① Slow sand filters →

→ Slow sand filters were first devised when the process of filteration was invented in England by James Simpson.

→ They may still be preferred on smaller plants at warm places, where covers on filters are not required to protected the filters from feezing. Slow sand filters normally utilize effluents from the plain sedimentation tanks, and are used for relatively clearer waters.

* construction of slow sand filters →

→ A typical section of a slow sand filter is shown in fig. The various parts of this filter are discussed below.

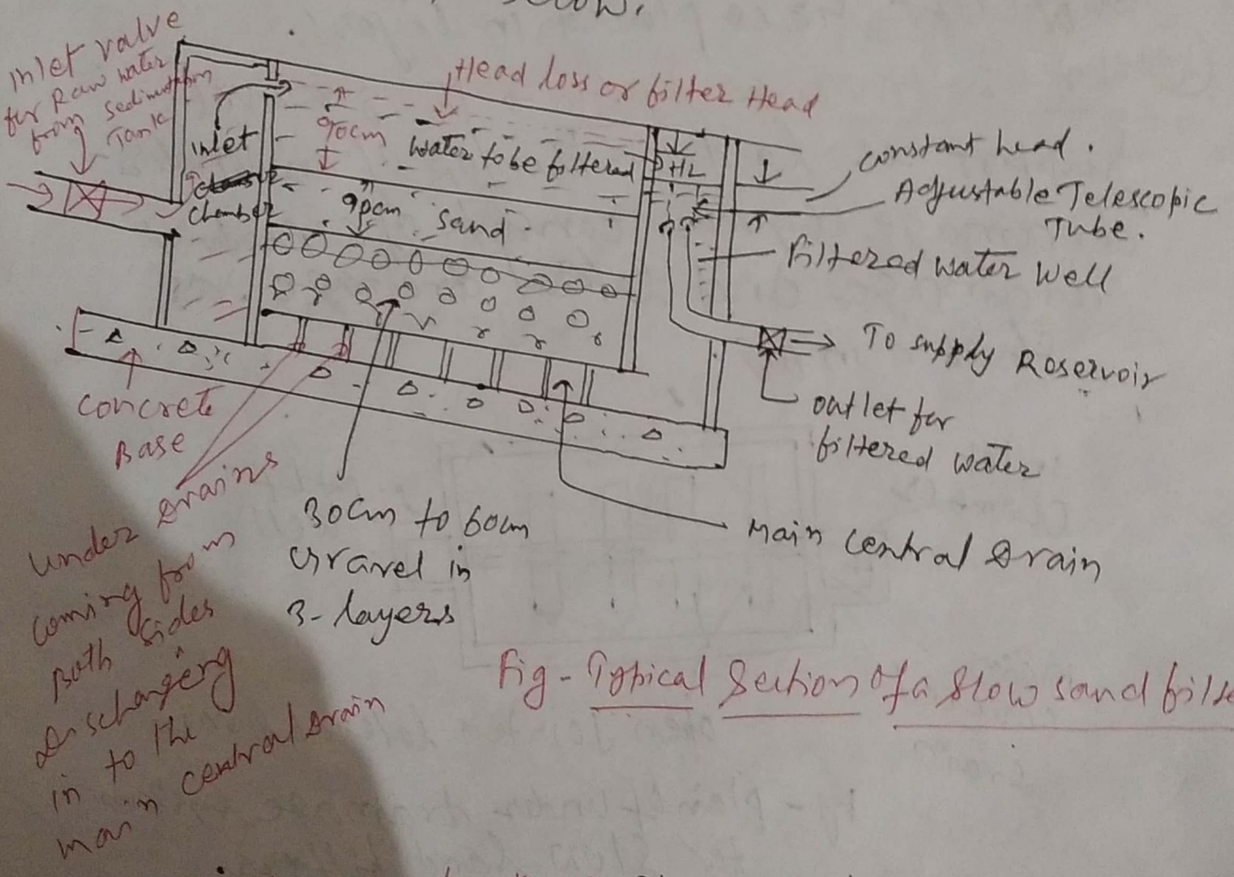

Fig - Typical Section of a slow sand filter

① Enclosure tank → It consists of an open water-tight rectangular tank, made of masonry or concrete.

→ The bed slope is kept at about 1 in 100 towards the central drain.

→ The depth of the tank may vary from 2.5m to 3.5
→ The plain area of the tank may vary from 100 to 2000 m2 or more; depending upon the quantity of water to be treated.

(ii) Filter media → The filtering media consists of sand layers.
→ about 90 to 110cm in depth
→ the effective size (D_{10}) of the sand varies from 0.2 to 0.4 mm and the uniformity coefficient ($\frac{D_{60}}{D_{10}}$) varies from 1.8 to 2.5 or 3.0

(iii) Base material → The base material is gravel, and it supports the sand. It consists of 30 to 75 cm thick gravels of different sizes placed in layers.

(iv) Under-drainage system → The gravel support is laid on the top of an under-drainage system. consists of a central drainage and lateral drainage. as shown in fig.

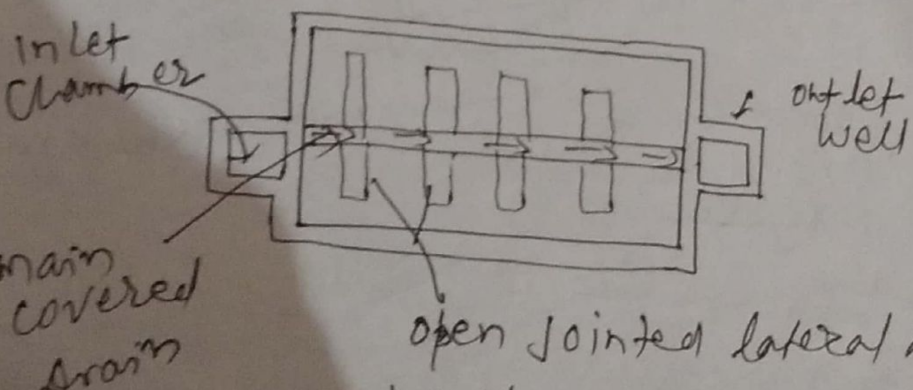

fig - plain of under drainage systems for slow sand filters.

→ The lateral are open joined pipe drains or some other kind of porous drainage ~~central drain~~. 3 to 5m apart on the bottom floor and sloping towards a main covered central drain.

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(v) inlet and outlet arrangements → An inlet chamber, is construction for admitting the effluent from the plain sedimentation tank without disturbing the sand layers of the filter and to distribute it uniformly over the filter bed. A filtered water well is also construction on the outlet side in order to collect the filtered water coming out from the main under drain.

(vi) other appurtenances → Besides these arrangements certain other appurtenances are provided for the efficient functioning of these filters. eg: vertical air pipe passing through the layers of sand may be provided and may help in proper functioning of the filtering layers.

→ the depth of water above the sand layer 1 to 1.5m

→ when this loss of head becomes high (0.7 to 1.2m) the filter unit must be put out of service and be cleaned.

* operation and cleaning of slow sand filters →

→ The treated water from the sedimentation tank is allowed to enter the inlet chamber and get distributed uniformly over the filter bed.

→ Water ~~entering~~ entering the slow sand filter should not be treated by coagulants. this is due to the fact that the dirty skin formed by the floc and carried to the filter considerably affects the economical working of the filter.

→ The loss of head called filter head or filtering head or filteration head is generally limited to a maxm value of about 0.7 to 1.2m.

→ The cleaning of slow sand filters is not done by back washing as is done for rapid gravity filters, but is done by scrapping and removing the 1.5 to 3 cm of top sand layer.

→ The top surface is finally raked, roughened, cleaned and washed with good water.

→ the amount of wash water required is generally small, say of the order of 0.2 to 0.6% of the total water filtered. cleaning is repeated as often as necessary until the sand depth is reduced to about 40cm or 50. then more sand is added.

→ the effective size of sand particles for slow sand filters varies from 0.30 to 0.35mm. ~~and the~~

→ The slow sand filters require large area (from 100 to 2000 m2) as compared to rapid sand filters.

→ The rate of filteration of a slow sand filter ranges from 100 to 200 litres/m2/hour.

→ the slow sand filter is more efficient for the removal of bacteria from the raw water to an extent of 99%.

→ It can remove turbidity of 50 p.p.m.

→ the cleaning of ~~san~~ slow sand filter is required when the loss of head or filteration head becomes more than 1.2m.

→ the cleaning period is taken as 1 month to 3 months.

→ ~~the cleaning period is taken~~ as

→ After cleaning the slow sand filter, the filter water should not be used for a period of 24 hours to 48 hours. used for town & village

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* Uses of slow sand filters → Slow sand filters are best suited for smaller plants and for purifying waters with low colour, low turbidities and low bacterial contents. However, because of their smaller rate of filtration, they require huge surface area and large volume of filtering material.

Q Design six slow sand filter beds from the following data.

population to be served = 50,000 person
per capita demand = 150 litres/head/day.
Rate of filtration = 180 litres/hr/m^2
length of each bed = Twice the breadth.
Assume max. demand as 1.8 times the average daily demand. Also assume that one unit, out of six, will be kept as stand-by.

Soln Average daily demand = population × per capita demand

= 50,000 × 150 litre/day

$= 75 \times 10^5$ litre/day

$= 7.5 \times 10^6$ litre/day

Max. daily demand $= 1.8 \times 7.5 \times 10^6 = 13.5 \times 10^6$ litre/day

→ Rate of filtration per day = 180 litre/m^2/hr.

= 180 × 24 litre/m^2/day

→ Total surface area of filters required

$= \frac{\text{Max. daily demand}}{\text{Rate of filtration per day}}$

$= \frac{13.5 \times 10^6}{180 \times 24} m^2$

$= 3125\ m^2$

→ Now, six units are to be used out of them one is to be kept as stand by and hence only 5 units should provide the necessary area of filter required.

∴ the area of each filter unit

$= \frac{1}{5} \times$ total area reqd $= \frac{1}{5} \times 3125$

$= 625 \, m^2$

→ Now, if L is the length and B is the breadth of each unit, Then

$L = 2B$ (given)

$2B \cdot B = 625 \, m^2$

$2B^2 = 625$

$B = \sqrt{\frac{625}{2}} = 17.7 \, m \simeq \underline{18 \, m}$

$\therefore L = 2 \times (17.7) = 35.4 \simeq \underline{36 \, m}$

→ Hence, use 6 filter unit with one unit as stand by each unit of size $36 \, m \times 18 \, m$.

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2) * Rapid Sand FILTERS or MECHANICAL SAND FILTERS

which water

→ in order to reduce the requirement of space and to increase the rate of filtration, a lot of research was conducted, which finally led to be development of rapid sand filters, or sometimes called mechanical sand filters.

* The rapid sand filters are two types viz

(i) one which utilise comparatively larger sized sand particles which allow greater rate of filteration as compared to that of slow sand filters. They are called rapid gravity filters.

(ii) one which utilize the developement of pressure over the filtering water and thereby increasing the rate of filtration. They are called pressure filters.

→ Rapid gravity filters are used for large municipal supplies, whereas pressure filters, being more handly may be used for small installation such as for industrial plant and swimming pools.

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[illegible] (ii) Rapid gravity filters → these filters employ coarse sand with effective size as 0.5 mm or so. On average, these filters may yield as high as [illegible] times the yield given by the slow sand filters.

* Construction of Rapid Gravity filters →

→ A typical section of a rapid gravity filter is shown in fig. The various parts of this filter are described below.

(1) Enclosure tank → It consists of an open water tight rectangular tank, made of masonry or concrete.

→ The depth of the tank may vary from 2.5 to 3.5 m.

→ The area of the filter units should not be kept larger and is generally limited to about 10 to 80 m² for each unit.

→ The No. of units at a filter plant may be roughly estimated by the equation Morrell and Wallace. i.e

$$\boxed{N = 1.22\sqrt{Q}}$$

where N = No. of filters unit

Q = plant capacity in million litres per day.

(2) Filter media → The filter media consists of sand layers, about 60 to 90 cm in depth and placed over a gravel support.

→ The effective size (D_{10}) of the sand varies from 0.35 to 0.55 mm and the uniformity coefficient ($\frac{D_{60}}{D_{10}}$) generally ranges between 1.3 to 1.7.

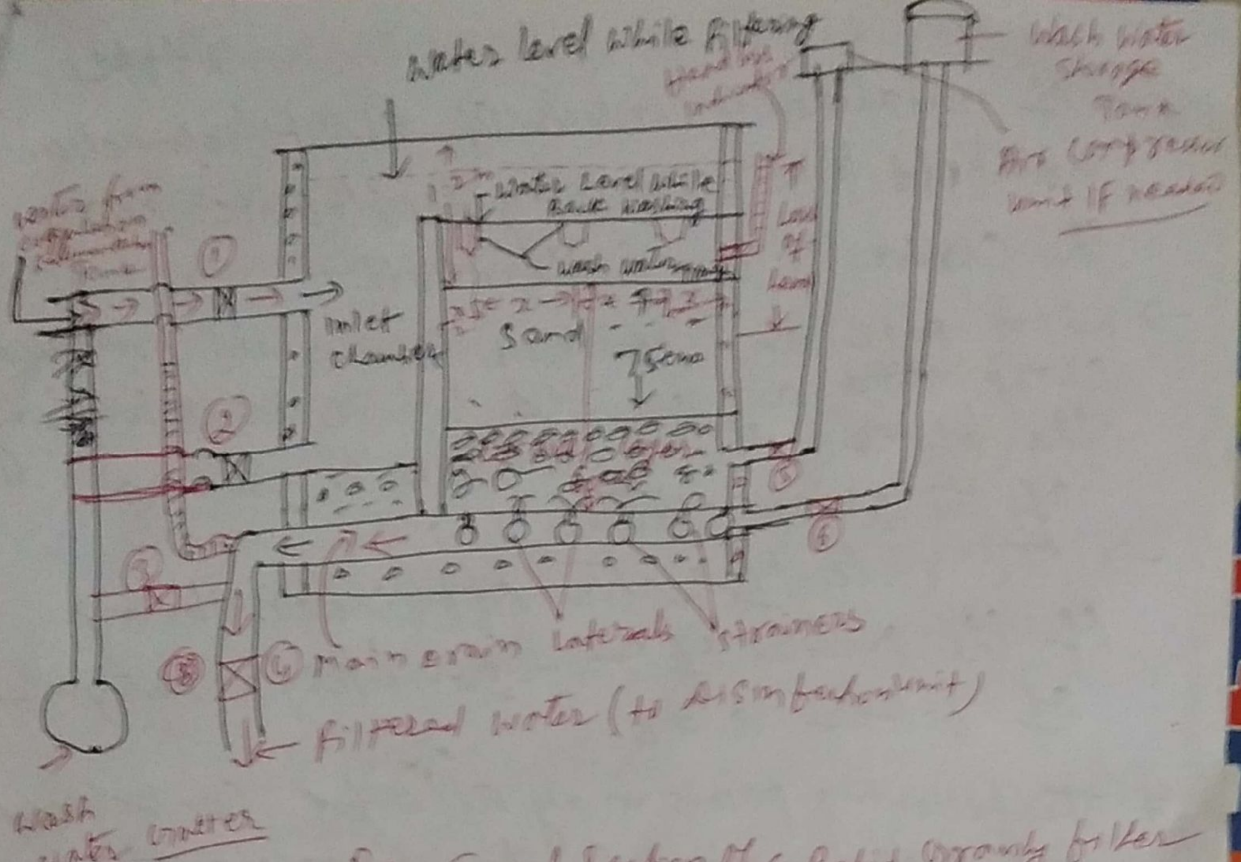

Fig - Typical section of a Rapid Gravity filter

(3) Base material → in slow as well as rapid gravity filters, the base material is gravel, and it supports the sand.

→ It consists of 60 to 90cm thick gravel of different sizes placed in layers. Generally five to six layers, each of 10 to 15cm in depth are used.

(4) Under-drainage system → in rapid gravity filters, the under drainage system serves two purposes viz (i) to receive and collect the filtered water, and (ii) to allow the back washing for cleaning of filter.

→ It should be capable of passing the wash water upward at a high rate of about 300-900 litres/minutes/m2 of filter area, or more, depending upon design.

→ The rate of application of wash water is so much higher than the rate of filtration.

(ii) Perforated pipe ...

(3) A Manifold and lateral system type of installation consists of about 40 cm dia manifold pipe running lengthwise along the centre of the filter bottom.

→ When pipe and strainer system is provided compressed air is used while backwashing the filter.- this results in the saving of the wash water

→ the rate of water application being of the order of 700 to 800 litre/minutes/m2 of filter area.

* the following points may also be considered and kept in mind, while designing the sizes of the pipes to be used in the above system.

(a) The total cross-sectional area of perforations should be about 0.2% of the total filter area.

(b) the cross-sectional area of each lateral should be about 2-4 times the total cross sectional area of perforations in it for dia. of perforation 13 mm and 6 mm respectively.

(c) The cross-sectional area of the manifold should be about twice the cross-sectional areas of the lateral drai

(d) $\dfrac{\text{length of each lateral}}{\text{dia. of the lateral}} \not> 60.$

(e) maxm permissible velocity in the manif to provide the required amount of wash water is about 1.8 to 2.4 m/sec.

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(6) other appurtenance → the more important among them are.
(i) Wash water troughs.
(ii) Air compressor
(iii) Rate controller
(iv) Miscellaneous accessories.

* Back washing → When sand becomes dirty, as is indicated by the excessive loss of head, the filter must be cleaned and washed.
→ The effective size of sand particles for rapid sand filters varies from 0.35 to 0.50 mm and the coefficient of uniformity is 1.6
→ The under drainage system receives and collects the filtered water and also allows back washing for cleaning the filter.
→ The water is forced at a pressure higher than the atm. pressure in rapid gravity filters. These filters required coagulation.
→ The rate of filtration of a rapid sand filter is about 30 times (i.e about 3000 to 6000 litres/m2/hour) to that of slow sand filter.
→ The rapid sand filter can remove bacteria upto an extent of 80% to 90% and turbidity upto an extent of 35 to 40 p.p.m.
→ The cleaning of rapid sand filter is required when the loss of head

or filteration head exceed 2.5m and cleaning period is taken as 2 to 3 days.

→ the rapid sand filter are cheap and economical as compared to slow sand filters.

③ pressure filters → The pressure filters are just like small rapid sand filters and placed in closed and water tight steel vessels cylindrical in shape.

→ The water is forced into the filters at a pressure greater than the atm. pressure

→ the rate of filteration varies from 6000 to 15000 litres/m2/hr.

→ the pressure filters are not used for treating municipal water supplies because of their most cost.

→ they are best suited for swimming pools, railway stations, individual industries, private estates etc.

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