PERSISTENT DAM SLOPE FAILURE

George was travelling to the hydro site accompanied by Jack, the specialist geotechnical consultant retained to provide advice for the new hydro development. Both had been summoned to the site to investigate the second downstream slope failure on a 25m. high dyke. The dyke formed part of a 20km. long canal built on a slightly sloping sidehill. The dyke had a height of about 5m. at the upstream end, gradually increasing to over 10m. at the downstream end near the powerplant intake. It was located far enough away from the edge of an escarpment to avoid numerous erosion gulleys leading down to the lower river bed. However, one particularly long and deep erosion gulley could not be avoided, and here the dyke was some 25m. high, and this was where the slope failures had occurred.

The dyke was founded on about 30 meters of over-consolidated glacial till which overlie horizontally stratified sandstone and shale. The slope of the erosion gulley traversed by the dyke varied between 3 and 3.5 horizontal to one vertical. A geotechnical investigation of the till in the gulley, which included 3 undisturbed samples extracted from depths of 1 to 3 meters, had been tested for compressive and shear strength, with the results indicating that the till could easily support a 25m. high dam with a downstream slope of 2.5 in 1. The gulley was cleared of trees and the overburden was removed to a depth of about 0.5m.

Construction of the dyke commenced at the upstream end, and 2 years later reached the gulley, after winter breaks of several months. The dyke section consisted of a central core of glacial till, with flanks of either till in the sections below 8m. high or a sandy gravel in higher sections, where the downstream slope was 2.5 in 1. When the dyke was being built across the gulley, the downstream slope failed in a shallow slide when the dyke was only 15m. high. After consultations with Jack, the failure was attributed to the use of excessively silty and wet sandy gravel obtained from a riverbed deposit. The material was removed, and the design changed to include sand filters and drains on the downstream face of the central till core, and the use of clean gravel at a slope of 2.25 in 1. This design was successful, and the dyke construction crew proceeded on downstream. However, after about 2 months in place, a crack appeared which arched in a curve across the downstream face, reaching to within about 3 meters of the crest, extending across most of the width of the gulley.

George and Jack were summoned to the site. They arrived in the evening during a mild snowstorm. Next morning, the crack, which was now several centimeters wide, was clearly visible as a black line in the snow. Over the next few hours the rate of movement of the slide increased to about 0.3m. per hour. By late afternoon it was possible to climb down into the open crack to the sliding surface near the edge of the gulley, where the height of the gravel fill was less than 2m. There, a perfectly smooth slickenside could be observed, with the gravel sliding on the surface of the glacial till foundation. The contractor was instructed to remove the slide material before it reached and polluted the river.

What had gone wrong?. With the powerplant almost ready for commissioning, there was no time to conduct an extensive investigation. The dyke had to be repaired immediately.

After a long discussion with all concerned at site, it was reasoned that since the slide was occurring at the contact with the till, a triangular cut should be excavated at the toe of the dyke to provide a horizontal foundation for a 4m. high rock berm to anchor the toe, and the downstream half of the dyke was rebuilt with the berm and heavy gravel at a slope of 2 in 1. This modification to the design proved successful. Further testing of the till foundation revealed that the surface half meter of the over-consolidated glacial till had lost considerable strength due to being exposed to the effects of freeze-thaw over two winters and had insufficient shear strength to support a dam.

Lessons Learned.

Jack, the geotechnical consultant was held in high regard, and his recommendations were never questioned. Despite this experience, he continued to work with the consultant until his retirement. The point here is that foundation engineering is not an exact science, and accidents will occur. However, there is another issue. Specialist consultants are not infallible, and their recommendations should always be discussed in detail, not accepted without question. If Jack's report had been scrutinized in detail, perhaps someone would have asked whether the effect of frost had been taken into account. Several years later I had the privilege of working with the late Dr. A. Casagrande. During several plane rides to the damsite, we got to know each other, and on one occasion he mentioned that he enjoyed working with our group of engineers. I thanked him for the compliment, and asked him why?. His reply surprised me - he said that we always questioned and discussed his recommendations, whereas most of his other clients accepted his work without question. This had made him aware that without critical scrutiny of his work, he had to be very careful that he did not make any mistakes, whereas with our group, he could put his ideas on the table for discussion, and sometimes these ideas could be modified to reduce cost or improve the design. Always have an open discussion with specialist consultants on their work, until all understand and are satisfied with the results.