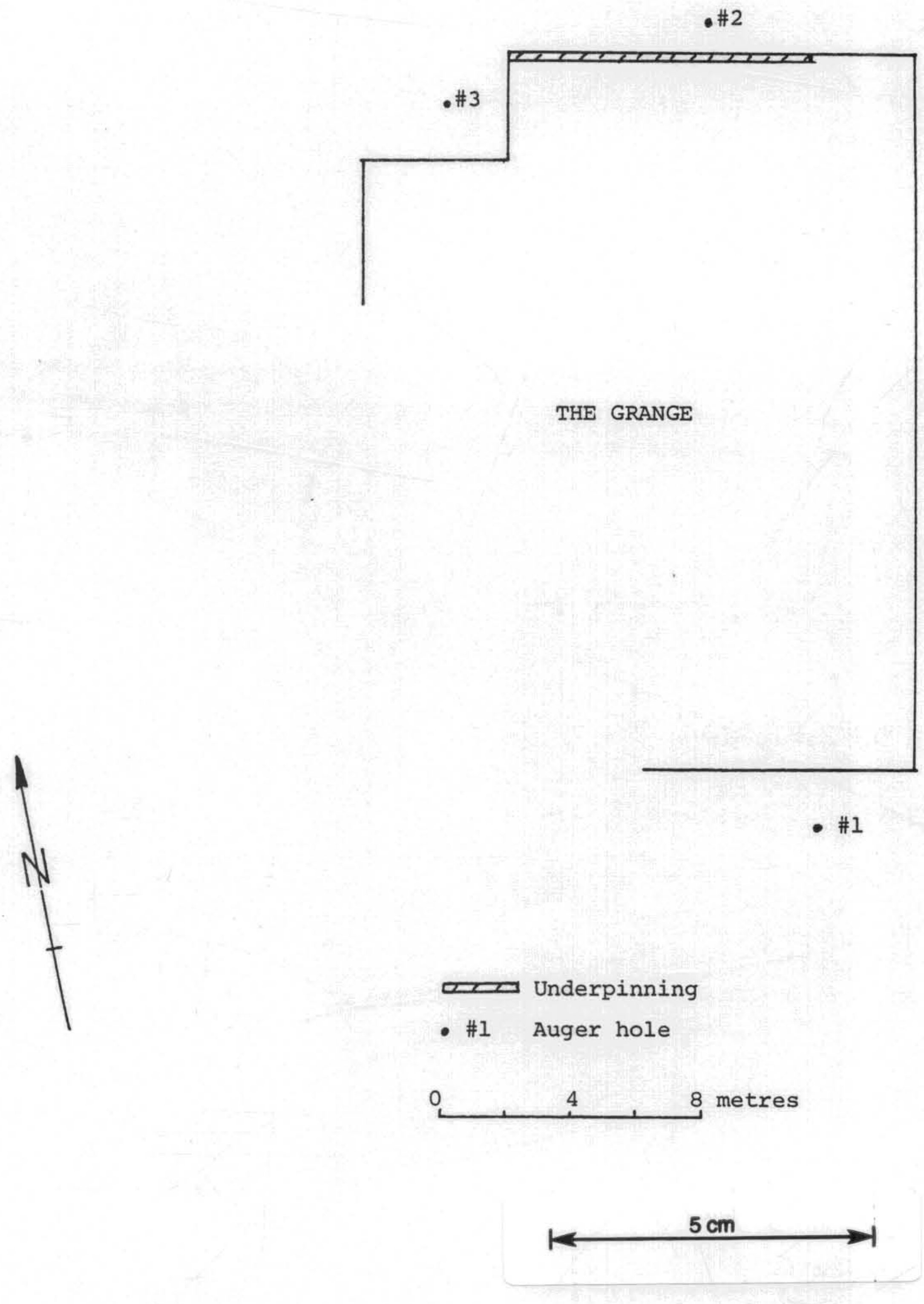



Figure 1. *Location of auger holes.*