

# Technical documentation

... further information will be available at your request.

DHI Water & Environment, one of the leading European Institutes for water and environment, has prepared a hydraulic assessment on our behalf for water-filled tubes used as flood protection. A selection of the calculations from the report will give you an idea of both the sliding stability and the safety factor for a given situation:

Calculation of sliding stability Notation in Fig. 1 below. The following symbols are used in the calculations:

- B base width of the barrier (ground contact)
- $H_w$  height of the retained water
- W weight of the barrier with water
- $P_w$  maximum water pressure at the base of the barrier
- $F_w^h$  horizontal force/m on the barrier due to the pressure of retained water
- $F_w^v$  vertical uplift/buoyancy force per m on the barrier due to the pressure of retained water
- $N'$  vertical effective force on the base of the structure ( $W - F_w^v$ )
- $F_s$  factor of safety against sliding
- $\delta$  angle of friction of the soil/structure interface
- $\gamma_w$  unit weight of the water ( $9.81 \text{ kN/m}^3$ )

## Assumptions

The calculations are based on the following assumptions:

The shear resistance of the base soil is entirely frictional, i.e. cohesion is assumed to be zero. This is a conservative approximation. Cohesion is the mutual attraction of soil particles due to molecular and capillary forces in the presence of water. In other words, the ability of a substance to stick to itself or molecular attraction which holds two particles together. Cohesion is high in clay (especially dry), but of little significance in sand.

The uplift force beneath the structure is linearly distributed.

The unit weight of water is assumed  $9.81 \text{ kN/m}^3$  (sweet water).

The width of the inflated barrier (two tubes) is  $2.5 \text{ m}$ .

The weight of the barrier (two tubes) is  $2 \times 1.17 = 23.3 \text{ kN}$ . This corresponds to 95 per cent of the volume of a circular tube with a diameter of  $1.25 \text{ m}$  filled with water.

## Determination of the safety factor

Another way of presenting the calculation results is by determining the safety factor for a given situation. A safety factor below one describes an unstable situation, therefore, the higher the safety factor, the higher the safety. Fig. 2 presents the calculated safety factor for four assumed friction angles. Namely 20, 25, 30 and 35, covering the relevant range for the interface friction between PVC and sand.

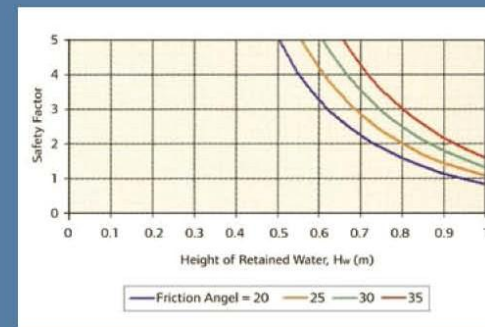


Fig. 2 Safety factor for typical friction angles (tube diameter:  $1.25 \text{ m}$ )

As an example, it can be seen that in case of a friction angle of 25, the safety factor is 1.4 for a height of retained water equal to  $0.9 \text{ m}$  and 1.0 for  $1.0 \text{ m}$ . If the friction angle is higher, e.g. 30, the safety factor will always be higher than one and the barrier is thus stable in all cases according to the calculations.

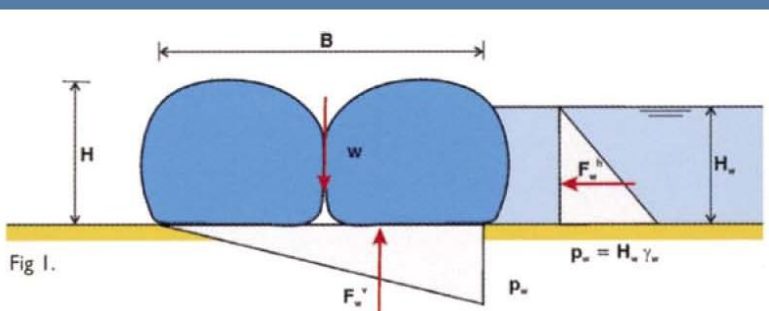


Fig. 1.

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