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Mechanics of Debris Avalanching in Shallow Till Soils of Southeast Alaska

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INTRODUCTION

Excessive slope gradient and pore-water stress in glacial till soils of the Karta series are primary factors in debris avalanche and flow occurrence in recently logged areas of southeast Alaska. Initial field investigations have indicated that during months of low rainfall, lateral movement of seepage water in these soils is limited to a zone 2 to 6 inches thick, directly above an impermeable, unweathered till surface. Seepage occurs along interconnected soil voids and partings produced by downslope growth of rootlets above this surface (Bishop and Stevens 1964, Swanston 1967a).[1]

During high rainfall periods, the soil becomes saturated, and the seepage zone thickens with substantial increases in flow. The increasing volume of water, moving laterally through the soil as saturated flow, causes a rise in the piezometric surface, with two important consequences: (1) increasing shear stress along potential sliding surfaces caused by rising seepage pressures and increasing unit weight of the soil materials, and (2) decreasing shear resistance resulting from increased pore-water pressure in the soil.

Historically, increased pore-water pressure has been shown to be a primary factor in the sliding mechanism of aggregate slopes. During periods of heavy rain, the quantity of water in the soil naturally increases. On saturation, excess water builds up, causing a rise in the piezometric level or "free" water level in the soil. The net effect is an increase in water pressure in the soil voids. Terzaghi (1950) has compared the effect of this increased pressure to the action of a hydraulic jack. The hydrostatic pressure of the water carries part or all of the weight of the overlying soil, in effect causing it to be jacked up or to "float," greatly reducing its "shearing resistance."[2]

Soil stability analyses, based on theoretical soil mechanics and modified by engineering experience and practice, have become standard procedures for engineering works involving steep natural, and constructed slopes with a potential slide hazard. Detailed descriptions of theory and practical application are presented in a number of texts, among them Terzaghi (1950, 1963), Terzaghi and Peck (1960), Hough (1957), Wu (1966), Taylor (1965), and Eckel (1958).

Direct application of theoretical soil mechanics principles to the evaluation of the effects of various physical parameters operative on natural slope soils is difficult because of the large number of variables involved. A number

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[1] Names and dates in parentheses refer to literature cited, p. 16.

[2] Shearing resistance is the resistance to a stress causing or tending to cause two adjacent parts of a solid to slide past one another parallel to a plane or contact.

of assumptions based on idealized conditions at time of failure and certain mathematical simplifications are required which limit the reliability of quantitative results. Such an analysis, however, does provide a useful means of estimating the forces known or believed to be acting on the slopes where sliding has occurred and of characterizing slopes according to their slide susceptibility.

This paper (a) reports on the applicability of standard soil mechanics techniques to an evaluation of the factors affecting debris avalanching in the steep, shallow, permeable till soils of southeast Alaska and (b) quantifies the relationships between these factors which, up to now, have only been suggested on the basis of field observations.

STUDY AREA

Maybeso Creek valley on Prince of Wales Island was chosen as the principal area of research. It was the location of the first large-scale clearcut in southeast Alaska, and an extensive road system had been developed allowing easy access to recent debris avalanching. Weather records had also been maintained for 10 years before these studies, with major debris avalanches noted. Finally, the valley is the center of the type area for the Karta soil series (Gass et al. 1967).

Three slide areas (fig. 1) in the valley were chosen for detailed study on the basis of accessibility and similarity of occurrence. Each of these developed during a heavy rainfall period in October 1961 and occurred in the soil zone of a continuous till sheet covering an oversteepened (> 30°) south-facing slope. Timber was harvested during the summer seasons of 1955-58 by the high-lead method.

Figure 1.—The north slope of Maybeso Creek valley showing the location of the three slides analyzed.