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Factors influencing decisions on land stability and proposed landslip zones

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In response to an enquiry from the Town and Country Planning Commission on a proposed subdivision at Camdale, the thoughts on the process for making a decision on land stability were recorded.

Many factors control the stability of a piece of land.

Firstly the geology. The Tertiary sediments of the North West Coast and Tamar Valley are un-indurated clays and sands and are the principal materials causing land instability. Other solifluction debris and the Kelcey Tier Beds of the Permian also cause instability but these are either not widespread or are in areas where the land use is not such as to aggravate movement.

The landforms developed on the Tertiary sediments are youthful, that is to say steep and undergoing active erosion. The second group of factors therefore consists of the slopes and changes of slope. The angle of slope that is unstable varies from 3° to 4° (where other factors are unfavourable) to 20° to 25° or even steeper where other factors are favourable. The plan shape of the contours is also significant. A re-entrant type of slope is able to channel run-off convergently and so concentrate water into a water course. The water will soften the sediments it can infiltrate and so cause a slip, if other factors allow it. At the same time a re-entrant slope is well supported by the spurs on either side of it.

Conversely, a spur causes divergent run-off and so dissipates the water but is left relatively unsupported by the re-entrants on either side. On balance, the influence of water runoff appears dominant over the support afforded by shape, and re-entrants slip more commonly than spurs.

The fact that a slip causes a re-entrant slope to form introduces the factors of previous history. Slips are self sustaining. Where a slip occurs, the land on either side is left less supported than before and may itself move. The material that slumps and flows downslope is mechanically stirred in motion and subsequently appears weaker than undisturbed material. The toe of the slip may be steep and so subject to further movement at some later time, and the heel leaves a steep face which tends to slip in turn and so propagate the slip upslope.

The climate, which in this context must be taken to include not only the average rainfall and evaporation but also the frequency of extremes, is an active factor in landslips. Rainfall supplies the lubricant to soften the clays and also aids the slip by supplying weight to the potentially moving mass. High evaporation stiffens the clays by removing water, but also opens up cracks which can freely accept water when rain next falls. An even gentle rainfall interspersed by moist, windless cool weather would engender less landslips than heavy rain and warm sunny periods with breezes. What is best for man is worst for land stability.

This axiom applies most strongly in the last and most potent factor of land use. Almost every one of man's activities in relation to the land is active in encouraging land movement, and this is not better illustrated than by residential subdivision. As soon as the subdivision is approved, men appear and cut down the trees. This reduces the removal of water from deep levels in the clays and leaves more to cause slipping. The roots of the trees die and the mechanical support they afford is removed. Then bulldozers appear and cut roads. This exposes the soil surface to sun and air and aids shallow drying, thus opening up surface cracks. Ditches are dug for drains, and these collect water into deeper layers, and also disrupt the equilibrium attained by the slope during its geological history. They also mechanically cut the surface layers and reduce their tensile and shear strengths.

House foundation trenches act similarly but in addition provide loading for the potentially unstable material and the vibration of vehicles and other machinery can trigger instability. In order to obtain a flat area surrounding the house cuts are made into the slope above the house, and are usually left insufficiently supported. Fill is tipped below the house to extend the flat area, but this at the same time this steepens the general slope, and with unconsolidated and disturbed material.

When the house is completed the purchasers move in, plant a garden, seed lawns and proceed to pour hundreds of gallons of water onto the land in an effort to make it fertile. At the same time the grass is kept cut short, ensuring that maximum evaporation takes place from the soil surface to form cracks and that the applied water penetrates as deeply as possible into the undrained levels of the clay.

Such movement as takes place (and some is inevitable) is enough to displace the joints of rigid sewer and stormwater pipes and make certain that the water which leaks from them as a consequence is applied where it can do most damage.

If a minor slip does take place, fissures are produced which are ideally placed to intercept every possible drop of run-off and further add to the mass of heavy lubricating water in the clay.

To add paradox to paradox, the most favoured sites are often those affording the best views, which in turn involve the steepest slopes.

It is obvious that the geologist who examines a new subdivision can only make an eyeball estimate of most of these factors. The Geological Survey has a geologist working full-time on landslip problems and several others with an active part-time interest in the phenomenon. There are considerable hopes that techniques can be devised that will enable quantitative estimates to be made of the landslip potential of an area. Slope shape can be measured but this is only one factor. The geology is not well known in detail as outcrops in un-indurated rocks are poor, but a drilling program is intended in the near future.

More indirect techniques for the measurement of the causes of movement, for example moisture content and clay mineralogy, exist and will be applied. The early course of movement may be detected by instrumentation and the whole process studied in detail.

The most difficult problem appears to be Man, and the Geological Survey is not qualified to advise here. The guidelines to palliative and preventive actions are geological, and the following model classification may be useful, and is the objective for the survey’s present studies.

Zone	*Description*	*Slope*	*Residential buildings*	*High load structures*	*Roads*
I	**Stable land** Risk infinitesimally small Most rocks	0–30°	Normal practices	Normal	Normal
II	**Talus** Considerable risk Basalt & dolerite talus Mudstone talus	30°	Too steep	Too steep	Fill supported, cuts battered & supported, adequate drainage, protection from run-off, warning system
III	**Low clay slopes** Slight risk Tertiary sediments Weathered basalt Dolerite-derived clay	0–6°	Shrinkage precautions, low loadings, tree planting	Pile or raft foundations	Cuts supported, adequate drainage, protection from high run-off
IV	**Potential** Some risk	4–20°	Limited cuts & fills, flexible drainpipes, no septic tanks, disposal of surface water outside risk area Tree planting, low loadings, impermeable linings in table drains Periodic measurements or warning systems	Raft or pile foundations, periodic measurements or warning system	Adequate drainage, cuts battered or stepped & supported
V	**Dormant** Considerable risk Tertiary sediments Kelcey Tier Beds		Building on slip toe only (<7°) otherwise as above warning system	No building	Adequate drainage cuts on toe, only stepped or battered and supported, warning system
VI	**Active** Evident risk Tertiary sediments		As above Building on slip toe only (<4°) warning system	No building	As above warning system

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