Internal setup in porous dams and dikes

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theme 2.3 Permanent protection of slopes against erosion. Rivers and shorelines.

Regular storm waves and tides generate groundwater flow and transient pore pressures in porous dams and dikes. The induced flow patterns show a decay and delay which is usually expressed by the well-known cyclic solution for a dam with a permeability K and effective porosity n, according to

$$h = H\exp(-x/\lambda)\cos(\omega t - x/\lambda)\ ,\ \ \lambda^2 = KDT/n\pi\ ,\ T = 2\pi\omega \qquad (1)$$

It explains that at distance x from the boundary (outer slope) where the free water moves with $H\cos(\omega t)$ the local amplitude decays with $H\exp(-x/\lambda)$ and delays with $t = x/\lambda\omega$. The average still water level D remains unchanged in this example. Geometric nonlinear effects occur which are related to the water depth D and the angle α of the outer slope of the dam or dike. They may cause the average water level inside the dam to rise significantly. This rise is referred to as internal setup S.[1] A closed form solution is proposed, according to

for $H << D$ $\qquad S/D = \xi F/2 \qquad$ (2a)

for $H \sim D$ $\qquad S/D = (1+\xi F)^{1/2} - 1 \qquad$ (2b)

Here, $\xi = cH^2/(2\pi n\lambda D\tan\alpha)$, c the air-intrusion factor and F refers to a typical case, either a closed or an open-end dam. The real dynamic internal water level is then obtained by adding the standard cyclic solution (1) to the internal setup (2). The paper will elaborate on the internal setup and illustrate consequences to the local stability in realistic situations, such as a harbour dam and a tidal river dike, which should protect the infrastructure in case of severe storm conditions.

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[1] Barends, FBJ (1986) Geotechnical aspects of rubble mound breakwaters design. Proc of Breakwaters'86, Thomas Telford, London. p:93-108.
Troch P et al. (1996) Full scale measurements of wave attenuation inside a rubble mound breakwater, Proc ICCE'96. p:526-527.