BUILDING RESEARCH & TRAINING CENTRE

INFLUENCE OF PLACEMENT CONDITIONS ON DESIGN AND PERFORMANCE OF ROLLED FILL EARTH AND ROCK FILL DAMS

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The design and subsequent performance of rolled fill dams or rockfill dams with an impervious core are governed by the strength and consolidation characteristics of the rolled fill material and also by the future behaviour of the foundation.

The rolled fill material is essentially a partly saturated soil compacted to attain a certain density corresponding to a certain strength.

The stability analysis of such structures is carried out by the "Limit design" method whereby failure is assumed to occur along a certain sliding surface when a certain proportion of the shear strength is exceeded. The problem is treated as one of plain strain.

For saturated clays the analysis may be carried out in terms of applied total stresses assuming that the clay at failure will act as a purely cohesive material having an angle of shearing resistance $\Phi = o$. Partly saturated soils have cohesion and friction. Even after the percolation of water through the body of the dam, they will remain unsaturated as this saturation is believed to take a considerable time; (Casagrande, Gueze).

Full saturation, however, may occur under the effect of high pressures forcing the air content into solution in the pore water. With normal ranges of loads, the cohesion and friction for such soils will be used in the analysis of stability.

The stability analysis, on the other hand, may be carried out by the "Elastic method", which, unlike the limit design method treats the dam and foundation as an elastic continuum possessing all characteristics of elastic bodies: obeying Hooke's law, fulfils the principle of reversibility of stress and strain, homogeneous, having a constant poissons ratio, constant density, having a constant volume, etc.

Terzaghi (1943) states that it is only with a factor of safety exceeding 3, that elastic methods are likely to give results comparable to the actual stress distribution; or in other words, if the actual stresses inside a dam are measured, they will correspond to design values only if the factor of safety exceeds 3, This is naturally a result of the departure of soils from ideal elastic properties. While a factor of safety of 3 or more against shear failure of soil may be used in foundation design due to the necessity to safeguard the structure against undue stresses caused by differential settlements, it is common practice to use a factor of safety of the order of 1.5 in earth dam practice where larger settlements (due to consolidation of fill material or foundation or both) may be tolerated or adjusted. Furthermore, an economy of about 30% in the everall volume of the dam can be effected if the factor of safety was 1.5 rather than 3. (In quick shear all soils except saturated clays, undergo volume changes. Elastic methods may thus be used for saturated clays failing in quick shear as in dams, where also a factor of safety greater than 2 in necessary to safeguard against soil creep of such large soil masses).

The limit design methods is based on using the actual strength and deformation characteristics of soil expressed by its cohesion, angle of internal friction and intrinsic pore pressures as determined from laboratory tests carried out under conditions simulating future behavious in the dam. This is different from elastic methods where the assumption of a purely elastic behaviour of the soil, together with smaller factors of safety may lead to the formation of over-stressed zones which in turn may lead to progressive failure.

The shear strength parameters of partly saturated fills do not vary considerably if determined by quick, consolidated quick, or slow tests (Taylor, Ramli) due to their large compressibility because of the air content. It is advisable therefore to use results of quick tests. The results of such tests, in terms of total stresses, are demonstrated in (fig. 1-a). It is seen that Φ_u changes from an initial value down to zero when the soil is saturated under high pressures. If results are expressed in terms of effective stresses (fig. 1.b), it will be seen that the corresponding ϕ' is constant over a significantly wide range of loads, The value of ϕ' differs only slightly from the true angle of internal friction ϕ_e . A stability analysis in terms of effective stresses will be more appropriate since it takes into consideration the more fundamental soil properties (cohesion and internal friction - $\phi_e = \phi'$) as ascertained by effective stresses. The following reasons for this procedure may be appreciated :