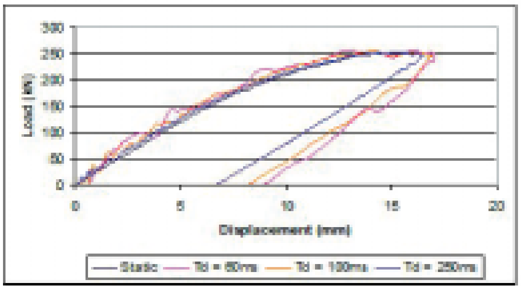

Figure 7.

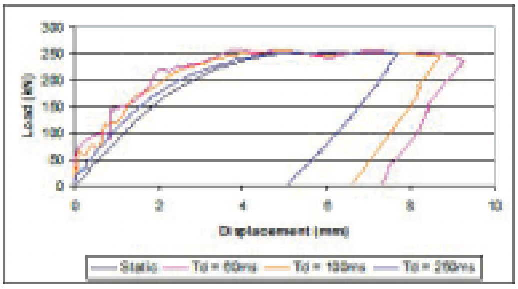

Figure 8.

CONCLUSION

In this article, the dynamic pullout test of a single soil nail was simulated using the Plaxis 8.2 dynamic module. At first, the ability of 'Plaxis 8.2' to accurately simulate the radiation damping effect of a vibrating shaft with an axisymmetric model was examined, and found to be closely comparable with the theoretical solution. From a series of parametric studies on the effect of element size, it is recommended that the α ratio (as defined in this article) should be larger than 2 to ensure the accuracy of stress propagation in this lumped mass finite element program.

The numerically simulated soil nail's dynamic pullout behavior has provided convincing results on the viability of a dynamic pullout test to assess the static pullout behavior of both stiff and extensible nails. Generally the dynamic pullout response is stiffer than the static pullout response, mainly due to the damping effect (radiation damping). The increase in loading duration decreases the damping effect, and consequently the dynamic pullout response will be closer to the static pullout response. For the simulated case, the radiation damping effect is negligible for loading durations > 100ms.

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WHAT IS THE MECHANICAL IMPACT OF

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Water pressures play a crucial role in the stability of dikes and excavations. Stability and deformation incorporating the actual local pore pressures is based on:

equilibrium: $\sigma_{ij,j}' = p_{,i}$ (1)

and can be obtained by PLAXIS. The pore pressure field is conceived as input, as a conditioned volume force. How this field is determined? Figure 1 shows a typical canal embankment near Delft in the Netherlands which conducts the excess water pumped out of the lowlands, here almost 4 meter under the canal water level.

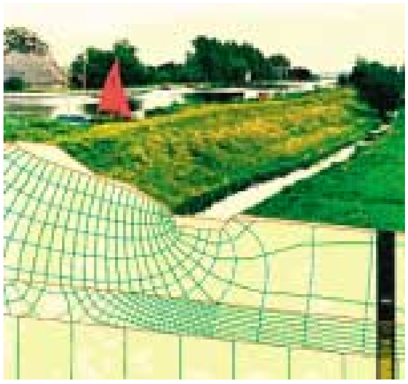

Figure 1: Stagnant flow in a canal embankment.

The stationary groundwater flow pattern in the geological stratification consisting of peat, clay, and sand (top down) can be determined by the porous flow equation:

stat. flow: $K_{ij}(p_{,j} + \gamma z_{,j})_{,i} = 0$ (2)

where anisotropy and inhomogeneity are included in the permeability K.

Capillarity and infiltration by rain, evaporation or overtopping water determine the dynamics of the groundwater table. Then the permeability K is a function of the moisture content θ. This flow field is described by:

unsat. flow: $K[\theta](p_{,i})_{,i} + \gamma K[\theta]_{,z} = \gamma\theta_{,t}$ (3)

For example, infiltration on a sloping surface shows a saturated zone on top and a wetting front propagating vertically, finally reaching the groundwater table underneath (see fig. 2)

Saturated groundwater flow including storage effects, like fluid compressibility β is formulated by:

compr. flow: $K_{ij}(p_{,j} + \gamma z_{,j})_{,i} = n\gamma\beta\, p_{,t}$ (4)

The so-called elastic storage, related to the compressibility of the porous medium: α, can be included in a similar manner:

stor. flow: $K_{ij}(p_{,j} + \gamma z_{,j})_{,i} = S\, p_{,t}$ (5)

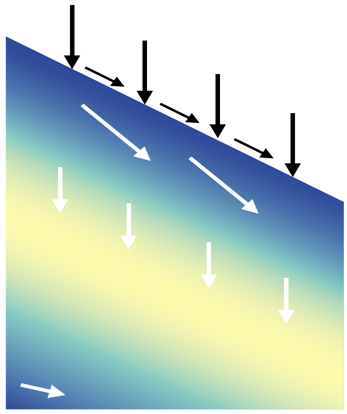

Figure 2: Infiltration in a sloping surface.

with a storage: $S = n\gamma\beta\ (1+\alpha\ /n\beta)$. From equation (2), (3), (4), and (5), the pressure field is obtained, which can be inserted in (1) to obtain the mechanical reaction of the soil. PlaxFlow is suitable to determine all these types of porous flow fields in a friendly and extensive manner.

Volumetric deformations in soil by loading or creep induce porosity changes and consequently pore pressures, particularly noticed in the saturated zone. Consequently the groundwater flow changes. This interaction is called consolidation. Thus S, like in equation (5), is incomplete, sometimes incorrect. The full groundwater flow is to be described by:

full flow: $$K_{ij}(p_{,j} + \gamma z_{,j})_{,i} = \gamma\ (n\beta\ p_{,t} + \varepsilon_{,t} + c\varepsilon\ /\ t) \qquad (6)$$

In cases with mainly one-dimensional deformation one may simplify $\varepsilon_{,t} = \alpha\ p_{,t}$ and omitting the creep term $c\varepsilon\ /\ t$ makes (6) equal to (5).

In general e, representing the volumetric strain, depends on a multi-dimensional soil response, stresses and creep, and consolidation is described by (1) and (6), simultaneously. These equations are coupled by p and e. Such type of problems can be treated with models like PLAXIS and DIANA.

A typical result of the consolidation effect is shown for a dike, suddenly loaded with a high river level. The response in the pore pressures after one hour is shown in figure 3.

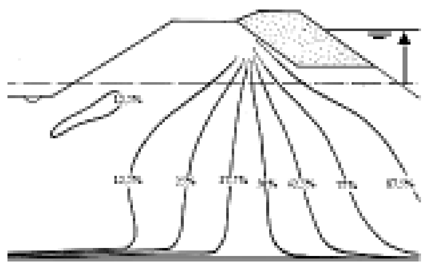

Figure 3: Two-dimensional consolidation effects.

Two typical effects are distinguished. The first one shows at the clay-sand interface (bottom, rear side) a relatively thin zone of consolidation. There, pore pressures react mainly vertically and they are strongly attenuated. This phenomenon is important in dike design under transient loading. A special simple model for this effect, WATEX, is available. The other peculiar effect is an immediate pore pressure increase under the lee side slope. When this was observed in a real dike in 1978 one thought: "Pore pressure increase indicates effective stress decrease, and hence, there is a stability problem for the lee slope." Well, this was one-dimensional thinking! The case is that the risen river water exposes a significant horizontal load on the dike that increases the horizontal effective stress. The corresponding porosity change causes the pore pressure increase. Here, the stability of the lee slope is not effected.

In this type of problems the phreatic surface and the semi-saturated zone play a significant role. The recent dike breach at Wilnis and Terbregge, in the Netherlands, in the dry summer of 2003 clearly demonstrate this fact.

At present, a semi-coupled combination of PlaxFlow and PLAXIS V8 cannot elucidate such phenomena properly. Maybe in near future a full coupling will be available.