Design of Rapid Sand Filter :

Step 1] Calculation of filter beds :

Assuming Rate of filtration = 4.8 $m^3/m^2/hr$

Number of beds is given by an Imperical Formula as

N = $\frac{\sqrt{Q}}{4.69} = \frac{\sqrt{625}}{4.69}$ = 5.33 = 6 No.

Provide 5 Beds and 1 additional bed stand by

Step 2] Calculation of Total area of filter bed :

= $\frac{Q}{Rate\ of\ Filtration}$ $\frac{m^3/hr}{m^3/m^2/hr}$ = $\frac{625}{4.8}$ =130.20 m^2

Step 3] Calculation of Size of Bed :

The length to width ratio for size of bed = 1.3 : 1 ; L/B =1.3

∴ Area of each Bed = $\frac{130.20}{5}$ = 26.04 m^2

Now, A = L x B

26.04 = 1.3 B x B

B = 4.47 mt. = 4.5 mt.

∴ L = 4.5 x 1.3 = 5.81 = 6 mt.

∴ Provide the size of bed = 6 x 4.5 mt.

Step 4] Calculation of Minimum depth of sand Bed :

Minimum depth of sand bed is read to prevent breaking through of beds and is given by imperical formula ;

L = $\frac{Q\ x\ d^3\ x\ h}{484.2\ x\ B\ x\ [\frac{60}{T+10}]}$

Where , Q = Rate of filtration in

= $\frac{4.8\ x\ 10^3}{60}$ = 80 $lit/m^2/min$

d – Diameter of sand particles = 0.05 cm

h = Terminal head loss = 2.5 mt.

B – Constatnt for response to filtration = 4 x 10^{-4} for average working condition

T – Temperature in ^0F in 20^0 C

- (20 x $\frac{9}{5}$) + 32.5 = 68.2^0 F

$\therefore L = \frac{80\ x\ 0.05^3\ x\ 2.5}{484.2\ x\ 4\ x\ 10^{-4}\ \ [\frac{60}{68.2+10}]}$ = 0.168 mt. > 0.074 mt ; Safe against crack, Safe

Step 5] Calculation of Gravel Bed :

Let us gravel bed provided for 45 cm as per following

Size Range in mm	Depth in Cm
65 - 38	15
38 - 20	9
20 – 12	9
12 – 5	6
5 – 2	6

Step 6] Design of Under drainage system :

i) Total area of Orifices :

Normaly 0.3 % of area of filter is taken

$= \frac{0.3}{100}$ x 6 x 4.5

= 0.081 m^2

ii) Calculation of Area of laterals :

Generally the ratio of Area of laterals to area of Orifices = 2 : 1

$\frac{\text{Area of laterals}}{\text{area of Orifices}} = \frac{2}{1}$

$\therefore$ Area of laterals = 2 x 0.081 = 0.162 m^2

iii) Calculation of Area of Manifold :

Generally the ratio of Area of Manifold to area of Laterals = 1.5 : 1

$\frac{\text{Area of Manifold}}{\text{area of Laterals}} = \frac{1.5}{1}$

Area of Manifold = 1.5 x 0.162

= 0.243 m^2

iv) Length of Laterals :

Length of each lateral = $\frac{Width\ of\ Bed - \ Diameter\ of\ Manifold}{2}$

$= \frac{4.5-0556}{2}$

= 1.972 mt.

$\therefore$ Number of Orifices = $\frac{\text{Length of each lateral}}{Spacing\ of\ Orifices}$

$= \frac{1.972}{25/100}$ = 7.88 = 8 No.

Total Number of orifices = Number of laterals x No. Of Orifices

= 58 x 8

= 464 No.

Area of one Orifice = $\frac{Ttal\ area\ of\ orifices}{Total\ No.}$

= $\frac{0.081}{464}$ = 1.74 cm^2

We Have ; Area = $\frac{\pi}{4}$ x d^2

1.74 = $\frac{\pi}{4}$ x d^2

d = 1.5 mt.

∴ Provide 15 mm ∅ diameter orifice on each lateral.

v) Diameter of mani fold

We Have ; Area = $\frac{\pi}{4}$ x d^2

0.243 = $\frac{\pi}{4}$ x d^2

d = 0.556 mt. = 55.6 cm = 56 cm

vi) Design of Laterals :

Let the diameter of lateral = 6 cm

Number of laterals = $\frac{Total\ Area}{Area\ of\ one\ lateral}$ = $\frac{0.162}{\frac{\pi}{4} \text{ x } (0.06)^2}$

= 57.23 = 58 No.

∴ Provide 29 Number of laterals on each side of manifold can be .provided

vii) Spacing of laterals (Along length = 6mt.)

Spacing = $\frac{Length}{No.Of\ Laterals}$ = $\frac{6}{29}$ = 0.206 mt = 20.6 cm.

viii) Design of Orifices :

Spacing of orifice is usually taken as Spacing of laterals = 20.6 cm

ix) Check for length of laterals :

Length of laterals < 60 x diameter of orifices

1972 mm < 60 x 15

< 900 mm

Hence not safe

∴ Provide the length of each lateral = 900 mm