GEOTECHNICAL

Geotechnical Engineering: Design Tables and Guidance for Root-Reinforced Slopes

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The problem of slope instability has been encountered for centuries. Many cases of slopes failures have been reported in many parts of the world, Kenya being one of them. In the past, many parts of Kenya have experienced many cases of slope instability leading to very destructive landslides that have destroyed properties and caused loss of life. Slope instability is very common in Central Kenya and parts of the Rift valley. This paper presents recommendations and design tables for root reinforced slopes.

At present, soil reinforcement using vegetation is a purely empirical approach. A method for root-reinforced soil needs to be developed to assist geotechnical engineers in applying engineering principles in order to put up safer slopes.

Differences among plant species in morphology and patterns of growth are assumed to influence their ability to acquire resources and, consequently, their competitive ability. Comparisons of root morphology, growth rate and topology of seedlings of several herbaceous plant species that occur in early to mid-successional fields revealed significant differences among species (Gray and Sotir, 1996, Osano and Mwea, 2008, Ekanayake et. al. 1997, Marden, and Rowan, 1993),). The typical landslide comprehensively investigated under this research occurred in Mung'aria Village situated in Murang'a North District and in the Sasumua Water Treatment Backslope, situated in Njambini Division, Nyandarua District in Kenya.

From the samples, it was observed that tree ferns and shrubs produced longer and more branched roots than did grass species. The grasses allocated proportionately more biomass to roots but do not produce deeper roots or better branching pattern. Tensile testing was conducted at the University of Nairobi Civil Engineering Laboratory using a Hounsfield Tensometer apparatus. It was noted that root tensile strength decreases with increasing root diameter, and follows a power law equation of the form in equation (equation 1).

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Generally, tensile strength can be well predicted by root diameter. The maximum root tensile strength values recorded was 39 N/mm2 for grass. The a and k values and the R2 values are shown Table 1. n is the number of roots tested.

It was noted that strong roots have high a-values and low k-values and vice versa. Shrubs generally have high a-values, but a great variation is noted within individual plant species. Shrubs species reinforce soils better than all other species tested and generally, their tensile strengths follow a power law curve (equation 2)

To know the contribution to soil strength by a certain shrub species on a slope, the number of roots of a single species crossing the shear plane, at approximately 1m depth, and average diameter of the roots should be established.

K values is calculated by using □ values and values. It is observed that K values should be between 0.5 and 0.999 for a better result for a root reinforced soil design. High K values are associated with high values, which are also associated with hard soil or rock, and thus reinforcement is not necessary. Equation 3 could then be applied to obtain Cr (kPa), which is the increase in shear strength due to the presence of roots. Cr = KtR (equation 3)

K is the (sin□ + cos □ tan), is the soil friction angle (º), □ is the angle of shear distortion in the shear zone, and tR is the total mobilized tensile stress of roots fibres per unit area of soil.

Easy-to-use design tables and graphs have been developed to determine the contribution of shrub roots to soil strength. It it is possible to estimate the contribution of roots to shear strength of a soil.

By estimating the number of roots crossing the potential shear plane, the average root diameter, the shear distortion angle and internal angle of friction, the contribution of roots to shear strength can be computed. Once the contribution to shear strength of a single root system has been determined, the total population in the area being considered is multiplied to obtain the aggregate shear strength value.

The information presented has certain limitations regarding its application to most naturally occurring root permeated soils as the tables do not give values for root diameters greater than 100mm. The growth pattern of shrubs has been assumed to be uniform so that with the same age or height, it is assumed that the same number of roots crossing the shear plane is the same for all the plants. Additional testing using varying soil conditions and a variety of root configurations is necessary to gain a more complete understanding of root reinforced soil behaviour.

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