4. Check Against Resuspension of Deposited Particles

Flow velocity that can initiate resuspension of deposited particles in the sludge zone, \( V \), is given by

\[
V = \sqrt{\left(\frac{8k}{f} \right) g (S_s - 1)}
\]

For unigranular particles \( k = 0.04 \) and

Weisbach - Darcy friction factor, \( f = 0.03 \)

\[
V = \sqrt{\left( (8 \times 0.04 / 0.03) \times 9.81 \times (2.65 - 1) \times (0.02 \times 10^{-3}) \right)} = 5.88 \times 10^{-2} \text{ m/s}
\]

To avoid resuspension, this critical displacement velocity should not be exceeded and horizontal velocity of flow in basin should be less than critical displacement velocity. Horizontal velocity of flow in settling basin at average flow, \( V_h \)

\[
V_h = \frac{Q}{(B \times D)} = 255.1 \text{ [m}^3/\text{hr]} / (3600 \times 9.09 \times 3.09) \text{ m/s} = 2.52 \times 10^{-3} \text{ m/s} < 5.88 \times 10^{-2} \text{ hence O.K.}
\]

5. Influent Structure

The influent structure is designed to minimize turbulence, to distribute the water and suspended solids uniformly across the width and throughout the depth of settling basin and to avoid deposition of suspended solids in influent structure. It may consist of an influent channel, submerged orifices and baffles in front of orifices.

Provide 0.6 m wide and 0.6-m deep influent channel that runs across the width of the tank. Provide 4 submerged orifices 0.20 m x 0.20 m in the inside wall of influent channel to distribute the flow uniformly into the basin. A baffle 1 m deep is provided at a distance of 1 m away from orifices to reduce turbulence.

Velocity of flow in channel at average design flow

\[
\text{Velocity} = 255.1 / (3600 \times 0.6 \times 0.4)
\]

\[
\text{Velocity} = 0.3 \text{ m/s.}
\]

Head loss through orifices

\[
\left(\frac{255.1}{3600 \times 4 \times 0.6 \times (0.2)^2 \times \sqrt{2 \times 9.81}}\right)^2 = 0.03 m
\]

6. Effluent Structure

The components of effluent structure are effluent weir, effluent launder, outlet box and an outlet pipe.

(a) Compute weir length & number of V-notches

outflow from sedimentation tank = 250 m\(^3\)/hr.

Assuming a weir loading of 200 m\(^3\)/d per m length of weir,
Weir length \[= \frac{(250 \times 24)}{200} = 30 \text{ m}\]

No. of 90° V-notches assuming centre to centre spacing of 200 mm.
\[= \frac{30 \times 1000}{200} = 150\]

(b) Provide 30-m length of effluent launder with V-notches fixed only on one side of the launder. For a 0.30-m wide effluent launder, the critical depth at the end of effluent launder can be computed from
\[y_2 = \left( \frac{(qL)^2}{(b^2) \times g} \right)^{1/3}\]
\[= \left[ \frac{(250/(2 \times 3600))^2}{(0.3)^2 \times 9.81} \right]^{1/3} = 0.11 \text{ m}\]

Depth of water at upper end of the trough, \(y_1\), is
\[= \sqrt{y_2^2 + 2(qLN)^2 / (gb^2 y_2)}{1/2}\]
\[= [0.11^2 + 2 \times (250/(2 \times 3600) \times 1)^2 / (9.81 \times 0.3^2 \times 0.11)]^{1/2} = 0.19 \text{ m}\]

Accounting for head loss due to frictional resistance in the launder channel and the free board, a depth of launder of 0.4 m may be provided.
APPENDIX 7.5
DESIGN FOR RADIAL CIRCULAR SETTLING TANK

I. PROBLEM STATEMENT
Design a secondary circular sedimentation tank to remove alum floc with following data.

1. Average output from settling tank = 250 m³/hr.
2. Amount of water lost in desludging = 2 %
3. Average design flow = 255.1 m³/hr.
4. Minimum size of alum floc to be removed = 0.8 mm.
5. Specific gravity of alum floc = 1.002
6. Expected removal efficiency of alum floc = 80%
7. Assumed performance of settling tank = Very good (n=1/8)
8. Kinematic viscosity of water at 20°C = 1.01 x 10⁻⁴ m²/s

II. DESIGN SOLUTION STEPS
Calculate the settling velocity of particles

\[ V_s = g \left( \frac{5}{3} - 1 \right) \frac{d^2}{(18 \times \nu)} \]
\[ = 9.81 \times (1.002 - 1) \times (0.8 \times 10^{-3})^2 / (18 \times 1.01 \times 10^{-6}) \text{ m/s} = 6.91 \times 10^{-4} \text{ m/s} \]

Reynolds number = \( N_R = \frac{(V_s d)}{\nu} = \frac{(6.91 \times 10^{-4} \times 0.8 \times 10^{-3})}{1.01 \times 10^{-6}} = 0.55 < 1 \)

Hence Stoke's law is applicable.

2. COMPUTE SURFACE OVERFLOW RATE, SOR
For ideal basin and complete removal of wanted particles

\[ V_o = V_s \]
\[ V_o = 6.91 \times 10^{-4} \text{ m/s} = 59.7 \text{ m/d.} \]

However due to short circuiting etc., basin efficiency is reduced and to achieve desired removal efficiency, the surface overflow rate has to be decreased.

\[ Y/Y_o = 1 - [1 + n V_o/(Q/A)]^{1/n} \]

For given values of \( y/y_o = 0.8 \), \( n = 1/8 \)

\[ V_o/(Q/A) = 1.78 \]

\[ Q/A = 59.9/1.7 = 33.49 \text{ m/d} \quad \text{O.K.} \]

This is acceptable as it is within the typical design range of 30-40 m³/m²/d.

3. DETERMINE THE DIMENSION OF TANK
Surface area of tank, \( A = Q/(Q/A) \)
= 255.1 x 24/33.49 = 182.8 m²

Hence diameter of tank = 15.26 m

Assume detention period, t, of 2.5 hours as given in Table

Depth of tank = Q x t/A = 255.1 x 2.5 / 182.8 = 3.49 m say 3.5 m

4. **CHECK FOR WEIR LOADING**

Weir length = periphery of the tank = \( \pi D = \pi \times 15.25 = 47.94 \) m

Weir loading = 255.1 x 24 / 47.94 = 127.7 m³/day < 300 m³/day

Hence O.K.
APPENDIX 7.6
DESIGN FOR TUBE SETTLERS

1. PROBLEM STATEMENT
Design tube settler module of square cross section with following data
1. Average output required from tube settler  = 250 m\(^3\)/hr
2. Loss of water in desludging  = 2% of output required
3. Average design flow  = \((250 \times 100) / (100 - 2)\)  = 255.1 m\(^3\)/hr
4. Cross section of square tubes  = 50 mm \(\times\) 50 mm
5. Length of tubes  = 1 m
6. Angle of inclination of tubes  = 60\(^\circ\)

2. DESIGN STEPS
1. Compute relative length of settler
\[ L_r = 1000 / 50 = 20 \]
Effective relative length of tube, \( L \)
\[ L = L_r - 0.058 N_r \]
\[ = L_r - 0.058 \times V_o d / v \]
\[ = 20 - (0.058 \times V_o \times 0.05) / (1.01 \times 10^{-6} \times 86400) \]
\[ = 20 - 0.033 V_o \]
where \( V_o \) is flow through velocity for tube settler in m/d

3. DETERMINE FLOW VELOCITY THROUGH TUBES
\[ S_c = V_o / V_o \times (\sin \theta + L \cos \theta) \]
\[ 11/8 = (120 / V_o) \times (\sin 60 + (20 - 0.03 V_o) \cos 60) \]
\[ V_o = 388.65 \text{ m/d} \]

4. COMPUTE TOTAL TUBE ENTRANCE AREA AND NO. OF TUBES
Tube entrance area  = \( Q / V_o = 255.1 \times 24 / 388.65 = 15.75 \text{ m}^2 \)
No. of tubes required  = \( 15.75 / (0.05 \times 0.05) = 6300 \)
Provide 6400 square tubes of 0.05 m \(\times\) 0.05 with 80 tubes along the length of the square module and 80 tubes along the width of the module.
Length of the tube module  = No. of tubes \( \times \) (inside dimension of square tubes + 2 \(\times\) thickness of tubes)
\[ = 80 \times (0.050 + 2 \times 0.005) \text{ m} \]
\begin{align*}
&= 4.24 \text{ m} \\
\text{Height of tube module for 1 m length of square tubes inclined at an angle of 60°} \\
&= 1 \sin 60° = 0.866 \text{ m} \quad \text{say 0.87 m}
\end{align*}

Therefore overall dimension of tube module \( = 4.24 \text{ m} \times 4.24 \text{ m} \times 0.87 \text{ m} \)

Size of individual square tubes \( = 0.05 \text{ m} \times 0.05 \text{ m} \)

Thickness of individual square tubes \( = 1.5 \text{ mm} \)
APPENDIX 7.7
DESIGN FOR RAPID GRAVITY FILTER

1. PROBLEM STATEMENT

Design rapid gravity filter for producing a net filtered water flow of 250 m³/hr. The relevant data is

(i) Quantity of backwash water used = 3% of filter output
(ii) Time lost during back washing = 30 minutes
(iii) Design rate of filtration = 5 m³/m²/hr
(iv) Length to width ratio = 1.25 – 1.33: 1
(v) Under drainage system = Central manifold with laterals
(vi) Size of perforations = 9 mm

2. SOLUTION

(a) Filter Dimensions

Required flow of filtered water = 250 m³/hr
Design flow for filter after accounting for backwash water and time lost in backwashing = 250 x (1+0.03) x 24 / 23.5 m³/hr

Plan area of filter required = 263/5 = 52.6 m²

Provide two filter units, two being minimum no. to be provided
Length x width = 26.3
Assume length to width ratio as 1.3:1
Width of the filter = (26.3/1.3)^0.5 = 4.50 m
Length of the filter = 5.85 m

Provide two filter units, each with a dimension of 5.85 x 4.50 m

(b) Estimation Of Sand Depth

Assume a depth of sand as 60 cm and effective size of sand as 0.5 m.

The depth can be checked against break through of floc through sand bed by calculating minimum depth required by Hudson formula

\[ Qd²h/1 = B \times 29323 \]

Where Q is the rate of filtration in gpm/sft, d is the sand size in cm, h is the terminal loss of head in ft., I is the depth of bed in inches and b is a breakthrough index whose value ranges between 4 x 10⁻⁴ to 6 x 10⁻³ depending on response to coagulation and degree of pretreatment of filter influent,
In metric units  \( Qd^3h/l = B \times 29323 \)

Where \( Q \) is in \( m^3/m^2/h \), \( d \) in mm and \( h & l \) are in m.

Assume \( B = 4 \times 10^4 \) for poor response to filtration and average degree of pre-treatment, terminal head loss of 2.5 m, rate of filtration = 5 x 2 = 10 \( m^3/m^2/hr \). (Assuming 100 % overloading of filter under emergencies), and assuming \( d = 0.6 \) mm as mean diameter,

\[
10 \times (0.6)^3 \times 2.5 \div 1 = 4 \times 10^4 \times 29323
\]

Minimum depth of sand required to avoid breakthrough = 46 cm. Hence the assume depth of 60 cm to be adequate to avoid break through of floc.

(c) Estimation Of Gravel And Size Gradation

Assume a size gradation of 2mm at top to 50mm at the bottom. The requisite depth \( l \) in inches of a component gravel layer of size \( d \) in inches can be computed from empirical formula

\[
l = k(\log d + 1.40)
\]

Where \( k \) varies from 10 to 14. The equivalent formula in metric units where \( l \) is in cm and \( d \) is in mm is

\[
l = 2.54(\log d)
\]

For \( k=12 \), the depth of various layers of gravel are

<table>
<thead>
<tr>
<th>Size, mm</th>
<th>2</th>
<th>5</th>
<th>10</th>
<th>20</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth, cm</td>
<td>9.2</td>
<td>21.3</td>
<td>30.5</td>
<td>40</td>
<td>49</td>
</tr>
<tr>
<td>Increment, cm</td>
<td>9.2</td>
<td>12.1</td>
<td>9.2</td>
<td>9.5</td>
<td>9</td>
</tr>
</tbody>
</table>

Provide a gravel depth of 50 cm

(d) Design Of Under Drainage System

Plan area of each filter  
\[
= 5.85 \times 4.50 = 26.33 m^2
\]

Total area of perforations  
\[
= 3 \times 10^3 \times \text{Area of filter} \\
= 0.0789 \text{ m}^2 \\
= 790 \text{ cm}^2 
\]

Total number of perforation of 9 mm dia  
\[
= 790/((\pi/4)(0.90)^2) = 1241.8 \\
\text{Say 1242}
\]

Total cross sectional area of laterals  
\[
= 3 \times \text{Area of perforations} \\
= 3 \times 790 = 2370 \text{ cm}^2 
\]

Area of central manifold  
\[
= 2 \times \text{Area of laterals} \\
= 2 \times 2370 \text{ cm}^2 
\]
Diameter of central manifold

\[
\sqrt{\frac{4740 \times 4}{\pi}} = 77.7 \text{ cm}
\]

Provide a commercially available diameter of 800 mm

Assuming a spacing of 15 cm for laterals,

The number of laterals \( = (2 \times 5.85 \times 100)/15 = 78 \)

Cross sectional area of each lateral \( = 2370/78 \text{ cm}^2 = 30.39 \text{ cm}^2 \)

Diameter of lateral \( = \sqrt{\frac{(30.39 \times 4)}{\pi}} = 6.22 \text{ cm} \)

Provide laterals of diameter of 80 mm

Number of perforation per lateral \( = 1242/78 \text{ say 16} \)

Length of lateral \( = 1/2 (\text{width of filter} - \text{dia of manifold}) \)

\( = 1/2 (4.5 - 0.8) = 1.85 \text{ m} \)

Spacing of perforations \( = 1.85 \times 100/16 = 11.56 \text{ cm} \)

Provide 16 perforations of 9 mm dia at centre to centre spacing of 115 mm.

(E) **COMPUTE DIMENSION OF WASH WATER TROUGH**

Assume a wash water rate of 36 m\(^3\)/m\(^3\)/hr

Washwater discharge for 1 filter \( = 36 \times 26.33 \text{ m}^3/\text{hr} \)

\( = 947.88 \text{ m}^3/\text{hr} \)

\( = 0.2633 \text{ m}^3/\text{sec} \)

Assuming a spacing of 1.6 m for wash water trough which will run parallel to the longer dimension of the filter unit.

No. of troughs \( = 4.50 / 1.6 = 3 \)

Discharge per unit trough \( = 0.2633 / 3 = 0.0878 \text{ m}^3/\text{sec} \)

For a width of 0.4m, the water depth at upper end is given by

\( Q = 1.376 \text{ bh}^{3/2} \)
0.0878 = 1.376 \times 0.4 \times h^{3/2}, h = 0.294 \text{ say } 0.3 \text{ m}

Assume a free board of 0.1 m, provide a depth of 0.4 m

Provide three trough of 0.4 m wide x 0.4 m deep in each filter

(f) Computation Of Total Depth Of Filter Box

Depth of filter box = sum of depths for (i) underdrains

(ii) gravel (iii) sand (iv) water depth (v) free board

= 0.8 + 0.45 + 0.6 + 1.2 + 0.3 = 3.35 m

(g) Determine Initial Head Loss

The sieve analysis of filter sand is as follows:

<table>
<thead>
<tr>
<th>Sand size, mm</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>1.0</th>
<th>1.45</th>
</tr>
</thead>
<tbody>
<tr>
<td>(% of sand smaller</td>
<td>0.0</td>
<td>2.0</td>
<td>10.0</td>
<td>27.0</td>
<td>50.0</td>
<td>70.0</td>
<td>90.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

than stated size)

Porosity of sand bed = 0.4

Sphericity of sand = 1.0

Head loss for a clean filter can be determined using Kozeny’s equation for stratified beds

\[
\frac{h}{l} = \frac{k \nu}{g} \left(1 - f\right)^2 \left(\frac{6}{\psi}\right)^2 \sum_{i=1}^{n} \frac{P_i}{d_i^2}
\]

Where \( h \) is the head loss, \( l \) the depth of sand bed, \( k \) Carman-Kozeny constant having a value of 5, \( \nu \) velocity of filtration, \( \nu \) kinematic viscosity, \( f \) porosity of clean bed, \( \psi \) grain sphericity, \( P_i \) fraction of sand and \( d_i \) geometric mean diameter of sand.

<table>
<thead>
<tr>
<th>Size of sand mm</th>
<th>% of sand larger than stated size</th>
<th>Sand fraction within adjacent sieve size ( p_i ) x 100</th>
<th>( d_i ) cm x 100</th>
<th>( p_i / d_i^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.0000</td>
<td>2</td>
<td>3.5</td>
<td>16</td>
</tr>
<tr>
<td>0.4</td>
<td>2.0</td>
<td>8</td>
<td>4.5</td>
<td>40</td>
</tr>
<tr>
<td>0.5</td>
<td>10.0</td>
<td>17</td>
<td>5.5</td>
<td>56</td>
</tr>
<tr>
<td>-----</td>
<td>------</td>
<td>----</td>
<td>-----</td>
<td>----</td>
</tr>
<tr>
<td>0.6</td>
<td>27.0</td>
<td>23</td>
<td>6.5</td>
<td>52</td>
</tr>
<tr>
<td>0.7</td>
<td>50.0</td>
<td>20</td>
<td>7.5</td>
<td>36</td>
</tr>
<tr>
<td>0.8</td>
<td>70.0</td>
<td>20</td>
<td>8.9</td>
<td>25</td>
</tr>
<tr>
<td>1.0</td>
<td>90.0</td>
<td>10</td>
<td>11.8</td>
<td>8</td>
</tr>
<tr>
<td>1.4</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td></td>
<td>233</td>
<td></td>
</tr>
</tbody>
</table>

\[
\frac{h}{l} = \frac{5 \times 500}{981 \times 3600} \times 1.01 \times 10^{-2} \times \frac{(1 - 0.40)^2}{(0.4)^3} \left[ \frac{6}{1.0} \right]^2 \times 233 = 0 / 0.337
\]

Head loss = 0.337 x 0.6 = 0.20 m

Head loss for clean filter bed for given sand is 0.20 m.
APPENDIX 7.8
PREPARATION OF FILTER SAND FROM STOCK SAND

1. PROBLEM STATEMENT

Prepare a filter sand of effective size 0.5 mm and uniformity coefficient 1.5 from the stock sand, the sieve analysis for stock sand being given as follows:

<table>
<thead>
<tr>
<th align="left">Sand size, mm</th>
<th>0.21</th>
<th>0.30</th>
<th>0.42</th>
<th>0.84</th>
<th>1.12</th>
<th>1.68</th>
<th>2.38</th>
</tr>
</thead>
<tbody>
<tr>
<td align="left">Cumulative weight, %</td>
<td>3.5</td>
<td>11</td>
<td>22</td>
<td>42</td>
<td>64</td>
<td>83</td>
<td>90</td>
</tr>
</tbody>
</table>

2. SOLUTION

The given size distribution of stock sand is plotted on log-normal probability paper and from the plot determine the percentages of sand having size less than the effective size of 0.5 mm ($P_4$) and having size less than the 60 percentile size ($P_2$)

\[ P_1 = 24\% \]
\[ P_2 = 43\% \]

(i) Hence percentage of usable sand

\[ = 2 \times (P_2 - P_1) \]
\[ = 2 \times (43 - 24) = 38\% \]

(ii) Percentage of stock sand below

Which stock sand is too fine, $P_4 = 1.2 \times P_1 - 0.2 \times P_2$

\[ P_4 = 1.2 \times 24 - 0.2 \times 43 \]
\[ P_4 = 20.2\% \]

Determine the size of this sand, $d_4$ from graph

For $P_4 = 20.2\%$, $d_4 = 0.41$ mm

(iii) Percentage of stock sand above

which stock sand is too coarse

\[ P_4 = 1.8 \times P_2 - 0.8 \times P_1 \]

\[ P_4 = 1.8 \times 43 - 0.8 \times 24 \]
\[ P_4 = 58.2\% \]

Determine the size of this sand, $d_4$ from the graph,

For $P_4 = 58.2\%$, $d_4 = 1.0$ mm

It follows that all stock sand finer than 0.41 mm size and coarser than 1.0 size should be removed to obtain the filter sand of effective size 0.5 mm and uniformity coefficient of 1.5.
APPENDIX 7.9

INFORMATION TO BE INCLUDED IN THE TENDER SPECIFICATIONS
FOR WATER TREATMENT PLANT

GENERAL

The principal requirement must be a spacious and convenient layout. The structures should represent a pleasing appearance with aesthetic features forming a balance between function and form. The interiors of the structures shall be eye appealing and in keeping with the objectives of the plant viz., production of pure and wholesome water.

While the mode of design and construction could be a matter of individual choice, it should be ensured that all materials, design, construction and fabrication details for different units including doors and windows conform to the IS Specifications and codes of practice wherever available and in their absence, to the established standards.

Adequate provision shall be made in the Civil Engineering works for laboratory, office buildings, administration area, sanitary facilities and water supply etc. The area requirement of these ancillary requirements shall be stipulated. Roadways with adequate lighting shall be provided. Adequate ladders or steps and handrails where required shall be provided for easy access to each unit of the treatment plant and wherever necessary, walkways should be provided. Interconnecting facilities shall be provided to enable the operator to move freely for maintenance and operation of the plant.

All water retaining structures shall be designed in conformity with IS 3370 while the other structures shall be designed according to IS 456.

The tender specifications should include inter alia, process requirements and specifications for equipment.

A. Process Requirements

1. The following data shall be furnished to the tenderers:

(a) Raw water analysis comprising of monthly average figures preferably for a full year period covering various seasonal variations in respect of, at least the following. If the full year data is not available, the worst seasonal values may be given:

(i) pH
(ii) Turbidity
(iii) Total Alkalinity
(iv) Total hardness
(v) Chlorides
(vi) Coliform organism (MPN)

(b) Any other additional data, if the water is known to contain constituents or contaminants which are required to be removed:
(i) Phenols
(ii) Tastes and odours
(iii) Colour
(iv) Carbon dioxide
(v) Algal content.
(vi) Iron
(vii) Manganese
(viii) Hardness (Carbonate and noncarbonate along with magnesium content of water)
(ix) Fluoride content, and
(x) Chlorine demand.

and any other pollutants arising from industrial effluents and agricultural runoff.

(c) Hydraulic data such as the relevant raw water inlet and filtrate outlet levels.

2. The following requirements shall be furnished:

(a) The flow requirements of the plant in terms of the nett output expected of the plant for a given period of time, say 23.5 hours a day (allowing for washing of the filters, etc. and also overload capacity.)

(b) The quality of the treated water in terms of pH, turbidity, coliform organisms (MPN) and E. coli; and where needed Iron, Manganese, Hardness (carbonate and noncarbonate along with Magnesium content of water), fluoride content and colour.

(c) Design parameters for various treatment units such as chemical dosing, rapid mixing, slow mixing, sedimentation, filtration and chlorination as well as special processes like aeration, microstraining, iron and manganese removal, fluoride removal, taste and odour control as per specific local requirements and in accordance with the details furnished in the Manual.

(d) A suggested layout of a Water Treatment Plant including following details, to the extent possible:

(i) Unit sizes and location of plant structures;
(ii) Schematic flow diagram showing flow through various units;
(iii) Piping arrangement including bypasses showing the material and size of pipes as well as direction of flow;
(iv) Hydraulic profile of the units showing the flow of water.
(v) Contour map of the area including provision for future expansion.
(vi) Approach roads and water supply facilities for construction purposes.
(vii) Other information about site such as proneness to flooding and earthquakes, groundwater table fluctuations, type and nature of soils.
met up to maximum anticipated depths, soil characteristics like bearing capacity and corrosivity, intensity and duration of rainfall and total annual rainfall, locations of areas for disposal of excavated spoils and of borrow pits if required for filling purposes.

e) The contract should establish where guarantees apply and clearly define their requirements performance guarantees must be demonstrated by a test run of specified length or over an agreed period of operation.

B. Mechanical Equipment

1. The following data may be given while inviting tenders for pumping plant:
   
   (a) Number of units required to work in parallel.
   
   (b) Nature of liquid to be pumped:
      
      (i) Fresh or salt water
      
      (ii) Temperature of liquid
      
      (iii) Specific gravity
      
      (iv) Amount of suspended matter present
   
   (c) Required capacity as well as minimum and maximum amount of liquid the pump must deliver.
   
   (d) Suction conditions:
      
      (i) Suction lift or suction head.
      
      (ii) Constant or variable suction condition.
   
   (e) Discharge conditions.
      
      (i) Maximum/Minimum discharge pressures against which pump has to deliver liquid.
      
      (ii) Static head description: constant or variable.
      
      (iii) Friction head description and how estimated.
   
   (f) Type of service: continuous or intermittent.
   
   (g) Pump installation: horizontal or vertical position. (If vertical type of pit, wet and dry).
   
   (h) Power available to drive the pump.
   
   (i) Space, weight or transportation limitations.
   
   (j) Location of installation.
   
   (k) Special requirements with respect to pump design: construction or performance.

2. The following requirements may be indicated.
(a) The pump equipment as well as the component shall conform to the relevant I.S. standards and in their absence, to any other accepted international or national standard.

(b) Any special duty conditions such as temperature, humidity, corrosive atmosphere should be specified.

(c) Submerged structure parts except hot rolled sections shall not be less than 6 mm thick under normal atmosphere and 8 mm in aggressive atmospheres.

(d) Prime movers and allied components such as electrical motor, starter switches reduction gear, drive mechanism, bearings, plummerblocks, etc. shall be of approved make.

(e) All rotating machinery particularly gears shall be designed with adequate safety margins and service factors.

(f) An itemwise price list of spare parts shall be furnished by the tenderer. At least two years requirement of fast moving spares should be supplied along with the equipment.

(g) The supplier of special equipments like softeners, recording gauges, rate controllers, chlorinators, proportioning chemical feeders, meters, etc. shall furnish the services of a competent representative for a specified number of days during a specified period to instruct the plant operating personnel in the maintenance and care of the equipment and to conduct tests and make recommendations for producing most efficient results.

(h) Equipment selection with respect to specification, spare units, spare parts and servicing can affect maintenance, operating and investment costs. It is the purchaser's responsibility to incorporate into the contract all requirements and limitation which affect cost. Equipment performance is usually guaranteed by the manufacturer.

The contractor shall furnish bonds converting items of work like mechanical equipments, piping, etc. for specified period as a guarantee of satisfactory operation and correction and correction of any defect in the work, material or equipments furnished by them.

On special equipment extended guarantees, maintenance over a period of time and supervision of a complete installation may be provided by the manufacturer. On most large equipments, the manufacturer provides field service with respect to installation.

(i) All water submerged parts, rotating mechanical parts, and steel pipes under water shall be adequately protected after surface preparation. Oil, grease, dirt, soil and all surface contaminants from structural and fabricated steel parts are removed by cleaning with solvent vapour, alkali emulsion, or steam. Loose rust or paint, weld spatter, etc. are removed by hand chipping, scraping, sanding, wire brushing and grinding. The bare finished shafting, finished flanges and other mechanical surfaces are protected by grease line or rust protection measures. Structural mechanism support and super structure, walkway, hand rails, fabricated shafts, etc., shall be protected with at least one coat of primer and two coats of paint. IS 800 - 1962 gives the code of practise for use of structural steel in general building construction.
APPENDIX 7.10

COMMON CHEMICALS USED IN WATER TREATMENT

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Chemical Name</th>
<th>Formula</th>
<th>Use</th>
<th>Available Forms</th>
<th>Commercial Strength</th>
<th>Appearance And Properties</th>
<th>Usual Solution or Suspension Strength</th>
<th>Method of Feeding</th>
<th>Materials Used For Handling Solution</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Activated Carbon</td>
<td>-</td>
<td>C</td>
<td>Taste and odour control, dechlorination</td>
<td>Granular</td>
<td>Not less than 80% C</td>
<td>Black granules 1-3 mm</td>
<td>Water passed through granular beds</td>
<td>Dry</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Activated carbon</td>
<td>-</td>
<td>C</td>
<td>Do</td>
<td>Black powder</td>
<td>Do</td>
<td>200 to 400 mg black powder insoluble</td>
<td>-</td>
<td>Dry or in slurry form careful mixing required to maintain proper slurry</td>
<td>Iron or steel tank</td>
</tr>
<tr>
<td>3</td>
<td>Activated silica</td>
<td>SiO₂</td>
<td>-</td>
<td>Coagulant aid</td>
<td>Produced at site as needed from sodium silicate and activating agents</td>
<td>-</td>
<td>Clear, often opalescent</td>
<td>0.6</td>
<td>Wet batch made up by pH Adjustment and aged</td>
<td>Mild steel or stainless steel or rubber containers</td>
</tr>
<tr>
<td>Sl. No</td>
<td>Chemical Name</td>
<td>Formula</td>
<td>Use</td>
<td>Available Forms</td>
<td>Commercial Strength</td>
<td>Appearance and Properties</td>
<td>Usual Solution or Suspension Strength</td>
<td>Method of Feeding</td>
<td>Materials Used For Handling Solution</td>
<td>Remarks</td>
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<tr>
<td>4.</td>
<td>Aluminium sulphate</td>
<td>Al₂(SO₄)₃ 4H₂O</td>
<td>Coagulant</td>
<td>Blocks; lump; powder</td>
<td>At least 16% Al₂O₃</td>
<td>Light tan to gray; crystalline acidic corrosive, slightly hygroscopic Brown to dark brown; crystalline, acidic, corrosive, hygroscopic</td>
<td>8-10%</td>
<td>Wet or dry</td>
<td>Acid proof brick tanks bitumen coated concrete or rubber lined tanks</td>
<td>Do</td>
</tr>
<tr>
<td>5.</td>
<td>Aluminium sulphate (ferric)</td>
<td>Al₂(SO₄)₃ 4H₂O (approx.)</td>
<td>Do</td>
<td>Do</td>
<td>15% (approx.) Al₂O₃</td>
<td>Brown solution, acidic, corrosive</td>
<td>8-10%</td>
<td>Do</td>
<td>High concentration of iron</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Alum liquid</td>
<td>Al₂(SO₄)₃</td>
<td>Coagulant</td>
<td>Solution sp. g. 1.1</td>
<td>8% Al₂O₃</td>
<td></td>
<td>Direct or in 1% solution</td>
<td>Wet, orifice box rotameter and proportionating pumps</td>
<td>Acid proof brick, tanks bitumen coated concrete or rubber lined tanks</td>
<td>Costs less than dry alum if close enough to source of manufacture</td>
</tr>
<tr>
<td>7.</td>
<td>Ammonium sulphate</td>
<td>(NH₄)₂ SO₄</td>
<td>Chloramine treatment in disinfection</td>
<td>Crystal</td>
<td>20-25% NH₃</td>
<td>White sugar sized crystals Colourless gas; pungent irritating offensive odour</td>
<td>0.1 to 0.5%</td>
<td>Wet</td>
<td>Stainless or plastic containers, Iron, steel or glass</td>
<td>Wet ammoniator</td>
</tr>
<tr>
<td>8.</td>
<td>Anhydrous ammonia</td>
<td>NH₃</td>
<td>Do</td>
<td>Liquefied gas</td>
<td>98-99% NH₃</td>
<td></td>
<td>-</td>
<td>Wet</td>
<td>Wet ammoniator</td>
<td>Dangerous chemical</td>
</tr>
<tr>
<td>Sl. No</td>
<td>Chemical Name</td>
<td>Common Name</td>
<td>Formula</td>
<td>Use</td>
<td>Available Forms</td>
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<tr>
<td>9.</td>
<td>Bentonite</td>
<td>Collodial clay</td>
<td>Al₂O₃(Fe₂O₃,MgO)</td>
<td>Coagulant aid, floc weighting agent</td>
<td>Powder pellets</td>
<td>80-90 % Ca(OH)₂</td>
<td>White powder, caustic</td>
<td>1.5%</td>
<td>Dry or wet. Can be fed in suspension</td>
<td>Iron, steel or concrete tanks</td>
</tr>
<tr>
<td>10.</td>
<td>Calcium hydroxide</td>
<td>Hydrated lime slaked</td>
<td>Ca(OH)₂</td>
<td>Disinfectant, taste or odour control</td>
<td>Powder</td>
<td>70% available chlorine</td>
<td>White</td>
<td>2 to 4%</td>
<td>Stone ware, plastic, rubber tank</td>
<td>Dangerous chemical</td>
</tr>
<tr>
<td>11.</td>
<td>Calcium hypochlorite</td>
<td>HTH, per chloron</td>
<td>Ca(ClO)₂·H₂O</td>
<td>Disinfectant, taste or odour control</td>
<td>Granular powder</td>
<td>40-90 % CaO</td>
<td>White or light gray, caustic</td>
<td>1.5%</td>
<td>Iron, steel or concrete tanks</td>
<td>Dangerous chemical</td>
</tr>
<tr>
<td>12.</td>
<td>Calcium oxide</td>
<td>Quick lime, burnt, unslaked lime</td>
<td>CaO</td>
<td>Disinfectant, taste or odour control</td>
<td>Pebble crushed lumps to powder</td>
<td>99-99.8 % Cl₂</td>
<td>Green yellowish gas, pungent, corrosive, heavier than air, health hazard</td>
<td>-</td>
<td>Dry or wet can be fed in suspension. Dry feeders generally discharge to slake before application</td>
<td>Iron, steel or concrete tanks</td>
</tr>
<tr>
<td>Sl. No</td>
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<tr>
<td>14.</td>
<td>Chlorinated ferrous sulphate</td>
<td>Chlorinated copperas</td>
<td>Fe₂(SO₄)₃</td>
<td>Coagulant</td>
<td>Yellow solution</td>
<td>Produced at site by reaction of chlorine and ferrous sulphate</td>
<td>-</td>
<td>3-5 %</td>
<td>Wet</td>
<td>Rubber lined or stainless steel containers; plastic containers</td>
</tr>
<tr>
<td>15.</td>
<td>Chlorinated lime</td>
<td>Bleaching powder, chloride of lime</td>
<td>CaO. 2CaOCl₂ H₂O</td>
<td>Disinfection</td>
<td>Powder</td>
<td>25-33 % available chlorine</td>
<td>White, hygroscopic, unstable pungent powder</td>
<td>1-2 %</td>
<td>wet</td>
<td>Plastic, stoneware or rubber tanks</td>
</tr>
<tr>
<td>16.</td>
<td>Chlorine dioxide</td>
<td>-</td>
<td>ClO₂</td>
<td>Taste and odour control disinfection</td>
<td>Gas</td>
<td>26.3 % available chlorine</td>
<td>Generated at site</td>
<td>0.1 %</td>
<td>wet</td>
<td>Plastic, soft rubber</td>
</tr>
<tr>
<td>17.</td>
<td>Copper sulphate</td>
<td>Blue vitriol</td>
<td>CuSO₄ 5H₂O</td>
<td>Algicide</td>
<td>Crystal lumps, powder</td>
<td>90-95 %</td>
<td>Clear blue crystals</td>
<td>1-2 %</td>
<td>Dry put in bags dragged behind boat, dusted on surface with special equipments.</td>
<td>Stainless steel, plastics</td>
</tr>
</tbody>
</table>