FILTER DESIGN EXAMPLE

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USA - Rapid Sand Filter Design

Inputs
Design a rapid sand filter to treat $Q = 20000 \text{ m}^3/\text{d}$
Allowing filtered water for backwashing: $Q_{BW} = 2\%$
Time used for backwashing per day = $t_{BW} = 0.50 \text{ hours}$
Assume the rate of filtration = $10 \text{ m/h}$
Number of Filters = 2.00
Length/Width of Filters = 1.30
Depth of Sand Media = 1.00 m
Solution:

Total filtered water = \(20\,000 \times 1.02 \times 24/(24(24-0.5))\) = 868 m³/h

Area of filter = \(20\,000 \times 1.02\) = 86.8 m²

Each bed area 86.8/2 = 43.4 m²

Let the length of the filter as: \(L/B = 1.3; 1.3B^2 = 43.4\) m²

Width = 5.78 m

Length = 5.78 x 1.3 = 7.51 m

Underdrainage system:

Total area of holes = 0.2 to 0.5% of bed area.

Assume 0.3% of bed area = \(0.3 \times 43.4 = 0.13\) m²

XSS Area of lateral = 2 (Area of holes of lateral)

XSS Area of manifold = 2 (Area of laterals)

Diameter of manifold = \((4 \times 0.52 /\pi)^{1/2}\) = 81.4 cm

Choose a standard diameter = 0.9 m

Assume c/c (center to center) of lateral = 30 cm.
**Holes**

Take dia of holes = 13 mm

Number of holes: \( n \pi (1.3)^2 / 4 \) = Total Area of holes = 860 cm\(^2\)

\[ \quad n = 4 \times \text{Total Hole Area} = 3.14(\text{Hole Diam})^2 \]

Choose total number of holes

\[ n = 4 \times \text{Total Hole Area} = 1934 \]

Number of holes per lateral = No of holes/number of laterals = 13

Area of perforations per lateral = 13 \( \times \pi (1.3)^2 / 4 \) = 17.24 cm\(^2\)

Spacing of holes = L_lateral/no of holes per lateral = 19.5 cm.

XSS. area of lateral = 2 \( \times \) area of perforations per lateral = 2 \( \times \) 17.24 = 34.5 cm\(^2\).

Diameter of lateral = \( (4 \times 34.5/\pi)^{1/2} \) = 6.63 cm

Choose a standard pipe diameter = 0.0900 m

Check: (Length of lateral < 60* Diam of Lateral)  
60 \( \times \) 6.63 = 3.98 m. l = 2.545 m.  
5.40 OK > L_Lateral
BW Trough Design

Number of BW troughs = 3
Distance between BW troughs lengthwise at $5.75/3 = 1.9$ m c/c.
Discharge of each trough = $Q/3 = 0.36/3 = 0.12$ m$^3$/s.

$Q = 1.71 \times b \times h^{3/2}$

Assume width of BW Trough =

$h = 0.3$ m

$= 40 + \text{(free board) 5 cm} = 45$ cm; slope 1 in 40

Clear water reservoir for backwashing

Duration of BW = 0.50 h

For 4 h filter capacity, Capacity of tank = $\frac{4 \times 5000 \times 7.5 \times 5.75 \times 2}{1000} = 1725$ m$^3$

Depth of BW Storage Tank = 5 m

Surface area = $1725/5 = 345$ m$^2$

$L/W = 2$

$L/B = 2; 2B^2 = 345; B = 13$ m & $L = 26$ m.

Volume =

Dia of inlet pipe coming from two filter = 50 cm.

Velocity in filter effluent pipe during filtration =

Diameter of the BW water pipe =

BW Water flowrate =

Velocity in the BW tank = 0.94 m/s

OK
**Air BW**

Air Velocity 1000 l of air/ min/ m² bed area (1 m/min = 60 m/h)

Time of air BW = 5 min

Air required During BW = 1000 x 5 x 7.5 x 5.77 x 2 = 4.32 m³ of air.

Blower Capacity = 60 m³/min

434 m³ Air

86.81 m³/min