

TR17-127-130

28. Further observations on landslips affecting the railway near Rhyndaston.

D.E. Leaman

An earlier report (Leaman, 1973) describing the landslips on this area recommended drilling and seismic investigations so that assessments on the nature of the slide problem, the form of the material and possible treatment methods could be made.

The results of the drilling and geophysical programmes are detailed below with some additional comments on surface features of the slips.

DRILLING

Four holes were drilled; one in each of the three slip areas and one other (BH 1) located west of the railway line about halfway down the slope to detect the presence of pressure water. The fourth hole (BH 4) was located near the head of the principal slip and the second and third holes (BH 2, 3) were centrally placed in the remaining slips.

Results

Bore hole 1

Depth (m)	Recovery (%)	Description
0-1.6	40	Sandstone fragments, sand, sandy clay.
1.6-2.0	80	Very deeply weathered, medium-grained, quartz sandstone.
2.0-2.5	35	Weathered quartz mudstone.
2.5-5.8	100	Massive mudstone. Very occasional fractures and only slightly weathered.

Bore hole 2

Depth (m)	Recovery (%)	Description
0-0.4	65	Soil, sand.
0.4-3.4	60	Very deeply weathered sandstone. Sandy pug.
3.4-5.3	75	Very weathered sandstone with clay.
5.3-6.6	60	Brecciate, fragmental material. Weathered.
6.6-9.8	78	Slightly weathered quite massive mudstone with a greenish colouration and occasional 60° joints.
9.8-13.1	90	Massive mudstone, slightly weathered. Very fine bedding.
13.1-13.8	100	Grey, medium- to coarse-grained quartz sandstone. Unweathered.
13.8-14.6	80	Slightly weathered mudstone.

Bore hole 3

Depth (m)	Recovery (%)	Description
0-2.0	60	Sandy soil.
2.0-2.7	50	Very weathered sandstone.
2.7-3.3	40	Shattered brecciate material.
3.3-11.5	95	Massive, slightly weathered quartz mudstone. Joints show traces of weathering with thin coatings of waxy clays.

Bore hole 3 (continued)

Depth (m)	Recovery (%)	Description
11.5-13.0	95	Weathered, shattered carbonaceous mudstone.
13.0-15.4	100	Fractured mudstone (50 joints/m). Slightly weathered.
15.4-16.0	100	Black mudstone, carbonaceous shale.
16.0-17.8	100	Massive, green mudstone. Joints at 30° to core.

Bore hole 4

Depth (m)	Recovery (%)	Description
0-1.5		Soil. Black, brown sand.
1.5-10.4	85	Very weathered creamy sandstone. Very soft and partly reduced to clay. Deep weathering is obvious on angled (45-60°) joints. Bedding only clearly seen below 9.5 m. Occasional carbonaceous bands are present.
10.4-11.5	70	Carbonaceous mudstone.
11.5-13.4	100	Weathered quartz mudstone. Shattered.
13.4-19.0	98	Grey, massive quartz mudstone. No angle joints. Unweathered. Very abrupt weathering gradation at 13.5 m.

Bore holes 2 and 3 establish the depth of the failure surface, which is indicated by the presence of a breccia. This material was not noted in BH 1. However, slip 1 failed during drilling and the surface of failure is known to be at about 3.5 m. Reasonably firm rock materials occur below the slip surface which would support piles or piers if they could be suitably excavated and protected from weathering.

GROUNDWATER CONDITIONS

The following table presents the approximate standing water levels with respect to the surface, in each bore hole at the time of drilling.

Bore hole No.	Depth (m)
1	4.9
2	7.6
3	6.7
4	11.3

It has also been demonstrated that there is no source of pressure water and that at the time of drilling, (Holes 1-3 in December, 1971), when active slippage had ceased, the water table was below the failure surface. It must be noted that the levels recorded will be for the regional water table or piezometric surface and may bear little or no relation to local levels within the examined areas which may contain perched water tables.

However, it is possible that the water table could rise to the level of the failure surface if infiltration is effective and rapid. These conditions are unlikely to occur if the water is supplied along fracture and bedding paths from outside the slip area. This conclusion is implied from the limited information available on the transmissivity (approx. 1490 l/day/m) of these rocks. The direct catchment is critical.

Recent visits to the area have shown that surface cracking is worse than previously described due to summer dessication. It is possible that continuous rainfall over two or three days would be sufficient to raise the water level sufficiently to cause failure. If the water table rises above the failure surface several effects occur; the surface is lubricated, the loading on the surface is increased by the weight of water above and increased pore pressures due to the head of water reduce the friction by increasing uplift pressure.

The actual amount of rainfall and water table rise necessary to initiate failure remains unknown, and indeed may vary in parts of the slips due to variation in water table, failure depth and material thickness.

#### SEISMIC EXAMINATION OF THE MAIN SLIP

A seismic refraction survey was undertaken on the main slip (area 1) in an attempt to detect the slip interface, the amount of slip material, or potential slip material present and if possible, that material most subject to failure. The survey was undertaken as a trial of this method in landslide conditions. Conventional interpretation of reciprocally shot spreads would provide answers as to the amounts of material and perhaps the slip interface, if it is the weathered rock-debris interface. The amplitude of displacement of the first arrivals was also examined with the hope that a pattern might emerge which would permit deduction of the least stable material. In order to achieve these goals, all geophones were buried to minimise surface coupling effects and the amplifiers switched to the same gain. Uniform charges were also used and two spreads were laid out, one E-W down the slope and the other N-S across the slope. The geophones of the E-W spread were all situated on slip material. The spread was return fired with central and extended shots with further shooting offset from the spread and slip area. The N-S spread overlapped two-thirds of the slip and extended for half its length on 'non-slip' material.

#### Results

The survey confirms a uniform soil thickness (60 cm), the soil having a seismic velocity of 150 m/s. Completely decomposed rock and debris has a maximum thickness of 3.5 m and a seismic velocity of 300-600 m/s. The greatest accumulations of soil and weathered rock were found in the E-W spread at the base of the slip. There was slight, but regular thinning of the material upslope with about 2.5 m near BH 1. The seismic velocity of the reasonably firm bedrock was 1500-1800 m/s (which is relatively low for this material, a velocity of >3000 m/s being fresh rock).

The N-S spread revealed 1.6-2.5 m of weathered rock and soil with no systematic variation along the spread. Further that part of the spread not on the failed material, but closer to the hill spur was generally on the thickest material. This suggests that the slip is a shallow soil slip which was presumably instigated after initial construction activity in the concavity of the hill slope. One part of the slope having failed decreases the likelihood of further failure across slope, even if potentially possible, and slips continue upslope from the original failure.

The study of the amplitudes of first arrivals revealed the following from the N-S spread.

- (1) The further the shot downslope, the higher the amplitude.
- (2) Shots downslope from BH 1 induce higher amplitudes than shots above this bore hole. This implies greater disruption of the material downslope and increasing disruption toward the toe.

(3) The most disrupted material lies between BH 1 and 10 m south.

The E-W spread indicates that the most disrupted material occurs from 2 m upslope to 7 m downslope of BH 1.

From the above comment for the E-W spread and comment (3) for the N-S spread the region of most disruption and likely future failure is immediately adjacent to BH 1 to the south-east.

Examination of records made while trains were passing suggests particle accelerations of 1-3% of  $g$ , where  $g = 9.8 \text{ m/s}^2$ . The reliability of this figure is unknown due to various assumptions made concerning the equipment used. However, a 'light' goods train caused up to three times the effect of a larger than normal 'Tasman Limited'.

#### GENERAL COMMENTS

In the ten week period since the slips were first examined, slip area 1 appears to have stabilised temporarily while slip area 3 remains active and parts of slip area 2 show signs of minor activity. Failed areas are related to high water levels and the effect may be very local. There has been a general increase in surface cracking and infiltration paths appear to be well developed.

When last at the site, the surface drains were noted to be partially blocked. It is important that such drains be well maintained.

In view of the probable critical relationship of the water table level and slip stability water level, observation holes are recommended in each slip. The water level would need to be recorded at least once each day and more often during and after periods of extended rainfall. It may then be possible to correlate a critical water level with subsidence under train load. Pumping water from the slip at certain times to ensure low levels until the longer term remedial measures previously suggested are applied may be necessary. These proposals should be considered in relation to those given in the previous report and some remedial or preventive action should be taken before autumn rains fall.

#### REFERENCE

LEAMAN, D.E. 1973. Report on landslips affecting the railway near Rhyndaston. *Tech.Rep.Dep.Mines Tasm.* 16:191-194.