

1977/36. Road foundation failures, Channel Highway, Tarooma.

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Abstract

The repeated failure of a section of the Channel Highway between Tarooma High School and Belhaven Avenue, Tarooma, is risking the severance of existing services located along the highway [EN285451]. Vertical movements in the pavement have reduced the riding quality, making conditions potentially hazardous for driving.

The highway embankment is constructed on a soft plastic expansive clay subgrade. Extensive cracking, disintegration and settlement of the pavement is attributed to a loss in the subgrade shear strength associated with an increase in moisture beneath the pavement. The impervious clays would provide sufficient confinement for pore pressures to develop locally resulting in uplift and failure.

Movement is being accelerated by an inadequate and poorly designed road drainage system which has enabled the seepage of surface and sub-surface water into the subgrade beneath the embankment.

Fissures have developed in the cutting above the highway at one location indicating that the ground adjacent to the road failure is in tension. A landslip has developed from the road failure and has the potential to cause house damage.

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The Kingborough Council requested an examination of the reoccurring failure of a section of the Channel Highway between the Tarooma High School and Belhaven Avenue [EN285451]. This section of road has been a source of trouble for a considerable period of time and has required continual maintenance.

DESIGN AND CONSTRUCTION

Sections of the Channel Highway have, over the years, required upgrading to cope with the greater volume of traffic and to provide residents with a pedestrian walkway. The widening of the section of roadway under discussion has involved the placement of additional fill on the downslope side. The road surface at this location is thus constructed largely on an embankment of fill material several metres thick. Drilling has revealed the foundations (subgrade) upon which the embankment is built as soft moist plastic expansive clay.

EVIDENCE AND CAUSES FOR FAILURE

For the purpose of this report, it is convenient to consider the road movement between the Tarooma High School and Belhaven Avenue as two separate failures: the Bus Stop 37 road failure and the Belhaven/Meath Avenue road failure (fig. 1).

BUS STOP 37 ROAD FAILURE

Severe cracking, disintegration and settlement of the road pavement is evident along a 60 m section of the highway. In plan, the failure has a semi-circular form; defects are highlighted by the repairs to the surface treatment. An indication as to the order of magnitude of vertical deformation that has occurred is observed in the downward curvature of the curbing on the upslope side of the road (plate 1). Relative settlement of up to 200 mm is evident.

The failure of the highway is considered to be the result of a series of related events, being caused primarily by the layout and design of the surface water drainage system. The highway at this point crosses a natural drainage course. A 750 mm diameter concrete drain has been constructed across the embankment to transfer the waters from this unnamed creek, together with road surface runoff water, to the lower side of the highway. This water subsequently flows into the River Derwent to the north of the Tarooma High School.

It is more than coincidence that the drain passes under the highway where the pavement has failed. An inspection of this cross-drain revealed a small amount of lateral movement, resulting in gaps of up to a few millimetres between pipe lengths. This has enabled water to escape into the embankment and subgrade, leading to failure.

The overall effect on the failure process resulting from an intermittent flow of water through the drain, requires consideration. For a given dry density, nearly all soils decrease in strength with increasing moisture content, being most marked in clayey soils. Conversely, soil strength increases with decreasing moisture content, but in clay soils this may involve considerable shrinkage with only a small percentage change in moisture.

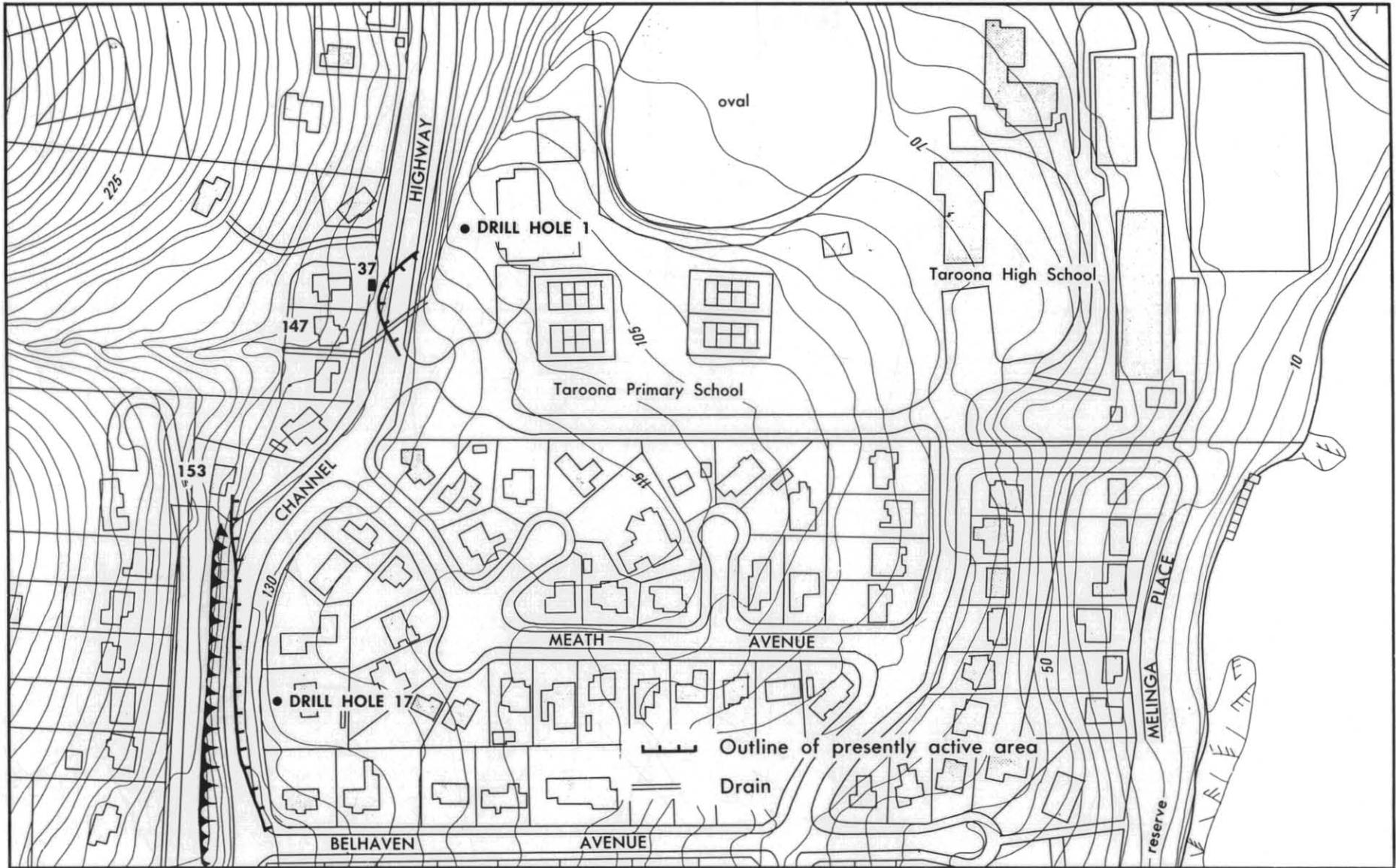


Figure 1. Location of active areas.

5 cm



Plate 1. *Settlement of road pavement, Bus Stop 37, Channel Highway.*

Thus one may have a situation where, in the drier weather, tensional stresses associated with differential shrinkage of the clays in the embankment are sufficient to cause cracking between pipe lengths. This then allows water to penetrate into the foundation, leading to failure through loss in soil shear strength. Both these processes are complementary in causing foundation failure.

In summary, the major factor contributing to the Bus Stop 37 road failure, is the drainage system. Failure is considered to be due largely to a decrease in soil strength associated with an increase in moisture beneath the pavement.

House damage

It is appropriate to comment briefly on the dwelling at 147 Channel Highway (fig. 1). Ironically, the drainage system that is attributed to causing the road failure at Bus Stop 37 has also been instrumental in bringing about extensive structural damage to this residence.

This house has a long history of movement, resulting in considerable cost to the owner for the remedial works carried out. The most extensively damaged section is along the southern side and in particular towards the south-west corner. Several years ago, pier foundations were used to support this side of the house, presumably in an attempt to isolate the building and substructure from differential seasonal movements associated with moisture changes in the expansive clay subsoil. This programme proved unsuccessful.

More recently (June 1977) two additional piers were added, involving excavation by pick and shovel to between 4.0 and 5.0 m in depth. This revealed 1.0-1.5 m of expansive brown/black clay overlying a light green/brown clay containing dolerite boulders in various stages of weathering. These clays are derived from the dolerite and Permian rocks which crop out upslope. Excavation, especially at lower depths, was hampered by the excessive inflow of water into the partially dug holes; a pump was necessary to keep water down to a satisfactory level for working. Water was entering through fissures at a rate of 3-4 l/min. The source for this water was found to be associated with the concrete drain carrying water from the creek which flows down from the steep slopes behind the block (fig. 1). This water subsequently crosses the highway at Bus Stop 37. The section of drain running across the block and the foundations of the dwelling on the southern side virtually coincide (plate 2). The drain has been constructed at a relatively shallow depth and has cracked extensively as a result of seasonal soil movements (plate 3). This has allowed water to penetrate under the house foundations which has subsequently lead to failure.

It is pertinent to note that the inflow of water into the excavation ceased within minutes of temporarily plugging the major cracks in the drain with clay. This suggests a well developed deep fissure system. The ground is in a state of tension, having the potential to create a landslip situation.

BELHAVEN/MEATH AVENUE ROAD FAILURE

Movement in the road foundations along this section of the highway is shown by a series of longitudinal cracks developed in the surface treatment (plate 4). These cracks are the result of a lateral movement in the embankment and, or, subgrade. Widths of up to 5 mm were noted, amounting to a total lateral movement in the vicinity of 35-40 mm across the width of the road. Significant vertical movement has occurred, as is shown by the

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Plate 2. Foundations of house at 147 Channel Highway, with drain location arrowed.

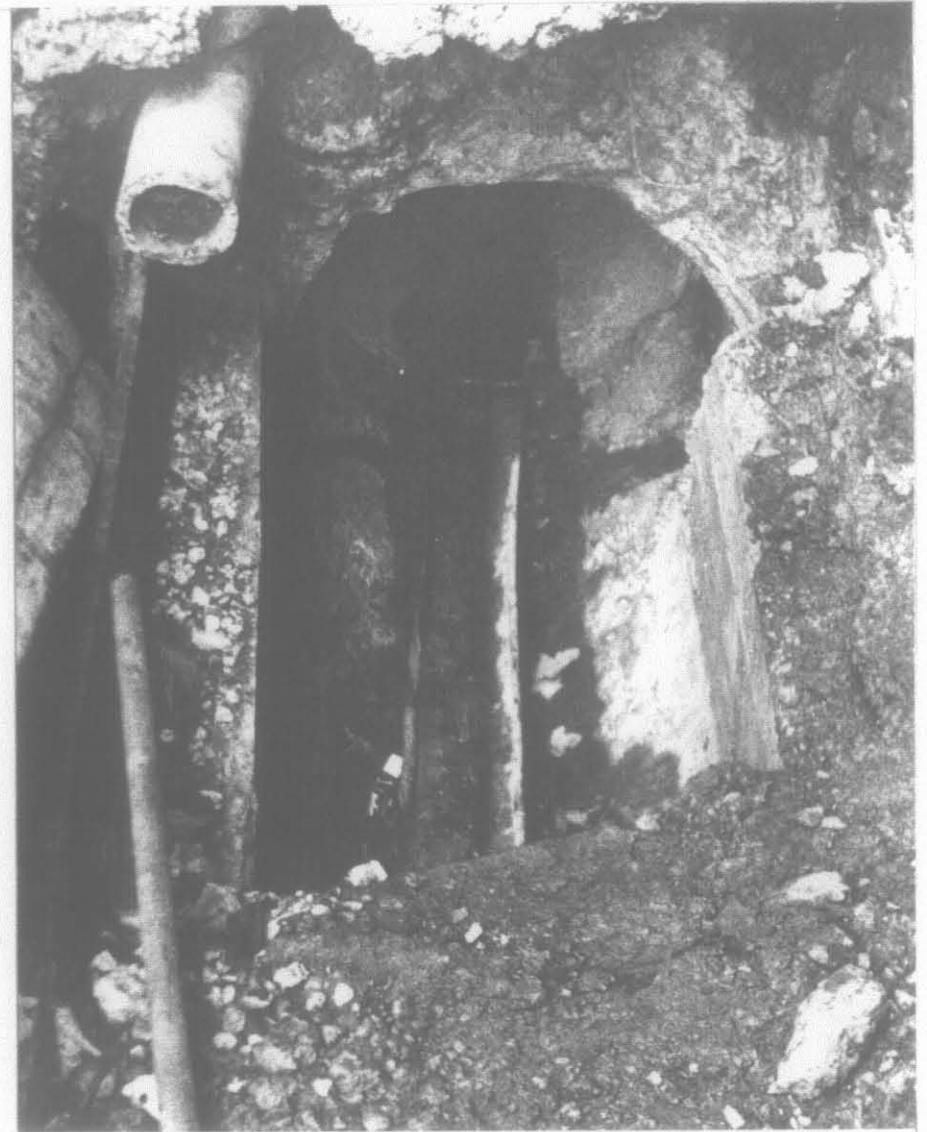


Plate 3. Fractured drain at 147 Channel Highway.

pronounced downward curvature of the road on the Kingston bound traffic lane, but the total amount is unknown. However, an indication as to the probable rate of vertical displacement can be estimated from a recent survey by the Department of Main Roads. Over a three month period (February-May 1977), differences in reduced levels averaged between 3-12 mm. Annually, vertical movements in the order of 12-48 mm could be expected. These vertical movements are having a significant effect on the riding quality of the pavement, making conditions potentially hazardous for driving.

The mechanism initiating the road failure, whether excessive stresses due to traffic, settlement related to consolidation of the embankment or subgrade, an inadequate drainage system causing loss in shear strength in the subgrade, insufficient pavement construction to offset cracking associated with seasonal moisture changes beneath the pavement, or a combination of these, is not known.

What is apparent and of greater concern is that movement is not confined only to the highway embankment. A series of tension cracks has developed in the cutting and ground above the highway, extending northwards from the roadway through to the driveway of the dwelling at 153 Channel Highway (plate 5). This house shows signs of structural damage. It is therefore necessary to consider the road failure as part of a landslip complex having the potential for further development if corrective measures are not taken.

Whilst it is not clear which mechanism initiated failure, it is apparent that movement is being accelerated by the ingress of water through unsealed cracks in the road surface and from the seepage of water into the subgrade from the higher ground adjacent to the road. The existing spoon drain is in a general state of disrepair, channeling surface runoff water directly into the slip zone. The bottom side of the highway is ill-drained; the row of poplar trees are possibly accentuating seasonal moisture changes in the subgrade beneath the embankment.

An unsuccessful drilling programme was carried out in an attempt to monitor hydrostatic pressures suspected beneath the embankment. Impervious clays situated below the embankment on the lower side of the roadway were encountered in Hole 17. These would provide sufficient confinement for pore pressure to develop locally, resulting in uplift and failure.

In summary, what may have commenced as a simple road failure, has now developed into a landslip involving ground on the upper side of the highway.

CONCLUSIONS

The following conclusions are applicable to both road failures.

- (1) A totally inadequate and poorly designed road drainage system has accelerated ground movement.
- (2) The ground above the highway is in a general state of tension; there exists potential for increased landslip activity.
- (3) There is risk of severance of underground services located along the highway.

RECOMMENDATIONS

An effective road drainage system is required to deal with both surface runoff and subsoil water. Existing drains should be repaired where damaged and checked regularly.

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Plate 4. *Longitudinal cracks developed in road surface.*



Plate 5. *Tension crack in ground above highway. Note disruption to spoon drain.*

Ground movements should be monitored, including the area in tension above the highway.

A second short drilling programme is required to determine groundwater levels and investigate the suspected hydrostatic pressures existing beneath the embankment.

REFERENCE

STEVENSON, P.C. 1975. Ground movement at Tarooma. *Unpubl.Rep.Dep.Mines Tasm.* 1975/69.

[6 September 1977]

APPENDIX 1

Summary of Proline auger logs

Hole No.	Depth (m)	Description
1	0-0.45	Topsoil - dark brown clay.
	0.45-0.9	Soft moist black plastic clay.
	0.9 -1.8	Soft moist brown plastic clay.
	1.8 -2.7	Soft moist light grey plastic clay.
	2.7 -3.7	Soft moist fawn plastic clay.
	3.7 -4.6	Soft moist brown clay.
	4.6 -5.5	Firm light brown gritty clay - fragments of quartz sandstone.
	5.5	Drill refused to penetrate to greater depth.
17	0-0.9	Topsoil - stiff green-grey clay. Moderately plastic.
	0.9-2.7	Stiff moist green-grey plastic clay containing quartz grains and small rock fragments.
	2.7-4.6	Similar to above - rock fragments mainly quartz sandstone.
	4.6-5.5	Water. Brown plastic clay. Limited returns.
	5.5-6.4	Tough orange/brown sandy clay.
	6.4-7.3	Tough fawn sandy clay.
	7.3-9.1	Stiff blue-grey plastic clay.