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1977/9. An assessment of the cutting failure at kilometre 15, Launceston to Western Junction line, Tasmanian Government Railways.

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The railway cutting at km 15 [EQ189020] has been examined on several occasions, most recently on 9-10 and 24 February 1977.

This assessment is made at the request of the Tasmanian Government Railways and is directed mainly toward the geological aspects of the problem.

The geological framework

The valley of Rose Rivulet which flows north into the North Esk is eroded about 150 m into the Tertiary rock succession. This succession consists of a very complex, laterally variable and poorly known series of clays, sands, gravels and lignites. Basalts are interlayered with this succession at several levels and the plateau on which Launceston Airport stands is formed by one of these.

On the more detailed scale of the cutting itself the geology is seen to be complicated, comprising a basalt complex overlying a sedimentary complex.

The sedimentary complex can best be seen along the new alignment. At the north end of the cutting the sediments- clays, sandy clays, markedly lenticular sands and lignitic clays are seen to dip gently south. They may be followed south along the cutting where quite sudden variations in the thickness of sand lenses are evident. The clays are firm tough grey materials which are not markedly moist, are moderately fissured, but from the soapy feel of some beds, are of high plasticity.

The bedding clearly outlined by the lignite seams may be followed south in the eastern batter and is shown on the drawings as a 'plane of discontinuity' a term which in this context does not appear to have a precise meaning. At about km 14.960 the lignite bands become disrupted turning nearly vertical and showing torn ends to the beds. This zone extends to about km 15.000 where normal S-dipping bedding is re-established. Further south, the sediment succession has been cut into by erosion and the steep sided channel has been filled with basalt of various forms. On the south side of the channel, which is about 20 m wide, normal bedding in sandy clays and sands is again re-established and continues toward the south end of the cutting.

On the western batter of the new cut the succession is not dissimilar, most elements seen on the east being still visible, but the plane of movement in the clays is the dominant feature, producing as it does a disruption in the otherwise smooth batter. The plane does not appear to be modified by the dip or the presence of particular clay horizons or lignites but has formed as a simple surface apparently irrespective of the geology. It has however formed immediately opposite the disrupted zone as shown by the lignite seams, and it appears likely that the disruption even though happening soon after the deposition of the clays has left a legacy of an area of residual strength which has been exploited by the modern failure.

The basalts overlie the sediments, and were emplaced after a period of erosion, so that the sub-basalt surface is irregular. A channel has been described above and this is only one example of the same kind of process which may be seen at the north end of the cutting where the sediment bedding is truncated by lava and other basaltic material.

The basalts were erupted, probably without much explosive activity from fissures aligned along NW-SE trending faults. The exact position of the fissures is not known and could be anywhere in the extent of basalt between the railway and the Breadalbane-Evandale road, or could have lain in the now eroded part of the basalt to the east where the Rose Rivulet valley now lies. The idea that the fissures were probably close is supported by the nature of the basalt complex. The upper part of the steep plateau edge shows normal hard basalt lava with columnar jointing, representing part of the lava flow away from the erupted fissure. The character of the basalt changes as it is followed north so that in the extensively failed slopes above the major rock fill berm, the basalt is heavily altered and mineralised, although still markedly columnar. This is taken to be the result of alteration very soon after eruption, probably by steam and other gases from the fissure. This has an effect on the rock similar to weathering but unrelated to depth below the present surface. The gravels too appear to be closely associated and some of them at least may owe their origin to the eruption directly.

Other parts of the gravels show fluvial character, resulting from fast flowing streams on the basalt surface possibly with material derived from nearby gravels of eruptive origin. Basalt pebbles form a very large proportion of both kinds of gravel.

The mechanical properties of the materials involved in the failure are dictated by their origin, and that is why the above account is relevant to the present problem.

There appear to be two separate although connected failures. The lower one which affects the new cutting batter is in clays and is that which has occasioned the installation of the soil anchors. The clays are part of the disrupted zone, and may, in terms of geological history, be regarded as the materials which took part in slumping in the sides of a steep sided channel cut in very soft plastic material in Tertiary times. For this reason the present failure in clays is localised.

The upper failure is in basalt and this occurs in two modes. In the hard columnar basalt failure has been in a block glide mode with very large segments moving slowly sub-vertically downward without rotation. The altered basalt has translated horizontally and the zone of gravels between the two has dropped in a 'graben' form. In all these motions the basalts and gravels are moving passivly on the cohesive and plastically deforming clays below. The materials of the basalt complex are effective aquifers and can supply water readily to the clays below.

The evidence for water in the basalt and corresponding pore pressures in the clays is not clear as little record was kept of it during or since the drilling of the investigation holes. The water table was assumed to exist only in fissures and this is commonly the case in Tamar Valley clays. The existence of seepages or spring lines is mentioned in past reports and it is accepted that the water conditions are the most potent factor in causing instability.

The remedial measures

It would be inappropriate to comment by hindsight on the choice of remedial measures except to say that the risks in deepening the original cutting were taken without informed geological advice.

The soil anchors have been disappointing in performance and as is common in fissured clay terrains, drains are often ineffective.

What is now proposed, and is indeed in progress, according to Mr Phillips' report of February 1977 is:

(1) The driving of forty wooden piles in the region of the existing anchor pads, and
(2) the removal of approximately 4 m of the top of the basalt batter to the extent of 16 000 m^3 and placing of fill at the foot of the basalt cliff.

Each of these measures in isolation could be expected to be effective in restraining the slips in the immediate vicinity. The removal of the top of the basalt and filling of the base area are of course in accord with established principles. Similarly the piling programme if applied to a clay slope in such a way as to increase the shear strength across the slip plane could not be found wanting. Nevertheless in combination, because of the linked nature of the upper basalt failure and the lower clay failure, the remedial measures as at present proposed appear to be insufficient. This is because of the progressive nature of the basalt failure, which continues to move even in the dry season. Such cohesion as existed in the columnar basalt area has been lost by the formation of the tension crack and the basalt is moving passivly on the plastic clays beneath. The movement is not such that stability can be expected to be regained and with the onset of the next wet weather movement must continue. The process whereby water collected by the basalt is supplied to the clay has been enhanced by the cracking.

Assuming then that the basalt will ultimately collapse onto the bench area the load that has been added by filling and which might have been sustained by the combined anchors and piles, will be vastly increased. This can only increase the movement of the bench and its batter onto the formation. Piling, even if it succeeds in mobilising sufficient shear resistance, can in the longer term only be regarded as a temporary measure which ultimately will require replacement.

A consideration of the original stable configuration of the area before the original cutting was constructed leads us to the belief that the closer this configuration can be attained the better. Whilst the present works may effect a short term measure of stability for the lower slip if the problems in the cutting are considered in their entirety a different and perhaps more expensive approach is necessary in order to provide a permanent cure for the problem. The most promising approach appears to be the construction of some form of cut and cover tunnel to protect the railway. Such a structure may be effected by well constructed block crib walls or reinforced concrete retaining walls held apart by beams top and bottom, or possibly by the use of a massive Armco type structure. The actual choice of the structure to be preferred is an engineering decision and will be dictated by such factors as cost, ease of construction and whether it is planned to duplicate the existing track at some time in the future. The tunnel would then be covered by rockfill obtained from the basalt cliff. In this way the requisite loading for the slip toes, the stiffness across the railway to resist the movement, the adequate drainage and the removal of the head load of the upper slip might all be combined. The steep artificial slopes which provide the potential energy for mass movement would also have been removed. In this way an approximation to the original land form might be attained and the long term stability of the works achieved.

[1 March 1977]