CHAPTER 14

CALCULATION OF SUPPLY AND DRAINAGE WATER SYSTEM DESIGN

14.1 OVERVIEW

Water supply system of the project consists of 2 parts:

Water supply system, domestic waste water.

- Water supply:
  
a) Water source: from the city's water resources.

b) Mode of water supply: combined with an underground water tank combined with overhead storage and pumping.

Water from the city water supply network passes through the clock and flows naturally into the underground water tank outside the hospital. Then the water from the tank will be pumped into the roof water tank through the pump and fed into the equipment used.

c) Ground and above ground reservoirs: underground water tanks are located outside the hospital. Use the city's tap water, existing pipeline. The pump transports water to an elevated water tank located on the roof.

- Sewage system:
  
a) Classification of wastewater: indoor wastewater includes solid wastewater, domestic wastewater.

b) Water discharge method: To use three water drainage systems. Solid waste (from toilets, urinals) leads into underground tanks. After treatment, the main drainage lines of the area along with the domestic sewage in combination with ventilation ducts.

14.2 WATER SUPPLY SYSTEM FOR THE BUILDING

14.2.1 CALCULATION FOR WATER SUPPLY SYSTEMS

a. Water consumption of equipment:

The water usage of the equipment is determined according to the formula (see TL2.6 TL (Design of water supply and drainage system)).(l / h)

In which: q - average flow of water used in a discharge of the equipment [see Table 2.2 TL (Design of water supply and drainage system)].
n - number of times used in 1 h [see Table 2.2 TL (Design of water supply and drainage system)].

N - number of devices.

**Table 14.2.1** Flow of water used for equipment.

<table>
<thead>
<tr>
<th>EQUIPMENT</th>
<th>WATER CAPACITY AT ONE TIME (l)</th>
<th>NUMBER OF TIMES IN ONE HOUR</th>
<th>NUMBER OF EQUIPMENT</th>
<th>WATER USAGE LEVEL Qhm (l/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet (Use tank)</td>
<td>8</td>
<td>6</td>
<td>116</td>
<td>5568</td>
</tr>
<tr>
<td>Urinal (Use valve)</td>
<td>4</td>
<td>12</td>
<td>45</td>
<td>2160</td>
</tr>
<tr>
<td>Hand sink</td>
<td>4</td>
<td>15</td>
<td>133</td>
<td>7980</td>
</tr>
<tr>
<td>Bathroom</td>
<td>10</td>
<td>4</td>
<td>70</td>
<td>2800</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>Qhm=18508 (l/h)</strong></td>
</tr>
</tbody>
</table>

**b. Total amount of water used per hour Qh**

According to CT 2.8 TL (Design of water supply and drainage system)].

We have: Qh = Qhm / k1

Where: Qhd (l/h): water consumption of equipment for 1 hour

k1: maximum use factor (1.5 to 2), usually 2

So: Qh = 18508/2 = 9254 (l/h)

**c. Choose a water supply method.**

Average water usage is 9254 l/h and 37 m above ground level. Select water supply plan with underground storage tank, pump station and overhead storage tank. This method only applies when the water pressure in the city pipe is low.
**Figure 4.2.1.2** Flow chart of water supply method

In which:

1 - water supply pipe from city water network

2 - the lock

3 - water meter

4 - underground storage tank

5 - Valve lock

6 - pumps

7 - soft coupling

8 - pressure gauge

9 - one-way valves

10 - high water tank

11 - float valves

12 - home water supply

13 - equipment used
d. Underground water tank design

• Water tank:

The water tank is responsible for regulating water intake and water storage during use. Water tanks can be built of reinforced concrete, stainless steel, brick ... Water tanks can be placed floating or sink depending on the needs and geographical conditions.

• Underground water tank design:

According to CT 2.10 TL (Design of water supply and drainage system), we have:

\[ Q_{tw} = \frac{(Q_{hm}.t_1)}{1000} \]

Inside:

- \( Q_{tw} \) - volume of underground water tank, (m³)
- \( Q_{hm} \) - total water flow of all equipment, (l / h)
- maximum water consumption time 1h ÷ 2h, select \( t_1 = 2h \)

\[ Q_{tw} = \frac{(9254.2)}{1000} = 18.508 \text{ m}^3 \]

Because the tank capacity must have a breathing space, the actual volume is determined

\[ Q_{tt} = \frac{Q_{tw}}{70%} = 18.508 / 70% = 26.44 \text{ m}^3 \]

With volume \( Q_{tt} = 26.44 \text{ m}^3 \)

We choose the size of the tank as follows:

- Width \( a = 4 \text{ m} \)
- Length \( b = 4 \text{ m} \)
- Height \( h = 2 \text{ m} \)

e. Design of high water tanks.

According to CT 2.11 TL (Design of water supply and drainage system).

We have: \( Q_{twh} = \frac{(Q_{hm}.t_2)}{1000} \)

Inside:

- \( Q_{twh} \) - high storage tank capacity, m³
- \( Q_{hm} \) - is the total water flow of all equipment, (l / h)
- \( t_2 = \) maximum time of use, select \( t_2 = 0.5h \)

\[ Q_{twh} = \frac{(18508.0.5)}{1000} = 9.254 \text{ m}^3 \]

Because the tank capacity must have a breathing space, the actual volume is determined.
Qtth = Qtwh / 70% 13.22 m³

With volume Qtth = 13.22 m³

We choose the size of the tank as follows:

Width a = 2.5 m

Length b = 3 m

Height h = 2 m

**f. Selection of water pump:**

Water pumps are used to transport water from the tank to the water tank. In today’s technology people use centrifugal pumps powered by electric motors. In addition to centrifugal pumps, other pumps can be used such as piston pumps, jet pumps, pneumatic pumps.

Generic water pumps are designed to include two automatic and fully automatic pumps (one pump, one backup pump). In the case of small civil works we can design a pump (do not use spare pump).

The pump is installed as a pump station. The pump station is a machine room with all the equipment used to operate and repair the incident, and also a place for work for management workers.

- Calculate the flow of the pump.

The water supply is calculated according to CT 2.13 TL (Design of water supply and drainage system):

\[ Q_{pw} = k_1 \cdot Q_{hm} / 1000, \text{ (m}^3/\text{h)} \]

In which:

- \( k_1 \) - coefficient of water use for the largest time, \( k_1 = 1 \)
- \( Q_{hm} \) - total water flow of equipment.

\[ Q_{pw} = Q_{hm} / 1000 = 18508 / 1000 = 18.508 \text{ (m}^3/\text{h)} \]

- Calculate the water supply pump head:

Water supply pump is calculated according to CT 2.17TL (Design of water supply and drainage system):

\[ H_{pw} = K_2 \cdot (H_1 + H_2 + H_3 + H_4), \text{ m} \]

Inside:

- \( K_2 \) - reserve factor (\( K_2 = 1.1 ÷ 1.2 \)), select \( K_2 = 1.1 \)
- \( H_1 \): pipe friction loss. For tube material VP average of 1m tube is damaged \( \approx 300\text{Pa} \)
- \( H_2 \): the local loss for \( H_2 = 0.5 \cdot H_1 \)
H3: Actual height, measured from the suction nozzle of the pump to the location of the highest tap,

\[ H_3 = 44 \, (\text{mH}_2\text{O}). \]

H4: Minimum pressure required, select \( H_4 = 7 \, (\text{mH}_2\text{O}) \).

\[ H = 1.1 \times (300.10 - 4.180 + 0.5 \times 300.10 - 4.80 + 44 + 7) = 59.1 \, (\text{mH}_2\text{O}) \]

With flow \( Q_{pw} = 18.508 \, (\text{m}^3 / \text{h}) \), the pressure column \( H = 59.1 \, (\text{mH}_2\text{O}) \)

We choose the pumps ETANORM-R 40-315, \( n = 1750 \, \text{rpm} \) will choose 2 machines to be able to run the session.

14.2.2 DESIGN OF WATER PUMP SYSTEM

Step 1: Select the preliminary velocity: \( \Box = 0.5 \sim 2 \, (\text{m} / \text{s}) \).

Step 2: Determine the diameter of the pipe section:

\[ d_{\text{tr}} = \sqrt{\frac{(4 \times Q)}{(\pi \times \Box \times \rho)}} \]

Inside:

- \( G \): is the water flow in the pipe, l / s.
- \( \Box \): velocity of water moving in the tube, m / s.
- \( \rho \): is the specific mass of water at medium temperature.

Step 3: Select the nominal diameter from the filter.

Step 4: Recalculate the velocity in the pipe according to the nominal diameter.

\[ \omega = \frac{(4 \times Q)}{(\rho \times \pi \times d_N^2)} \]

Determine the diameter of the water supply pipe from the city main pipeline to the underground reservoir:
- We have average level of water:
  \[ Q = \frac{Q_h}{3600} = \frac{9254}{3600} = 2.54 \text{ (l / s)} \]

- Choose the preliminary velocity: \[ \omega = 1.5 \text{ (m / s)} \]

Determination of diameter of pipe section:
\[ d_{\text{tr}} = \sqrt{\frac{4 \times Q}{\pi \times \omega \times \rho}} = \sqrt{\frac{(4 \times 2.54)}{(3.14 \times 1.5 \times 1000)}} = 0.045 \text{ m} \]

Inside:
- \( G \): is the water flow in the pipe, l / s.
- \( \omega \): velocity of water moving in the tube, m / s.
- \( \rho \): is the specific mass of water at medium temperature.

Select the nominal diameter \( d_N = 50 \text{ mm} \)

Recalculate the velocity in the tube to the nominal diameter.
\[ \omega = \frac{4 \times Q}{\rho \times \pi \times d_N^2} = \frac{(4 \times 2.54)}{(1000 \times 3.14 \times 50^2)} = 1.3 \text{ m / s} \]

In the range (1 -> 2 m / s) -> reasonable

Determining the pipeline from pump station to overhead tank:

- We have average level of water:
  \[ Q = Q_{pw} = 9254 \text{ (m3 / h)} = 2.57 \text{ (l / s)} \]

- Choose the preliminary velocity: \[ \omega = 1.5 \text{ (m / s)} \]

Determination of diameter of pipe section:
\[ d_{\text{tr}} = \sqrt{\frac{4 \times Q}{\pi \times \omega \times \rho}} = \sqrt{\frac{(4 \times 2.54)}{(3.14 \times 1.5 \times 1000)}} = 0.046 \text{ m} \]

Inside:
- \( G \): is the water flow in the pipe, l / s.
- \( \omega \): velocity of water moving in the tube, m / s.
- \( \rho \): is the specific mass of water at medium temperature.

Select the nominal diameter \( d_N = 50 \text{ mm} \)

Recalculate the velocity in the tube to the nominal diameter.
\[ \omega = \frac{4 \times Q}{\rho \times \pi \times d_N^2} = \frac{(4 \times 2.54)}{(1000 \times 3.14 \times 50^2)} = 1.3 \text{ m / s} \]

In the range (1 -> 2 m / s) -> reasonable
Determine the diameter of the water pipe supplied to the equipment.

According to Table 2.2 TL (Design of water supply and drainage system), determine the additional unit load of the supplied water and the diameter of the water pipe supplied to the equipment.

**Table 14.2.2 Water Supply Unit Charges**

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Water supply unit load</th>
<th>Diameter of pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet (use tank)</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Urinal (use valve)</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Hand wash basin</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Bathroom</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

**14.3 WATER DRAINAGE SYSTEM FOR HOSPITAL**

**14.3.1 INTRODUCTION**

When designing the sewage system for sanitary wares, the following requirements should be met:

- Different types of wastewater.
- The size and slope of the sewage pipe.
- Size of settling tank, wastewater septic tank.
- Location of connection with wastewater treatment plant ...

**14.3.2 WASTE WATER DRAINAGE SYSTEM**

a. Design of waste water tanks.

As shown in Table 4.1 TL (Design of Water Supply and Sewerage System), determine the volume of sedimentation tank: \( W = \frac{2.5 \times Q_h}{1000} = (2.5 \times 9254) / 1000 = 23,135 \text{ (m}^3\). \)

\[ W = 23.135 \text{ (m}^3\) \]

b. Design of sewage system.

- All sewers have a slope of at least 1.65% with DN100 and 1.00% with larger pipe sizes, no need for slope.
- The diameter of the horizontal soft waste water hose must be at least \( \varphi 80 \).

- The horizontal diameter of the horizontal pipe must be \( \varphi 100 \).

- Diameter of pipe out of sanitary ware:

**Table 4.2 TL** (Design of water supply and drainage system) determines the wastewater unit load.

**Table 14.3**: Waste water load

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Water supply unit load</th>
<th>Diameter of pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilet (use tank)</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>Urinal (use valve)</td>
<td>4</td>
<td>50</td>
</tr>
<tr>
<td>Hand wash babin</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>floor drain</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>Bathroom</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>

- For vertical pipes, the pipe diameter must be greater than or equal to the diameter of the horizontal pipe connected to the vertical pipe.

**Ventilation system**

The ventilator has a minimum diameter of \( \varphi 50 \).

The vertical ventilation duct is equal to or larger than 0.5 times the diameter of the sewer pipe.

**14.3.3 DRAINAGE WATER SYSTEM**

With a surface area of rain water drainage is \( S_1 = 1725 \text{ m}^2 \), surface area of contact surface \( S_2 = 0 \text{ m}^2 \)

The rainfall intensity of Ho Chi Minh City is \( q_5 = 496 \text{ mm} / \text{hr} \) [TCVN 4474: Appendix q5 in some localities]

Choose the safety factor \( K = 2 \).

So the rainfall of the roof is determined by the formula:

\[
Q = K \times \left( (S_1 + S_2) \times q_5 \right) / 3600 (l / s) = 2 \times (1725 + 0) \times 0.496) / 3600 (l / s) = 475.3 \text{ hr}
\]

- Based on TCVN 4474 Table 9. Rainfall Flow Rate for Equipment
Select rainwater collector and drain hose at 150 mm diameter

- We have the number of rainwater collectors at the roof level = Q / 35 = 49 hoppers

Similarly, the number of rainwater pipes at the roof level = Q / 50 = 34 pipes

- Worksheet of rainwater pipe for the project:

<table>
<thead>
<tr>
<th>Serial</th>
<th>Explain</th>
<th>Acreage (m²)</th>
<th>Parameter</th>
<th>Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ATTIC</td>
<td>1725</td>
<td>496</td>
<td>475.3</td>
</tr>
</tbody>
</table>

TCVN 4474, Table 9: Rainfall Flow Rate for Equipment

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>80</th>
<th>100</th>
<th>150</th>
<th>200</th>
<th>250</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funnel / F.Trap(l/s)</td>
<td>5</td>
<td>12</td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pipe / D.Pipe(l/s)</td>
<td>10</td>
<td>20</td>
<td>50</td>
<td>80</td>
<td></td>
</tr>
</tbody>
</table>