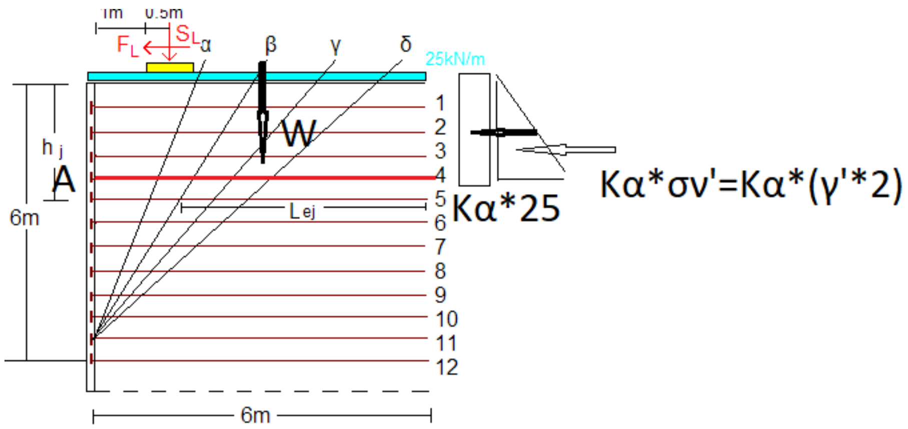
GEOTECHNICAL ENGINEERING IN THE DESIGN OF STRUCTURES:
NTUA Athens 19/1/2024

REINFORCED EARTH

A reinforced earthfill wall is to be constructed as shown in the Figure using 12 geogrid layers and compacted fill. Apart of its own weight the wall must support a uniform distributed load of 25kN/m at its surface and a strip load with vertical and horizontal components S_L=10kN and F_L=5kN respectively acting on a contact area of width b at the wall surface. The parameters of the compacted fill are γ=20kN/m^3, $\varphi'=32^0$, c'=0, Ka=0.307.

(1): Check the stability of the earthfill wall by considering 4 potential failure surfaces (α), (β), (γ) and (δ) starting at the face of layer 11 at angles 70, 61.5, 54 και 48^0 to the horizontal. Establish which of these is the most critical by constructing polygons of forces. Hence establish the force Tmax required for wedge stability.
(2): find the ultimate force carried at any level, Tj = Tpj + Tsj + Tfj, and compare with design strength
(3): using the most critical surface, check that the required total tensile strength is provided by the reinforcement $\sum_{j=1}^{m} P_j * L_{ej} * (c' + \sigma_{vj} * \mu) \geq T_{max}$, where Lej=length of reinforcement in the resistant zone. Take μ=α*tanφ' where α=0.5



2) Lets consider the forces along reinforcement layer No4: we need σv for Tpj
σv= 25kN/m2+4*0.5m*20kN/m3 + S_L/(6m*1m) simple calculation.

More accurately: calculate moments about A and find eccentricity e=ΣMoments/ΣVertical forces (the forces being drawn in the figure e.g. W=weight and active forces on the right i) first due to distributed weight 25kN/m3 and ii) due to lateral active pressure = Kα*σv'=0.307*(20kN/m3*2m) at a depth 2m (the force is the area of the rectangular an the triangle respectively, see arrows).

σv' is going to be larger than in the simple calculation because the sum of the vertical forces will be applied in a reduced area B'=B-2*e-->B'=6-2*e

Given Svj=0.5m (the vertical distance between layers of reinforcement) Tpj can be calculated as well as the rest of the forces using the following expressions. The acting tensile force along the reinforcement is the sum of these forces and should be less that the design strength of the reinforcement.

$$T_j = T_{pj} + T_{sj} + T_{fj} - T_{cj}$$

$$T_{pj} = Ka \times \sigma_{vj} \times S_{vj}$$

$$T_{sj} = Ka \times S_{vj} \times S_L / D_j,$$

$$D_j = (h_j + b) \overset{+d}{\rightarrow} h_j \leq (2d - b)$$

$$D_j = (h_j + b)/2 \rightarrow h_j \geq (2d - b)$$

$$T_{fj} = 2 \times S_{vj} \times F_L \times Q \times (1 - h_j \times Q)$$

$$Q = \{\tan(45^0 - \varphi_p'/2)\}/(d + b/2)$$

3) Now the force transferred to the ground by each layer of reinforcement would depend on its length within the passive zone. Once the critical failure surface has been found we know geometrically this length. We have already calculated σν for layer No4 hance we can calculate F4=P4*L4*σν*μ, where P is the perimeter of the reinforcement for a nail P=2πR for the geogrid 1m*1m times 2 if we consider top and bottom of the reinforcement.

The sum of Fj >> Tmax=145kN