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27. Examination of a landslip at St Leonards

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A landslip has developed near two reservoirs used in the Tamar Water Supply Scheme to supply water to the Municipality of St Leonards and the East Tamar region, including George Town. The Rivers and Waters Supply Commission requested investigation into the danger to the reservoirs from the slip and what measures could be undertaken to stabilise the area.

The slip first developed about 2 years ago and it was thought that it was initiated by a leaking concrete drain pipe. This pipe has since been replaced by a steel pipe. Recommendations on methods to stabilise the slip included the digging of french drains through the slip, surface drainage of the slip fractures and the planting of trees in the slip material, have been made by Stevenson (1972). The movement appeared to have stopped since that time until after heavy rains about mid-February 1972 when movement recommenced which disturbed soil over a much larger area. Stock entry into the area has been largely responsible for failure of the trees planted to become established.

The reservoirs are situated about 1.5 km along Benvenue Road on the northern side of the North Esk River and about 0.5 km south-east of Abels Hill Road. The slip is in a small valley near the reservoirs.

GEOLOGY

The geology of the area has been mapped by Longman *et al.* (1964) and rock units in the immediate vicinity are Jurassic dolerite, Tertiary sediments of the Launceston Beds, Tertiary gravel (sub-basalt), Tertiary basalt and Tertiary(?) laterite.

Dolerite occurs on the north-west side of Abels Hill Road in one large and one small body. Tertiary sediments of the Launceston Beds occur along the sides of the North Esk Valley to levels above the reservoirs. Where shallow excavations have been made, these sediments consist of clay, but sand beds could be present as they are in other localities within the Launceston area. Underlying the basalt which caps Abels Hill, are rounded gravels which have at some locations, been cemented with iron oxide as evidenced by boulders down hill from the basalt. No definite exposures of this material were observed, the only evidence of its presence being boulders of cemented gravel and pebbles in talus from old slips, apart from one possible outcrop north-west of the reservoirs. The gravel bed is probably not very thick, as there are only small quantities of derived material down hill from the basalt. The gravel probably represents a valley deposit covered later by basalt as it flowed down from a north-east direction. Basalt 15 m in maximum thickness, remains as a capping on the top of Abels Hill. Small areas of laterite and, or bauxite can be seen where the dolerite and Tertiary sediments are in contact.

DISCUSSION OF LAND STABILITY

The area where the reservoirs are situated is fairly steep and the whole hillside has been subject to slips at some time in the past. The land surface has a very hummocky nature and there are several areas of internal drainage at the heels of the old slips. No recent movement is visible on the old slips but the fact that they are still clearly recognisable, indicates that they were probably, at least in part, of a rotational nature. The landslip that has developed recently is of the slow earth-flow type, the heel of the slip being about 30 m from the reservoirs and on a slope of 10-12°. The

ground surface is fractured and buckled by the movement and some areas of the surface are held together by the intermeshing of grass roots. The area affected by the slip, at this stage, is about 3300 m^2.

Seepages can be seen in some areas near the heel and parts of the toe area are saturated with water. If further movement occurs on the slip, a steep scarp will develop at the heel. With support for the material uphill from the scarp removed, combined with the load of the reservoirs, it is quite likely that the reservoirs could become involved in the slip.

Causes of the slip

It was thought that the original movement was caused by a leakage in a drainage pipe which has since been repaired. Three possible reasons for the recommencement of movement are given below.

(1) As there has already been a slip in the area, the land surface was very broken by tension cracks associated with the slip. Preceding the heavy rain in mid-February, there was an extended dry period when drying cracks would develop in the clay. These factors meant that when rain occurred, the slip area would act as a trap for rainwater falling directly on the slip and for surface water flowing down hill from above it. Subsurface material would quickly become saturated.

(2) Underground water originating from uphill catchment areas could be directed to the slip area if suitable subsurface geological features are present. If sand beds or more permeable horizons than the clay occur within the Launceston Beds then such a situation could develop. There are no other obvious seepages in the immediate vicinity but if permeable horizons exist they could have been disrupted by old slips.

(3) There is a possibility that either the reservoirs or pipelines are leaking, supplying water to the slip. This seems a fairly remote possibility as the concrete drain pipe has been replaced by a steel pipe and where the pipe is exposed there are no signs of leakage. The sealing material on the bottom of the reservoirs has been examined quite recently and was found to be in a sound condition.

As the movement recommenced after heavy rains, it is likely that the first factor mentioned is the main reason for the recent movement although either or both of the other possible causes could contribute to this movement. A method of determining whether the reservoirs or pipeline systems are leaking would be to place a suitable radio-isotope in the reservoirs and then monitor the seepages for radioactivity. Another means, as suggested by Mr Schaffner, would be the use of the fluoride ion concentration. The water supply is to be fluoridated in the near future and if the fluoride content of the seepage water before fluoridation is sufficiently different from that of the water supply after fluoridation, this could provide a means of determining whether leakage is occurring. Whether water is being supplied to the slip from an underground source could only definitely be determined by drilling uphill from the slip.

REMEDIAL MEASURES AND RECOMMENDATIONS

No matter what the source of the water supplying the slip, drainage should be undertaken so that water does not accumulate in the slide mass. As the cause of the recent movement is largely and possibly entirely due to rainwater entering directly into the slip area, drainage around the heel of

the slide to prevent surface water from uphill entering the slip area is essential. If there is any danger of water seeping underground from these drains, then they should be lined. The slide mass itself should be drained so that the rainwater falling directly on the slip area does not accumulate. This could perhaps best be achieved by draining the toe area first and on drying out, this area would have a stabilising effect on the slide. The draining could be extended up the slide towards the heel. When the heel was reached, it could probably be determined if any of the water is derived from an underground source and if it was, then it would be necessary to leave the drainage system open.

If the draining is undertaken during an extended dry period and drainage is complete, then it should be quite safe to use machines to remould the surface of the slip without fear of causing further movement by vibrations. If the surface is reshaped to remove the areas of internal drainage and tension cracks that at present occur in the slide mass, infiltration of water into the slide mass could be expected to decrease markedly. Rolling and grassing of the area would ensure that rainwater escapes from the area by surface means, as quickly as possible. The planting of trees would also aid in stabilising the area but they would need to be protected from stock until they are fully established.

If drainage of the slide mass is unsuccessful, then remoulding of the surface will not be possible. Other methods could be attempted to harden the slide mass. These include grouting with cement or injection of sodium silicate with gel forming compounds. These methods are normally used in sandy and gravelly material but some success has been obtained in clay soils where fractures develop (Baker and Marshall, 1958; Zaruba and Mencl, 1969).

If underground water is found to be supplying some of the water to the slip, little can be done to prevent it from entering the area. A possible old slip occurs uphill from the reservoirs, with a large flat area and some internal drainage in front of the slip plane. This area should be drained as water could be seeping down the slip plane.

Two or three diamond drill holes could quite usefully be drilled upslope from the heel of the slip to examine the nature of any permeable material that might occur and also to examine generally, the material in the landslip area in a relatively undisturbed condition. Care would be necessary to prevent water from this operation reaching the slip area.

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