



CONSULTING ENGINEERS

Angels Nursery, Yapton Road, Barnham - Buoyancy Calculation for balancing pond

Using Section AA on Drawing 5108 to calculate the cross-sectional area, and to use as a basis for calculating the forces per linear metre of the pond.

Water table assumed to be existing ground level = 8.800

Water level in pond assumed to be 8.000 (Invert level), water assumed to be in sump area between 7.750 and 8.000 level during winter months, at the time when water table is likely to be high.

Buoyancy force (uplift)

Displaced water = $8.800 - 8.000 = 0.800\text{m}$ of water depth

Cross-sectional area of pond within water table = 7.92m top width, 3.42m bottom width

Area = 4.54 sq.m

Density of water = 1000kg/m^3

= 9.81 kN/m^3

Buoyancy force = $4.54 \times 9.81 = 44.5\text{ kN (uplift)}$

Anchor force acting on pond

Topsoil on pond liner = 0.15m depth

Length of topsoil along bottom surface of pond = 8.25m

Length of saturated topsoil below 8.000 level = 3.48m

Area = $0.15 \times 3.48\text{m} = 0.522\text{ sq.m}$

Length of unsaturated topsoil above 8.000 level = 4.77m

Area = $0.15 \times 4.77\text{m} = 0.715\text{ sq.m}$

Density of Wet Topsoil = 1850 Kg/m^3

$$= 18.15 \text{ kN/m}^3$$

Density of Dry Topsoil = 1600 Kg/m^3

$$= 15.7 \text{ kN/m}^3$$

(Ref: EngineeringToolbox.com)

Force of saturated topsoil = $0.522 \times 18.15 = 9.47 \text{ kN}$

Force of unsaturated topsoil = $0.715 \times 15.7 = 11.22 \text{ kN}$

Total = **20.7 kN**

Less the displaced volume of water by topsoil

$$= (0.522 + 0.715) \times 9.81 = 12.13 \text{ kN}$$

Net effect of topsoil = $20.7 - 12.13 = \mathbf{8.57 \text{ kN (downward force)}}$

Overall Buoyancy force = $44.5 - 8.57 = \mathbf{35.93 \text{ kN (uplift)}}$

Therefore, min pond Ballast required = 35.93 kN

If Heavy Clay liner is used as ballast

Saturated Clay = 2300 Kg/m^3 or 22.56 kN/m^3

Unsaturated Clay = 1900 Kg/m^3 or 18.64 kN/m^3

(Ref: EngineeringToolbox.com)

For the Section AA, the length along the underside bottom surface of the pond = 8.25 m

Per metre width required force = $35.93 / 8.25 \text{ m} = 4.35 \text{ kN}$

Ratio of unsaturated/saturated soil = $3.48 / 8.25 = 0.42$ saturated, 0.58 unsaturated

Average density of clay liner = $(22.56 \times 0.42) + (18.64 \times 0.58) = 20.28 \text{ kN/m}^3$

$4.35 \text{ kN} / 20.28 = 0.214 \text{ m}$ depth of clay required.

However, displaced water by clay = $8.25\text{m} \times 0.214\text{m} \times 9.81 = 17.32\text{kN}$

Therefore Buoyancy = **17.32kN (uplift)**

Try Ballast depth x 2.5

$0.214\text{m} \times 2.5 = 0.535\text{m}$ depth of clay

$8.25\text{m} \times 0.535 = 4.41\text{sq.m} \times 20.28\text{kN/m}^3 = \mathbf{89.51\text{kN}}$

However, displaced water by ballast = $8.25\text{m} \times 0.535\text{m} \times 9.81 = \mathbf{43.3\text{kN}}$

Therefore Buoyancy = $(43.3\text{kN} + 44.5\text{kN}) - 89.51 = -1.7\text{kN}$ (**Down force**)

Therefore ok. Clay ballast required under pond = 0.535m depth

Given the water table level and depth of water in pond is assumed to be constant the same depth of aggregate can be applied across the width and length of the underside of pond