ENVIRONMENTAL ENGINEERING

Notes by-

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FILTERATION OF WATER

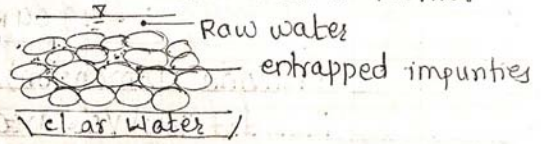
* Filteration is the process of removing particulate matter & bacterial impurities which are not removed in sedimentation. The water is passed through porous material.

* Objects of filteration:-
1) To remove suspended, colloidal & other impurities from water which causes turbidity to water.
2) To reduce bacterial load up to 90%.
3) To reduce odour & colour.
4) To alter chemical characteristics of water.

* Theory / Mechanism of Filteration:-
Theory of filteration involves -
1) Mechanical Straining
2) Sedimentation
3) Biological Metabolism.
4) Electrolytic changes.

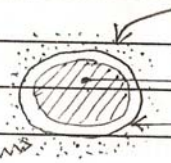
MSBE
MSEB
V. Imp.

1) Mechanical Straining:-
Voids present in filter media acts as sieve or strainer When water passes on such medium, the particles larger than voids are entrapped in the voids. The particles such arrested further acts as mat & improve filteration.



2) Sedimentation:-
The voids bet^{n} sand grains of filter acts as a small sedimentation tanks. Thus suspended load is removed in this mechanism.

3) Biological Metabolism:-
The growth & living process of living cells is known as biological metabolism. As the surface of sand layer gets coated with a film; which ~~is food for~~ contains some bacterias. These bacteria's eat the organic impurities & convert then in to harmless compounds. Thus most of the bacterial load is removed.

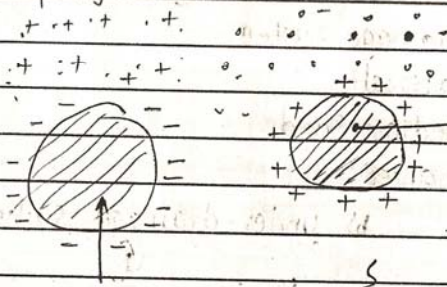


converted harmless compounds.

(4) Electrolytic charges :-

It is observed that soil grains of filter are charged electrically of some polarity. & according to ionic theory, as some particles having oppositely charge than that of sand grain gets neutralized resulting in change in chemical characteristics of water.

After some time, the electrical charges on sand grains get exhausted so it is necessary to clean the filter & restore this property.



For Negatively charged soil grain: According to theory of ionisation

Neutralization + Changed water cht.

* Properties of filter sand :-

Free from clay, loam, vegetable matter, organic impurities etc.
Uniform in nature & size.

* Effective Size of Sand :- The size of sieve in mm through which 10 % wt. of sand passes.

* Uniformity coefficient = Size of sieve in mm thr which 60 % wt of sand pass / Size of sieve (mm) thr which 10 % wt. of sand pass

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* Materials of Filter :-
  1) Sand
  2) Anthracite
  3) Garnet & ilmenite
  4) Gravels.

* Classification of Filters :-

A] Based on Rate of Filterat^{n}
  a) Gravity Filter :-
    1) Slow Sand Filter
    2) Rapid Sand Filter
  b) Pressure Filter

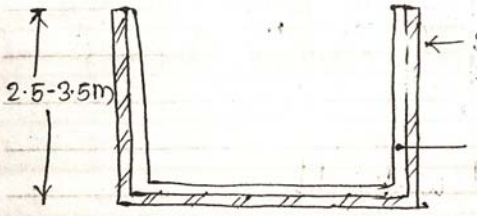
B] ased on Material of filter media
  a) Sand Filters
  b) Anthracite Filter
  c) Metal fabric/ Microstainers/ Stainless steel fabrics
  d) Diatomaceous earth filter

C] Based on depth of filter media
  a) Deep granular
  b) Precoat Filter

I] Slow Sand Filter

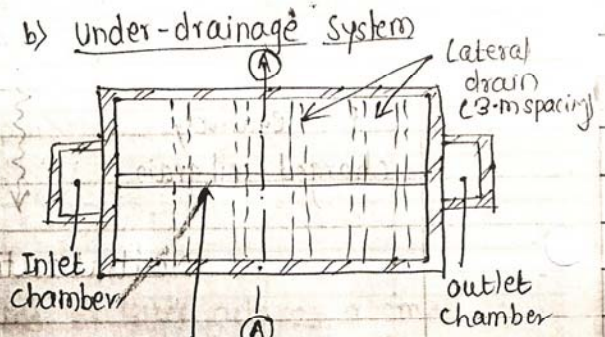
Essential Parts :- a) Enclosure tank (EUBFA)
b) Under drainage system
c) Base material
d) Filter^{n} media - Sand
e) Appurtenances.

a) Enclosure Tank.



C/S of enclosure tank (Sect^{n} A-A)

b) Under-drainage System



Plan of under drainage system.

In under drainage system, lateral drains are provided from central drain & spaced at a dist of 2·5 to 3·5m. Lateral drains may be open end or porous or open jointed tiles.

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c) Base material:-

Topmost layer	: 15 cm thk.	Size	3 to 6 mm
Intermediate	: 15 cm thk.		6 to 20 mm
	: 15 cm thk.		20 to 40 mm
Lowest layer	: 15 cm thk		40 to 65 mm
	600 mm thk.		

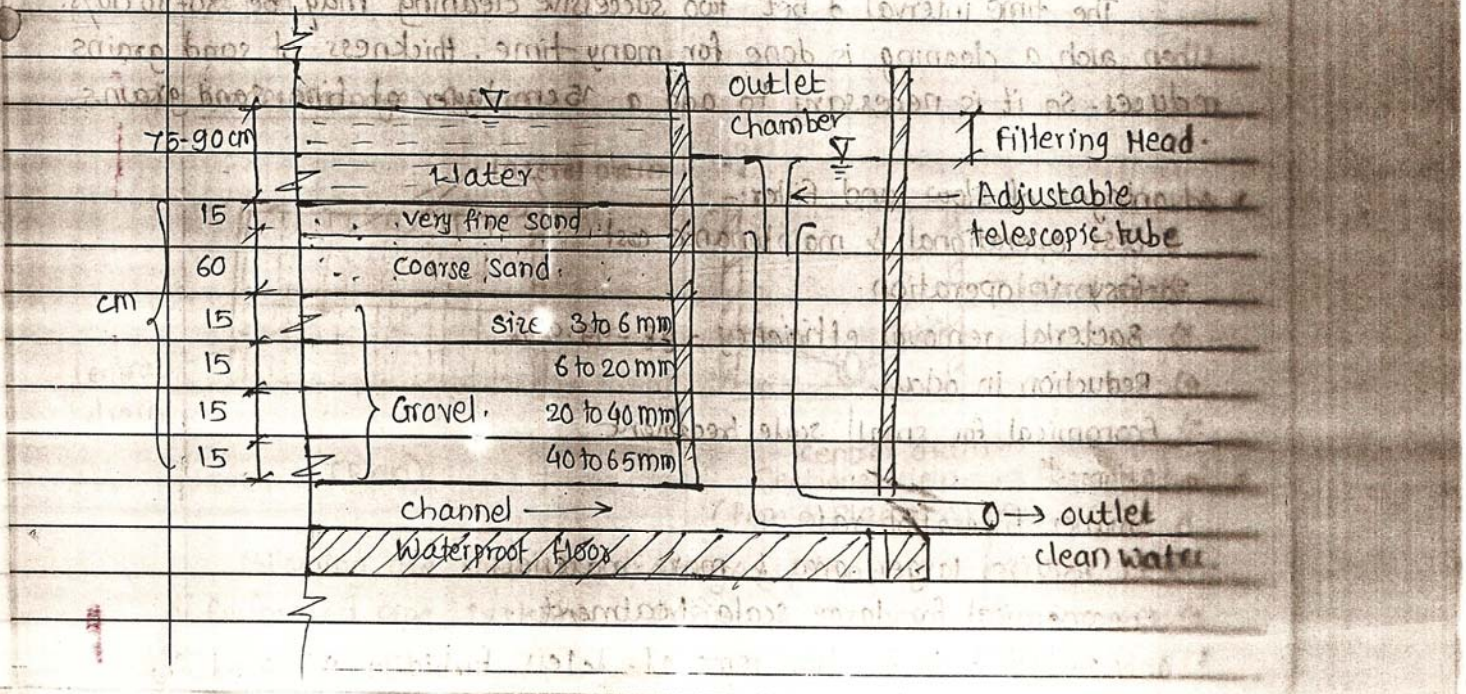
d) Filter media - Sand:-

Depth of filter media : 75 to 90 cm.
Effective size : 0.2 to 0.35
Uniformity coeff : 2 to 3.

This is topmost layer of filter which contains 15cm top layer of fine sand & then rest of layer of coarse sand.

e) Appur- Appurantances:-

1) Instruments used to measure loss of head.
2) Controlling depth of water above filter media.
3) Controlling constant rate of flow thr filters.
4) Adjustible telescope to maintain constant discharge
5) Vertical air pipe.



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Working of filter:-

Water coming from sedimentation tank is fed to filter. The water travels from various layers of sand & gravel & by virtue of various mechanisms i.e. MSEB (Mechanical Straining, Sedimentation, Electrolytic charges & Biological metabolism) water gets purified as explained.

If coagulants are used for sedimentation, it adversly affects working of filter. So coagulants should not be used. The depth of water is generally kept equal to the depth of sand.

Filtering head is the difference bet° water level in filter tank & outlet chamber. When filtering head reaches to its max. value, working of filter is stopped & cleaned out.

Cleaning of filter:-

When filter head reaches up to 1.3 m, water in the tank is drained out. Top 2 to 3 cm of sand layer is scrapped & removed. Then water is admited in the tank. This water is kept for 12 hours so that biological film formson the sand grain, and by virtue of biological metabolism, impurities which are entrapped bet° soid grains are converted in to harmless chemical compounds, which are slowly drained out. This is done for another 2 days. Then the filter is allowed to run for filteration.

The time interval b/t two successive cleaning may be 30-90 days. When such a cleaning is done for many time, thickness of sand grains reduces. So it is necessary to add a 15 cm layer of fine sand grains.

* Advantages of slow sand filter:-

1) Less operational & maintenance cost.
2) Easy in operation
3) Bacterial removal efficiency - 98 - 99.9 %
4) Reduction in odour.
5) Economical for small scale treatment

* Limitations:-

1) Smaller filteration rate
2) It requires larger area & more materials.
3) Uneconomical for large scale treatment.
4) Only 20-25% taste & colour removal. & less turbidity removal eff.

Rapid Sand Filters / Mechanical Filter :-

These filters requires coagulation treatment on water before they enter in the filter. The slow sand filters requires more area, so to avoid this larger area, it is necessary to increase the rate of filteration, which can be done in two ways -

1) By increasing size of sand, the friction bet° water & filter media can be minimised. : Gravity type
2) By allowing water under pressure. : Pressure type.

Gravity type Rapid Sand Filters :-

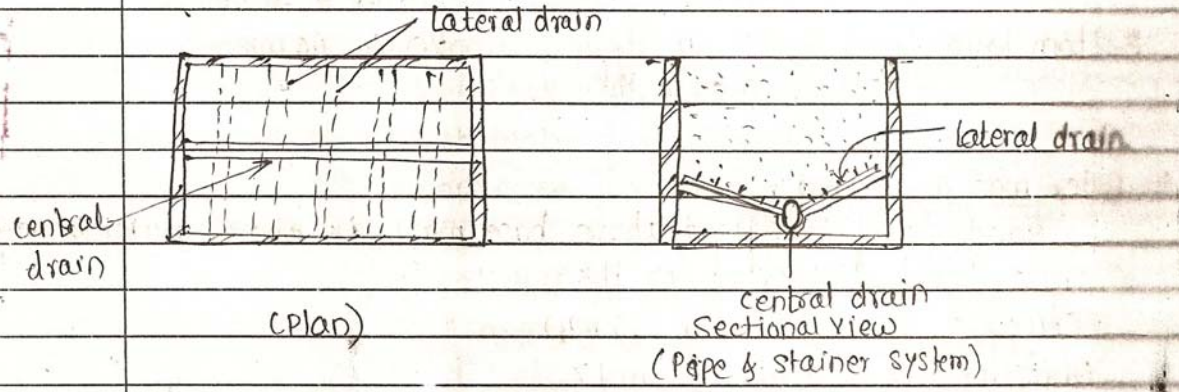
Essential parts :-

1) Enclosure Tank.
2) Under-drainage System
3) Base material.
4) Filtering media.
5) Apperatances.

Enclosure tank :-

Enclosure tank is constructed either in masonry or concrete. The sides & beds are made watertight. Depth of tank is 2 to 3.5 m.

Underdrainage System :-



Following are common drainage system :-

1) Perforated pipe system 2) Pipe & stainer system

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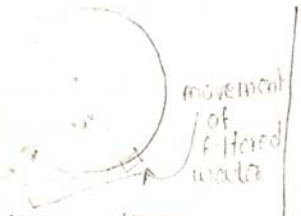
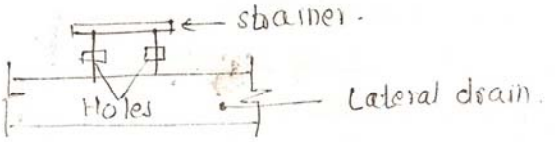
1) Perforated pipe system:-

In this system perforated lateral drains are attached to central drain. The lateral drains are spaced @ 15 to 30 cm c/c. The lateral drains are provided with holes at bottom as shown. The holes may be in series or staggered on either sides. The c/c dist. bet° holes is kept about 7.5 to 20 cm.



2) Pipe & strainer system:-

In this systems lateral drains are attached to the central drain. But strainers are placed instead of holes in the perforated pipe system.



3) Base material -

Base matl. generally gravel is used & placed above under-drainage system. The base matl. should be free from clay, dust, vegetable matter, silt etc. The gravel should be shong, durable & rounded shape. These graveds are graded & kept in the thk. of 15 cm as -

Topmost layer	15 cm thk	3 to 6 mm size
Intermediate layer	15 cm thk	6 to 12 mm
	15 cm thk	12 to 20 mm
Bottom layer	15 cm thk.	20 to 40 mm
	60 cm thk.	

4) Filter media of sand -

Sand layer is placed above base matl. i.e. above gravel & depth of sand layer is 60 to 90 cm thk.

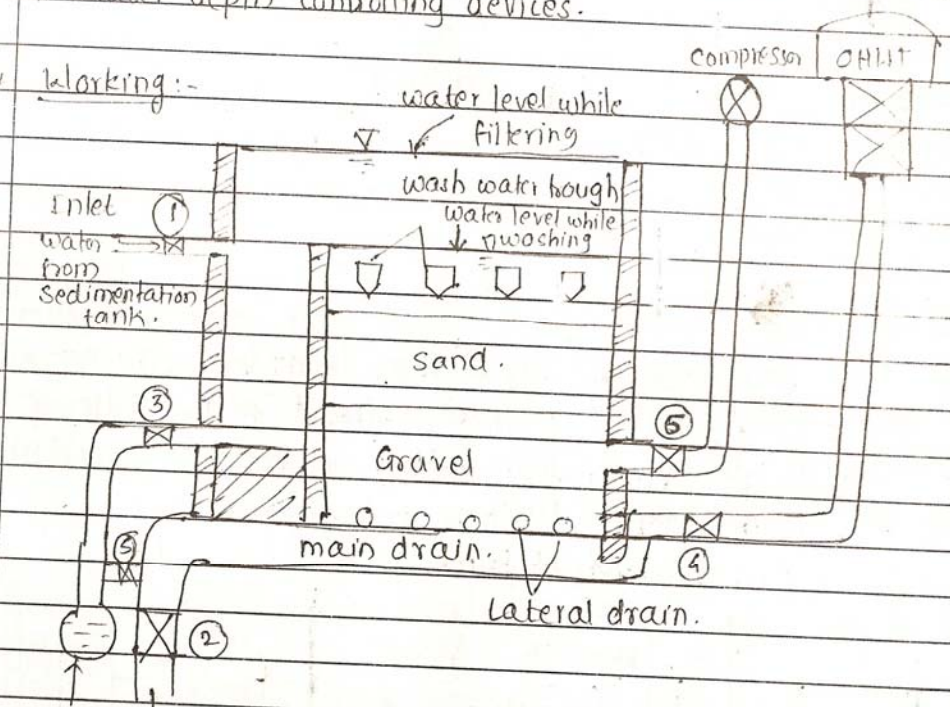
Effective size :- 0.35 to 0.5 mm

Uniformity coefficient : 1.2 to 1.7

5] Appurtenances :-

a) Air compressors :-
b) Wash water troughs.
c) Controlling devices for quantity of water.
d) Loss of head measuring devices.
e) Water depth controlling devices.

7] Working :-



Valve ① - Inlet valve
Valve ② - Filter water storage tank valve
Valve ③ - Wash water - from drain water valve
valve ④ - Wash water storage tank wat valve
valve ⑤ - Compressed air valve.

Open inlet valve ① & water from coagulation sedimentation tank is admited to the filter. Then valve ② is kept open & filtered water is collected in a tank. All the remaining valves are kept closed while working of filteration is going on.

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3] Cracking of filter bed :- The earthly particles shrink & cracks in the sand bed. These are seen near wall junctions. This affects working of filters.

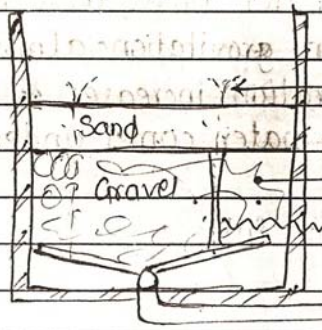
4] Sand incrustation :- The size of sand particle gets increased when heavy treatment of lime is given in coagulation process. Hence effective size of sand gets increased.

○ ○ ○ ○ ○ ○ ← original sand particles.

◎ ◎ ◎ ◎ ◎ ◎ ◎ ~ Effective size increases.

5] Jetting & Soil boiling :-

This results during back washing. The water moves from the voids which offers minimum resistance for the flow. If the flow vel. is more, the gradation of sand & gravel gets disturbed & sand gets lifted upward. This phenomenon is known as jetting & soil boiling.



← Sand boiling or jetting.
Disturbed grading.
Void of least resistance to flow.
compressed water

6] Sand leakage :- During the process of back washing the grading of gravel gets disturbed & under such conditions if voids are more than the size of sand particles, these particles flows with water & known as sand leakage.

Comparism of slow sand filters & Rapid sand filters

Item	SSF	RSF
① Rate of filteration	100-200 lit/hr/m²	3000-6000 lit/hr/m²
② Loss of head	15 cm initial 100 cm fina	30 cm initial 3 m final.
③ Size of bed	Smaller	Larger
④ Coagulation	Not reqd.	Reqd.
⑤ Size of filtering media	Eff. size = 0.2-0.35 mm Uniformity coeff = 2-3	Eff. size = 0.35-0.6 mm Cu = 1.2-1.7.
⑥ Period of cleaning	1 to 2 months	2-3 days.
⑦ Efficiency	Very efficient in the removal of bacteria but less efficient in removal of colour & turbidity.	less efficient in removing bacteria, more efficient in removal of odour & turbidity.
⑧ Economy:	High initial cost.	Cheap & economical.
⑨ Flexibility	Not flexible	Flexible
⑩ Supervision	Not essential.	Skilled supervision reqd.
⑪ Depreciation cost	low	High

Pressure filters:-

They are watertight tanks & water flows through filter under the pressure which is more than ~~gravitation~~ atmospheric pressure. Due to which rat of filteration increases & the filtered water has less head loss. & water comes under pressure requiring less surface area.

There are two types of pressure filter-

- Horizontal Type.
- Filter type.

Construction:-

The pressure filters are closed steel cylinders. The dia. of pressure filters from 1.5 to 3.0 m.

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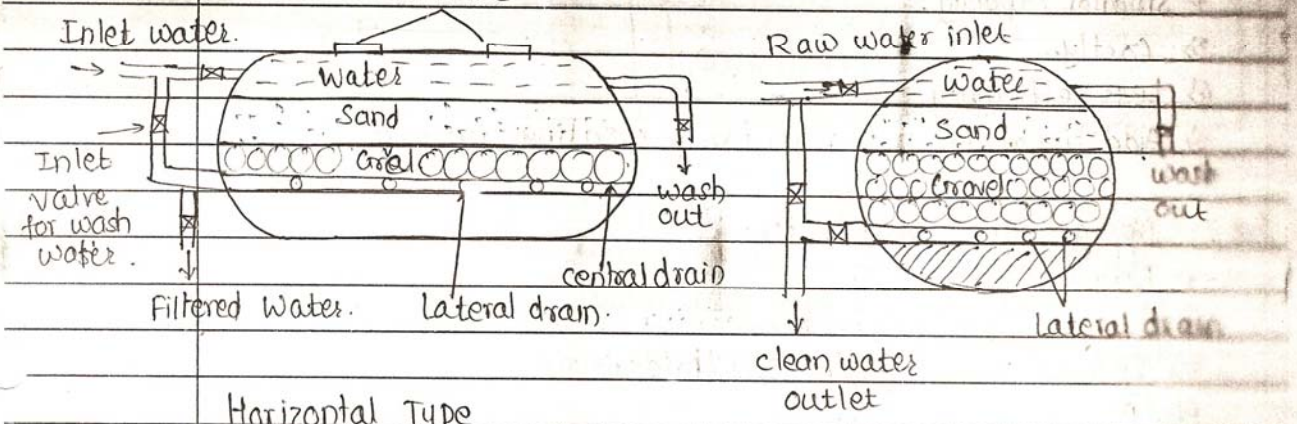
* Working:-



Horizontal Type

Water mixed with coagulants is directly admited to pressure filter. The all the valves are kept in closed position except raw water inlet & clean water outlet valve.

* cleaning:-

Compressed air is blowed through the inlet valve. & then wash water is allowed to flow in reverse fashion. The cleaning of pressure filter is done automatically & frequently, by adjusting the cleaning procedure at the predetermined interval of time or loss of head.

* Efficiency: Not efficient for bacterial load.

* Advantages:-

1) Manual supervision is not reqd.
2) Water comes out with pressure so no pumping is reqd.
3) Ideal for small estates.
4) Less area reqd.
5) Sediment° & coagulation is not reqd.
6) Flexible in operation. i.e. Filtera°n rate can be controlled.

Disadvantages:-

1) Repairing is difficult.
2) Smaller capacity.
3) Costly.

Prob

i) Populat^n = 50,000
ii) Demand : = 150 l/hr/day /capita
iii) Filteral^n rate = 180/h 180 l/hr/day
iv) P

Sol^n:-

Total daily demand = Populat^n x Demand
= 50,000 x 150
= 7.5×10^6 l/day

Max. demand = 1.8 x Total demand
= 13.5×10^6 l/day.
Q = $13.5 \times 10^6 / 24 = 562.5 \times 10^3$ Lit/hr

Surface Area reqd = $\frac{Q}{\text{Rate of filteration}}$

$= \frac{562500}{180}$

$= 3125\ m^2$

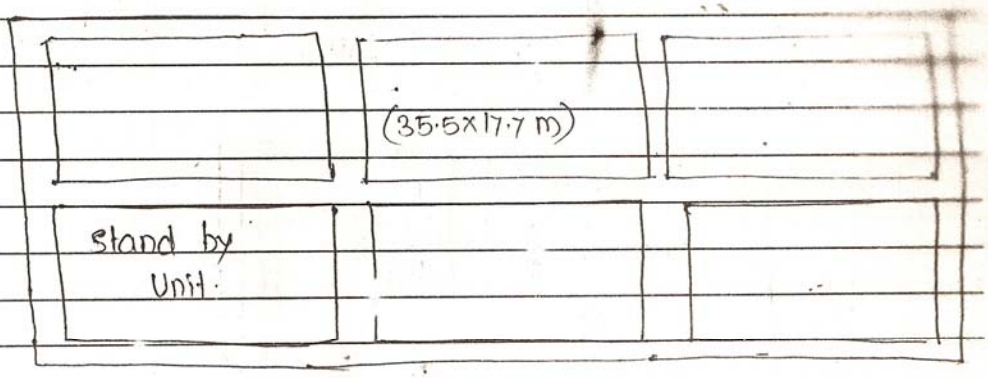
Provide 6 units along with one unit as stand by

∴ Area of each filter = $\frac{3125}{5} = 625\ m^2$

Assume $\frac{L}{B} = 2$

~~L = 62.5, B = 35.5m~~

L = 35.5m ; B = 17.7m.



Layout of Slow sand Filter.

Pro: Design Rapid Sand Filter.

Population : 80,000

Rate of water supply = 200 l/hr/day

Rate of filteration = 5000 l/hr/m².

$Q = 200 \times 80,000$

$= 16 \times 10^6$ l/hr/day.

$Q_{max} = 1.5 \times 16 \times 10^6$

$= 24 \times 10^6$ l/hr/day.

Assume 30% water reqd. for washing per day & 30 min. reqd. for filtering.

$\therefore Q_{max} = \frac{1.03 \times 24 \times 10^6}{24 - 0.5}$ lit/hr.

$= 1.052^{\times 10^6}$ lit/hr.

Surface area reqd = $\frac{Q_{max}}{\text{Filterat}^n \text{ Rate}}$

$= \frac{1.052 \times 10^6}{5000}$

$= 210 \text{ m}^2$

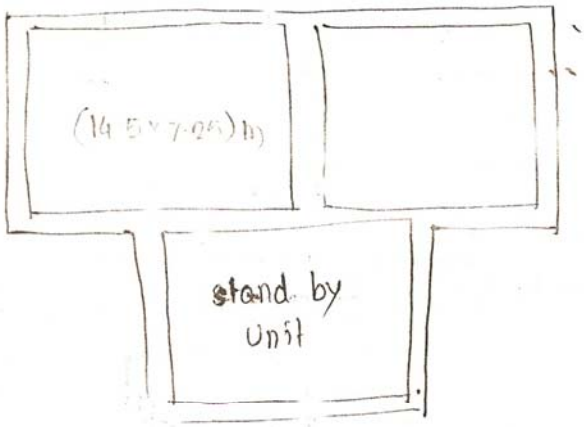
Provide two units.

∴ Area of each unit = 105 m²

$L/B = 2 \Rightarrow L = 2B \Rightarrow A = 2B^2 = 105 m^2$

$\therefore$ $L = 14.5m$, $B = 7.25m$

Provide one stand by unit



			Size
Provide :-	Depth of very fine sand	= 15 cm	0.35 m
	coarse sand	= 60 cm	0.6 mm
	Gravel : Top layer	= 15 cm	- 3 to 6 mm
	Intermediate	= 15 cm	6 to 12 mm
		= 15 cm	12 to 20 mm
	Bottom	= 15 cm	20 to 40 mm
	Depth of water	= 100 cm	
	free board	= 25 cm	
	under drain depth	= 40 cm	
		Total H = 300 cm.	

Qty. of wash water = 3% of Qmax

$= 0.03 \times 24 \times 10^3$

$= 7.2 \times 10^5$ lit/hr/day.

* Provide central drain pipe of dia. 10 cm.
Dia. of lateral drain = 50 cm.
Dia. of perforated pipe's hole = 10 mm.

Thk. of wall = 230 mm. with water proofing matl.