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DESIGN OF CLEAN WATER AND WASTEWATER INSTALLATION SYSTEM IN CWI-1 TOWER 3, ITS SURABAYA

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ABSTRAK

Pengelolaan air yang efisien merupakan hal krusial bagi pembangunan berkelanjutan, yang mencakup pemanfaatan sumber daya yang optimal, pengelolaan lingkungan yang bertanggung jawab, serta kemampuan menghadapi kekurangan air. Penelitian ini berfokus pada Gedung CWI-1, Menara 3, di kampus ITS Surabaya, dengan tujuan untuk menghitung perkiraan kebutuhan air bersih dan volume air limbah yang dihasilkan, merancang tata letak sistem, menentukan dimensi pipa dan kapasitas tangki, serta menyusun rencana anggaran biaya. Perkiraan kebutuhan air bersih didasarkan pada total luas lantai dan tingkat hunian, yang kemudian digunakan untuk menghitung ukuran pipa, kapasitas tangki bawah tanah dan atas. Perhitungan volume air limbah menggunakan metode Unit Alat Plumbing (UAP), dan ukuran pipa ditentukan berdasarkan hasil perhitungan SPS. Hasil penelitian menunjukkan total kebutuhan air bersih sebesar $170 m^3/hari$, dengan debit puncak (per jam) $34{,}03\ m^3/jam$ dan debit puncak (per menit) $1{,}7\ m^3/menit$. Sistem air bersih menggunakan pipa dengan ukuran ¾ inci, 2 inci, dan 5 inci. Kapasitas tangki air bawah tanah dihitung sebesar 36 meter kubik (6 x 3 x 2 meter), sedangkan tangki air atas adalah 39,7 meter kubik, yang kemudian dioptimalkan menjadi 20 meter kubik untuk efisiensi biaya. Volume air limbah yang dihasilkan adalah $9{,}97\ m^3/hari$, terdiri dari $1{,}77\ m^3$ air hitam dan $8{,}2 m^3$ air abu-abu. Sistem pembuangan air limbah menggunakan pipa berdiameter 2 inci dan 4 inci. Pengelolaan air hitam dilakukan dengan satu tangki septik berkapasitas 5 meter kubik per hari, sedangkan air abu-abu diolah menggunakan dua tangki masing-masing dengan kapasitas 8 meter kubik per hari. Total biaya yang diperkirakan untuk sistem air bersih dan pengelolaan air limbah adalah Rp2.002.400.000.

Kata kunci : Air Bersih; Air Kotor; Kapasitas Tangki; IPAL

ABSTRACT

Water equity is critical to sustainable development and requires, among other things, sound resource use, environmental stewardship, and resilience to scarcity. This research focuses on the CWI-1 Building, Tower 3, on the ITS Surabaya campus; the goals are to estimate clean water demand and wastewater discharge, design the system layouts, interpret pipe sizes and tanks capacities, and develop a cost budgeting plan. Clean water demands are estimated from the total floor area to estimate occupancy, and then pipe sizes, ground, and roof tank capacities are calculated. Wastewater discharge is estimated using the Plumbing Fixture Unit (PFU) method, and pipe sizes are derived from the PFU calculations. The results show a total clean water demand of 170 m^3/day, with a peak hourly flow of 34.03 m^3/hour and peak minutes flow of 1.7 m^3/min. The clean water system uses pipe sizes of ¾ in, 2 in, and 5 in. The groundwater tank capacity is calculated to be 36 m^3 (6 × 3 × 2 m), and the roof water tank at 39.7 m^3, though optimized to 20 m^3 for cost efficiency. Wastewater discharge amounted to 9.97 m^3/day, consisting of 1.77 m^3/day blackwater and 8.2 m^3/day greywater. The wastewater system uses 2-inch and 4-inch pipes. Blackwater is managed with a single septic tank of 5 m^3/day capacity, while greywater is treated using two tanks of 8 m^3/day each. The total estimated cost for the clean water and wastewater systems is Rp. 2,002,400,000.

***Keywords** : Clean water; Wastewater; Tank Capacity; IPAL*

1. BACKGROUND

Water management is one of the most important aspects of sustainable development, along with resource efficiency, environmental preservation, and water resource scarcity. Efficient water systems are designed and implemented in contemporary high-rise structures, particularly campus towers, to safeguard occupant health, operational efficiency, and environmental compliance. The increasing number of high-rise buildings raises the need for sustainable water solutions and, more generally, high-quality innovation in building distribution and wastewater management. Effective water systems that support the property's upkeep must be designed for every high-rise campus building to work well. In conclusion, this study aims to investigate and provide modern, practical solutions to meet the specific requirements of Tower 3 on the ITS Surabaya campus concerning water distribution and wastewater treatment in high-rise buildings, while also providing a system layout with components for both infrastructure considerations and recommendations for resources and implementation planning.

2. METHOD

A. Clean Water Calculations

The method used to determine clean water requirements is based on the number of occupants in the building. The following are the steps for calculating clean water requirements in Tower 3, ITS Surabaya:

1) Determine the number of occupants.

The total number of building occupants forms the basis of the clean water demand estimation. The number of users is calculated using **Equation 1**, which converts the building's functional capacity or floor area into population equivalent.

$$\text{Total Occupants} = \frac{\text{Effective Area}}{\text{Density}} \quad (1)$$

2) Calculate the building's clean water consumption (Qd).

Once the number of users is known, the total clean water consumption can be estimated using **Equation 2**. This step determines the daily water demand based on buildings functions.

$$\text{Qd} = \Sigma\,\text{Occupants} \times \text{ Water consumtion /person/day} \quad (2)$$

An additional 20% is needed to account for leaks.

3) Calculate the average water demand (Qh).

To represent normal operational conditions, the average hourly water demand is calculated using **Equation 3**, dividing the total daily usage over the buildings usage period.

$$\text{Qh} = \frac{\text{Qd}}{\text{T}} \quad (3)$$

Where:

Qd = Water consumtion (m^3/day)

T = Average duration of water usage per day (hours)

4) Calculate peak (hour) water demand (Q_h-max).

Calculate the peak hourly water demand using **Equation 4** to determine the highest expected water usage within a hour.

$$\text{Qh}_{\text{Max}} = \text{C1} \times \text{Qh} \quad (4)$$

Where:

Qh = Average water demand (m^3/day)

C1 = Constant (in the range of 1,5 - 2,0)

5) Calculate peak (minutes) water demand (Q_m-max).

Calculate the peak minutes water demand using **Equation 5** to determine the highest expected water usage within a minute.

$$\text{Qm}_{\text{Max}} = \text{C2} \times \text{Qh}/60 \quad (5)$$

Where:

Qh = Average water demand (m^3/day)

C2 = Constant (in the range of 3,0 – 4,0)

B. Tank Dimensions

The tank functions as a water storage unit prior to distribution to the serviced residences. Its purpose is to minimize continuous pump operation while ensuring stable flow and pressure, The calculation of tank dimensions is preceded by determining the service pipe capacity using **Equation 6**.

$$\text{Qs} = \frac{2}{3} \times \text{Qh} \quad (6)$$

Where:

Qs = Service pipe capacity

The capacity of the underground tank (GWT) is determined using **Equation 7** to provide adequate storage for daily and reserve demand.

$$\text{VR} = \text{Qd} - (\text{Qs} \times \text{T}) \quad (7)$$

Where:

Qd = Water consumtion (m^3/day)

Qs = Sevice pipe capacity (m^3/day)

T = Average duration of water usage per day (hours)

The capacity of the upper tank (RWT) is then determined using **Equation 8** to ensure stable pressure and continuous supply to the distribution network.

$$\text{VE} = [(\text{Qp} - \text{Qh}_{\text{max}}) \times \text{Tp} + (\text{Qh}_{\text{max}} \times \text{Tpu})] \quad (8)$$

Where:

Qp = Q_{m-} Max

TP = Peak time interval (min)

Tpu = Pump operating time (min)

C. Dimensions of Clean Water Pipes

The sizing of clean water pipes is determined based on the peak-usage flow rate. The process begins with the assumption of flow velocity (V), which generally ranges between 0.3 m/s and 2.5 m/s (Noerbambang & Morimura, 2005). After the velocity is defined, the flow rate (Q) is calculated using the peak-minute discharge, applying the Q_m-max value. The obtained Q value is then used to calculate the required pipe diameter (D) using **Equation 9**, which is subsequently adjusted to match the standard pipe sizes available in the market.

$$D = \sqrt[2]{\frac{4 \times Q}{v \times \pi}} \quad (9)$$

Where:
D = Pipe inner diameter (m)
Q = Discharge (m^3/sec)
v = Velocity (m/sec)

The selected diameter from the market is subsequently used to verify the actual flow conditions in the system to check that it complies with the standard of 0.3 m/second to 2.5 m/second using **Equation 10.**

$$V_c = \frac{Q}{\frac{1}{4} \times \pi \times D^2} \quad (10)$$

D. Water Pressure

The calculation of water pressure on each floor aims to verify whether the pressure at plumbing fixtures remains within the design limits for multi-story buildings. According to Bernoulli's principle, an increase in flow velocity results in a decrease in fluid pressure. Therefore, in this calculation, flow velocity is neglected to obtain the maximum pressure on each floor. Water pressure is determined using **Equation 11.**

$$P = \rho \times g \times h \quad (11)$$

Where:
ρ = Water density (kg/m^3)
g = Gravity acceleration (m/s^2)
h = height (m)

E. Head Pump

The calculation of pump head in the clean water system is established to check that the determination of pressure height necessary to operate the pump is appropriate, when operating the pump. The resulting assessment of the appropriate pump type to transport water from the lower tank to the upper tank, is determined from this calculation, assuming a flow velocity of 0.3 m/s to 2.5 m/s (Noerbambang & Morimura, 2005). The static head is calculated considering:

- The vertical distance between the water levels in the lower and upper tanks.
- The distance from the water surface in the groundwater tank to the highest point ever reached by the water.

The H system value is obtained by summing the Major and Minor head losses in the piping system. The calculation as follows:

a) Hf Mayor, represents the head loss caused by friction along the length of the pipe, both horizontal and vertical orientations can be calculated using **Equation 12.**

$$Hf_{Mayor} = \frac{10{,}66 \times Q^{1{,}85}}{C^{1{,}85} \times D^{4{,}85}} \times L \quad (12)$$

Where:
C = Pipe material value (PVC = 130)
D = Diameter (mm)
Q = Discharge (m^3/second)

b) H Minor, represents the head loss due to pipe accessories can such as valves and fittings, the equation for valve loss explained in **Equation 13** and for valve loss in **Equation 14** :

$$Hfm\ V = n \times Kb \times \frac{V^2}{2.g} \quad (13)$$

Where:
n = Number of valve
Kb = Valve loss coefficient (0,98)
V = Velocity (m/second)
g = Gravity

$$Hfm\ T = n \times Kb \times \frac{V^2}{2.g} \quad (14)$$

Where:
n = Number of valve
Kb = Turns loss coefficient (for 90 degrees = 0,98)
V = Velocity (m/second)
g = Gravity

After calculating the head losses for valve loss and turns loss, the total is then used to calculate the Hf Minor of the system using **Equation 15**, as shown below**:**

$$Hf\ Minor = HFm\ T + HFm\ V \quad (15)$$

After determining both the major and minor head losses, the total pump head (H pump) is calculated using the **Equation 16** as shown below:

$$H\ Pump = H\ Static + Hf\ Minor + Hf\ Mayor \quad (16)$$

F. Wastewaster Calculations.

The calculation of wastewater flow begins with determining the volume of grey water and black water using **Equation 17**. This equation considers the number of uses and the amount of water required per usage. After the discharge is obtained, the number of sanitary fixtures—such as toilets, sinks, and floor drains—is identified to estimate the total wastewater load using UAP method, the dimensions of the wastewater pipes are then determined.

$$Q_w = \text{Qty} \times \text{Water needed per usage} \quad (17)$$

G. Velocity Control.

The control is conducted to ensure that the velocity lies within the permissible range to prevent both sedimentation (when the velocity is too low) and potential pipe damage (when the velocity is too high). Velocity limit as 0,6 m/sec – 1,6 m/sec.(Soufyan Moh. Noerbambang & Takeo Morimura (2005)).The hydraulic characteristics of the pipe are determined based on the inner diameter (id) and flow velocity previously obtained. The following equations, adapted from Ven Te Chow (1959), are used to calculate the key parameters necessary for flow analysis in partially full circular pipes, as presented in **Equations 18** to **26**, as shown below:

Equation 18. The normal depth of flow (y_n) is calculated based on the pipe's inner diameter (id):

$$y_n = \frac{2}{3} \times \text{id} \quad (18)$$

Equation 19,the parameter t is obtained by subtracting the pipe radius (r = id/2) from the normal depth:

$$t = y_n - r \quad (19)$$

Where :

r = id/2.

Equation 20, the flow angle (θ) is determined using the ratio of t to the pipe radius.

$$\text{Cos}\ \theta = \frac{t}{r} \quad (20)$$

Equation 21, the central angle of the water surface (α) is calculated from the flow angle.

$$\alpha = 360° - 2 \times \theta \quad (21)$$

Equation 22, the water surface width (T) is calculated using the normal depth and inner diameter.

$$T = 2 \times \sqrt{y_n \times (\text{id} - y_n)} \quad (22)$$

Equation 23, the wett area of the pipe is determined from the central angle and inner diameter.

$$\text{Wet area} = \frac{1}{8} \times (\alpha - \text{Sin}\ \alpha) \times \text{id}^2 \quad (23)$$

Equation 24, the wett perimeter (P) is calculated using the central angle and pipe diameter.

$$P = \frac{1}{2} \times \alpha \times \text{do} \quad (24)$$

Equation 25, the hydraulic radius (R) is derived from the pipe geometry and central angle:

$$R = \frac{1}{4} \times \left(1 - \frac{\text{Sin}\ \alpha}{\alpha}\right) \times \text{id} \quad (25)$$

Equation 26, finally, the flow velocity (V) is obtained using the hydraulic radius, slope (S), and Manning roughness coefficient (n):

$$V = \frac{1}{n} \times R^{\frac{2}{3}} \times S^{0,5} \quad (26)$$

Where:

n = Manning roughness coefficient (0,013)

H. Wastewater Tank.

The determination of septic tank and STP capacities follows directly from the discharge values obtained, ensuring that the system design aligns with the estimated wastewater load.

I. Gardens Watering.

The water requirement for garden sprinklers is calculated using **Equation 2.27**. This takes into account the total garden area L, the water needed per unit area W_n, and the sprinkler application frequency. The total water demand Q_w is obtained by multiplying the garden area by the unit water requirement and the number of sprinkler events as shown below:

$$Q_w = L \times W_n \times \text{Frequency} \quad (27)$$

Where:

L = Total garden area (m^2)

W_n = Water needed (0,002 m^3/m^2)

J. Cost Estimation.

The method used in preparing the cost estimate uses AHSP from Permen PUPR 2024 and HSPK East Java 2024. Cost calculation uses **Equation 28.**

$$Tc = \Sigma\ (\text{Volume} \times \text{Unit price}) \quad (28)$$

3. RESULT AND DISCUSSION

A. Clean Water.

The tower's clean water system follows a down-feed configuration. Water is first supplied from the municipal source (PDAM) to the Groundwater Tank (GWT), from which it is pumped up to the Roof Water Tank (RWT). From he RWT, water is distributed downward through the building's piping network to all serviced floors.

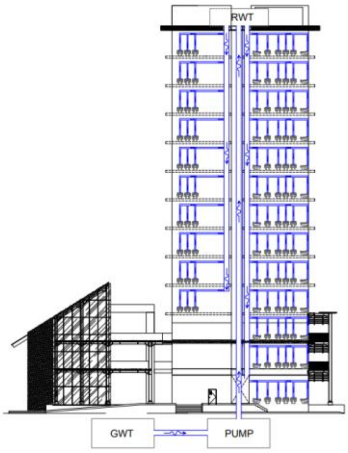

Figure 1 Clean Water Scheme

The calculation of the number of occupants in a building is divided by floor and then added together to determine the total number of occupants in a building.

Table 1. Total Occupants.

No	Floor	Area (m^2)	Effect ive area (%)	Effective area (m2)	Density (m2/ person)	Occcupants (Person)
1	1st floor	1633,11	60%	979,87	3	327
2	2nd floor	882,40	60%	529,44	3	177
3	3rd floor	846,90	60%	508,14	3	170
4	Auditorium	314,74	60%	188,84	3	63
5	4th floor	693,00	60%	415,80	3	139
6	5th floor	693,00	60%	415,80	3	139
7	6th floor	693,00	60%	415,80	3	139
8	7th floor	693,00	60%	415,80	3	139
9	8th floor	693,00	60%	415,80	3	139
10	9th floor	693,00	60%	415,80	3	139
11	10th floor	693,00	60%	415,80	3	139
12	11th floor	693,00	60%	415,80	3	139
13	12th floor	693,00	60%	415,80	3	139
14	13th floor	693,00	60%	415,80	3	139
Total		**10607,15**		**6364,29**		**2127**

Source: Calculations.

Based on **Equation 1**, it was estimated that the occupants on the 1st floor would number 327 people, meaning the total number of occupants for the building was 2127 people. **Equation 2** calculated the clean water demand (Qd) based on the total occupancy and the functional classification of the building, which was $170.16\ \mathrm{m^3/day}$. To estimate potential losses from leakages and/or other system failures, a 20% add-on was added to Qd, which calculated the total clean demand to be $204.19\ \mathrm{m^3/day}$.

Equation 3 was used to calculate the average hourly clean demand (Qh), which was calculated to be $34.03\ \mathrm{m^3/hour}$, which represented the expected flow rate required to fulfil daily operational demands. Then, **Equation 4** was used to calculate the peak hour clean demand (Qhmax) at $34.03\ \mathrm{m^3/hour}$, which is related to the maximum demand expected in any hour. Finally, **Equation 5** estimated the peak usage in a minute (Qmmax) at 1.70 $\mathrm{m^3}$/minute, which accounts for the highest anticipated instantaneous demand during peak periods of short duration.

B. Tank Dimensions.

The groundwater tank capacity was calculated in two steps. The service flow rate was determined by calculating two-thirds of the average hourly water demand to find a value of, using **Equation 6**. The required tank volume was then calculated by applying **Equation 7**, transferring the total 6-hour service flow from the 24-hour use building cycle, resulting in a tank volume of $34{,}03\ m^3$. For practical design value, the tank was increased to $36m^3$. The groundwater tank was fabricated with a modular Fiberglass-Reinforced Plastic (FRP) construction material to provide structural durability, resistance to corrosion, and ease of installation.

Simmilarly the calculation for roof water tank firstly using **Equation 8**, the calculation for the roof water tank capacity, assuming $\mathrm{Tp} = 60$ and $\mathrm{Tpu} = 15$ minutes. Under these assumptions, the effective tank volume was calculated to equal $39.70\ \mathrm{m^3}$. For implementation, it was rounded to $40\ \mathrm{m^3}$ and by design is using a single $20\ \mathrm{m^3}$, with refilling four times per day. FRP (Fiberglass Reinforced Plastic) tank material is easy and quick to maintain, durable throughout its use, and resistant to corrosion, which is suitable for high-rise building installations.

C. Dimensions of Clean Water Pipes.

Calculate the pipe dimensions first by finding the flow rate in each pipe channel. Example: at point GWT-1, the flow rate is known to be $0.0286\ \mathrm{m^3/sec}$, then it is known that the PVC pipe material has a friction coefficient of 130 with an assumed velocity of $2.3\ \mathrm{m/sec}$, using **Equation 9** the corresponding pipe diameter was obtained as 125.3 mm, which is equivalent to a 5-inch pipe in the market. This dimension was selected to ensure optimal flow velocity and minimize head loss within the system.

Following the determination of the pipe diameter (D), the actual flow velocity in the selected pipe could be checked in order to ensure that the velocity is within the acceptable limits for design. Using **Equation 10**, the calculated velocity of 2.16 m/s was determined to be under the acceptable conditions for clean water distribution systems. Thus, the pipe diameter is appropriate for hydraulic and design standards.

D. Water Pressure

Water pressure calculation in the main pipe based on the height difference achieved by the water flow on each floor, as shown below:

Table 2. Pressure Calculations.

Floor	Height per floor (m)	Elev difference	Pressure (kg/cm)
Roof	-	-	-
13	4	4	0,3997
12	4	8	0,7994
11	4	12	1,1992
10	4	16	1,5989
9	4	20	1,9986
8	4	24	2,3983
7	4	28	2,7981
6	4	32	3,1978
5	4	36	3,5975
4	4	40	3,9972
3	4	44	4,3969
2	4	48	4,7967
1	5	53	5,2963

Source: Calculations.

Calculation on the 1st floor using **Equation 11**, as follows:

$$P = \rho \times g \times h$$
$$= 1000 \times 9{,}8 \times 53$$
$$= 519400\ \mathrm{N/m^2}$$
$$519400/100000 = 5{,}194\ bar$$
$$5{,}194 \times 1{,}0197 = 5{,}296\ \mathrm{Kg}/cm^2$$

E. Head Pump.

The initial step in figuring out the pump specifications is to calculate the static head or the vertical distance that the water has to be lifted. The static head for this system is 54.8 m, which is shown in **Figure I**. Once the static head is known, the total system head (Hsystem) can be determined by incorporating the major and minor losses through the piping network to ensure that the pump provides enough pressure for the system to function properly in the building. Using **Equation 12** Hf Mayor value is $4{,}401m$.

Following the equation for major head loss, the next step is to find the minor head loss. Minor head loss is the pressure drop caused by accessories in the system, such as valves and turns, and each is considered separately using the minor loss equations. Using **Equation 13** for valves and **Equation 14**, the total minor head loss is summed using **Equation 15,** respectively, with the value of Hfm V to be 0,23 m and Hfm T to be 2,1m.

Adding the Hfm V and Hfm T or using **Equation 15,** Hf Minor value is 2,3 m. Furthermore, obtaining the static head, H major, and H minor, the data can be summed to provide the H pump. This value can be calculated in **Equation 16,** the value of H Static here determined to be 61,54 m, the pump will generate that pressure to overcome the entire elevation change and associated friction losses within the system. The determined flow rate (Q) and pump head (H) are graphically plotted onto the Ebara pump performance curves to identify and select the appropriate pump model, as shown in **Figure 2.**

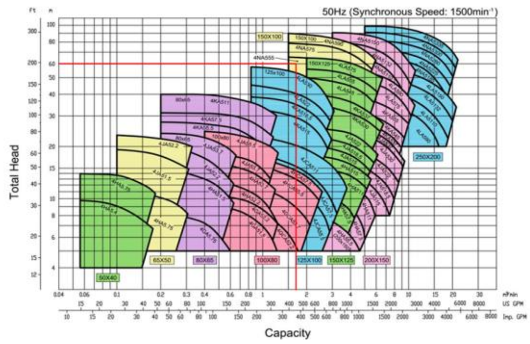

Figure 2. Pump Chart

Source:(https://www.ebaraindonesia.com/id/)

F. WasteWater Calculations

The building's wastewater system uses a gravitational flow configuration, meaning that wastewater flows from the floors that are being serviced naturally to the treatment units below, using gravity for flow, thus does not require supplemental pumping and is an effective drain, as shown in **Figure 3** below:

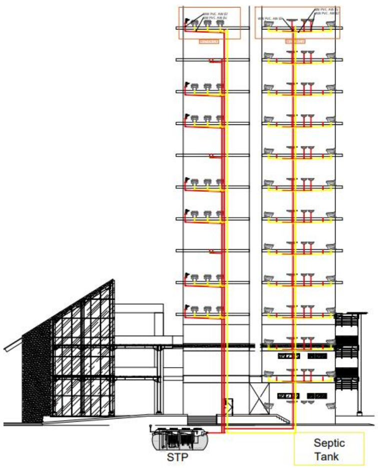

Figure 3. Wastewater Scheme.

The first step in designing the wastewater system is to determine the number of plumbing fixtures and the water required per usage. These values, which provide the basis for calculating wastewater discharge, are summarized in **Table 3** below.

Table 3. Frequency.

Plumbing fixtures	Usage	Water needed
Closets	0,9	14
Urinoir	0,5	5
Lavatory	2	10
Sink	1	15
Floor Drain	-	15

Source: Calculations.

Here is an example of calculating the volume of dirty water on the 1st floor, using **Equation 17,** with a known total of closets on 1st floor to be 10, and in one day usage assumed to be 0,9, the volume can be determined to be 126 liters.

Table 4 . Calculation for Wastewater

Plumbing Fixtures	Closet	Urinoir	Lavatory	Sink	Floor Drain
Usage (Assumption)	0,9	2	3	4	2
Usage (Litre)	14	5	10	15	15
1st floor	126	20	120	120	240
2nd floor	100,8	20	180	420	210
3rd floor	100,8	20	180	60	210
Auditorium	-	-	-	-	
4th floor	163,8	40	270	60	300
5th floor	163,8	40	270	60	300
6th floor	100,8	20	180	60	300
7th floor	163,8	40	270	60	300
8th floor	163,8	40	270	60	300
9th floor	100,8	20	180	60	300
10th floor	163,8	40	270	60	300
11th floor	163,8	40	270	60	300
12th floor	100,8	20	180	60	300
13th floor	163,8	40	270	60	330
TOTAL	1776,6	400	2910	1200	3690
m3/Day	1,77		8,2		

From the table above, it can be concluded that for total volume of Wastewater was $9{,}9\text{m}^3/\text{day}$ with $1{,}77\text{m}^3/\text{day}$ from Blackwater and $8{,}2\ \text{m}^3/\text{day}$ for Greywater. The dimensions of the wastewater pipes are determined based on the calculated wastewater discharge from each fixture. For example, the closet pipe on the first floor is sized by first calculating the total unit appliance points (UAP):

$$\text{T UAP} = \text{Qty} \times \text{UAP value}$$
$$= (10 \times 40$$
$$= 40$$

The minimum trap diameter for a closet is 75 mm. Therefore, for closet pipes is use 110 mm or 4 inch. And for the Greywater is using standardized 2inch pipe diameter.

G. Velocity Control.

Velocity control is performed to maintain flow within a certain range so that sediment does not settle in the pipe at lower flow velocities, whereas too much flow velocity can potentially damage the pipe. In this system, the flow velocity is limited to 0.6–1.6 m/s (Soufyan Moh. Noerbambang & Takeo Morimura 2005), which resulted in a pipe diameter (id) of 109.9 mm. The hydraulic terms for the pipe, or normal depth, flow angle, wetted area, perimeter, hydraulic radius, and flow velocity, are then calculated using **Equations 18-26** to fully describe the pipe. The calculated velocity value is $0{,}78\ m/s$,wich sits between the range of $0{,}6 - 1{,}6\ \text{m}/s$.

H.Wastewater Tank.

From **Table 4,** the volume of discharge can be used to determine the capacity for the tank; the result, septictank is using one 5 m^3 tank and for STP is using two 8 m^3 tank.

I. Garden Watering.

The water requirement for watering is calculated using **Equation 28**. Given that the total garden area (L) is 265 m^2, the total water demand can be determined by multiplying the area by the unit water requirement and the frequency of watering; therefore water needed for watering the garden is $0{,}0000061\text{m}^3/\text{sec}$ or $0{,}0216\ m^3/h$

J.Cost Estimation.

The total cost of the clean water pipe work is Rp 229.541.664,47 . And for the Wastewater is Rp 251.491.730,70, the total is Rp 2.002.397.638,44 rounded up to be Rp 2.002.400.000,00.

Table 5. Cost Recapitulation.

No	Job Descriptions	Total Price	
1	Preparation Work	Rp	4.158.000,00
2	Excavation Work	Rp	1.212.286,65
3	Embankment Work	Rp	387.576,61
4	Sanitary Equipment Work	Rp	891.420.960,21
5	Clean Water Works	Rp	229.541.664,47
6	Wastewater Works	Rp	251.491.730,70
7	Pump Installation	Rp	85.779.936,30
8	Pump Installation	Rp	339.969.681,50
	Sum Price	Rp	1.803.961.836,44
	Tax (11%)	Rp	198.435.802,01
	Total Price	Rp	2.002.397.638,44
	Roundup	Rp	2.002.400.000,00

4. CONCLUSION

The CWI-1 Building, Tower 3, at ITS Surabaya is occupied with 2.127 people and requires a daily clean water supply of 170 m^3/day, with wastewater production totaling 9,97 m^3/day, of which 1,77 m^3/day is blackwater and 8.2 m^3/day is greywater. The clean water system experiences peak flows of 34,03 m^3/hour and 1,7 m^3/ minute, distributed through PVC AW pipes ranging from ¾ to 5 inches in diameter. Wastewater is carried through pipes ranging from 2 to 4 inches. Groundwater is stored in a 36 m^3 FRP tank, while the roof water tank, originally 39,7 m^3, has been optimized to 20 m^3 FRP tank to improve cost efficiency. Blackwater is treated with a 5 m^3/day septic tank, while greywater is handled by two 8 m^3/day tanks. Altogether, the installation of the clean water and wastewater systems is estimated at Rp 2,002,400,000. To aid in implementation and follow-up, provide isometric drawings and pipe-network schematics, which can be used in plumbing installation and equipment selection, and advise checking treated wastewater quality regularly before reusing or discharging. But the most important process is to use Building Information Modeling (BIM) to lock down coordination, perform clash detection, have quick access to quantity takeoffs, and simplify future maintenance and revisions.

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