Water Conservation Calculations in Eco-Friendly Office in South Jakarta

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Abstract. The clean water crisis and environmental issues require us to make wise efforts in using clean water. Significant savings in the use of clean water can be achieved by conserving air. In this project, a rental office building was designed in the Setiabudi area, South Jakarta that can make the most of the rainfall possible to locate and use it. In addition, the type of waste is managed so that the recycling process can be selected. Besides that, clean water management is also carried out according to the level of quality and use. In this project, clean water is divided into two, namely primary water and secondary water. Primary water is used for human needs and secondary water for human and machine needs. Liquid waste from human activities is divided into gray water which will be recycled and black water which is not recycled. From the results of this recycling and harvesting rainwater with a temporary catchment area only from the roof, the conservation conservation is 52.8%.

Keywords: rental office, water conservation, water recycle, rainwater harvesting.

1. Introduction
Setiabudi, Kuningan Timur, South Jakarta, is a CBD (Central Business District) area where the CBD area has high business development. In the current pandemic conditions, for the CBD area, occupancy for Q4 in 2020 has reached 81% (Colliers International, 2020) [1]. According to national.tempo.co, the use of water is very dependent on the level of occupancy [2].

The United Nations Environment Program (UN) in 2015 states that water consumption in buildings is the second largest in the world after electricity, at 25% [3]. And according to research data in Building Tech, that the water consumption in office buildings is relatively high compared to other buildings, which is 25% of all other uses [4].

Based on data from the World Resources Institute’s Aqueduct analysis, the risk to clean water quality in Jakarta, including in the Setiabudi area, is in a very high pollution phase per year [5]. This is also supported according to a report by the DKI Jakarta Environmental Management Agency (BPLHD) in 2011, 71% of river water in Jakarta is heavily polluted, 20% is partly polluted, and 9% is lightly polluted [6]. Meanwhile, the source of raw water from PDAM comes from river water that has been heavily polluted. Thus, the processing cost increases, which causes the selling price of water from PDAM to increase every year. Resulting in the number of buildings that still use groundwater sources due to the low price.
This is supported by CNBC Indonesia news in 2019, in Figure 1 where there are still many commercial buildings that use groundwater. Seen in the figure below, the condition of deep groundwater availability in the Setiabudi area experiences a vulnerable zone and conditions of shallow groundwater availability experience a partially critical zone. Whereas in this area the use of groundwater should be reduced by doing water conservation.

**Table 1** Site data

|          |       |
|----------|-------|
| Area     | 4812 m² |
| KDB      | 40%    |
| KDH      | 30%    |
| KLB      | 5      |
| KTB      | 55%    |
| KB       | 30 Floors |
| Setbacks | N= 6m E= 6m |
The research location is located on Jl. Perintis No.8 RT.3 / RW.5, Kuningan, Kuningan Tim. Setiabudi District, South Jakarta City, the site is in the Office, Trade and Service Zone. The selection of this location is because this location has a high occupancy so that it has an effect on increasing the need for clean water. In addition, this location also has a water crisis condition, because there are still many commercial buildings that still use groundwater. The purpose of this research is to design the application of water conservation in office buildings to determine the size of the secondary, primary, and filtered water output and harvested rainwater needs.

### Table 2. Precedents

| No | PRECEDENTS | Water Tank Size | Water Needs | Loc. Water Tank |
|----|------------|-----------------|-------------|-----------------|
| 1. | 1315 Peachtree Street | 37.8 m³ | 2940 m³/year | Underground |

2. **Sampoerna Strategic Square**

This building uses 2 types of clean water, namely primary water sourced from PDAM which is used for human activities, consisting of employees, guests, kitchens, cleaning services with a total water requirement of 435 m³/day; and used to fill the water hydrant tank of 450 m³. The results of these human activities produce liquid waste which is processed at STP to produce secondary water of 310 m³/day and waste in the form of blackwater of 125 m³/day. This blackwater waste is channeled into a sewer (PD PAL). Secondary water is then used for cooling towers of 2070 m³/day and irrigation of 40 m³/day.

From these precedents, it can be learned how clean water and wastewater management is also the layout of wastewater treatment and the position of the water tank. Both primary water and secondary water. The conclusions that can be drawn as lessons and examples that can be applied to this project are, in most precedents buildings, the location of the reservoir is underground or the basement, and the size of the reservoir tanks ranges from 2.5 to 4 times the daily water consumption.
2. The methodology
In this rental office project, it will be designed with the application of water conservation. The data analysis method used is quantitative. The quantitative approach is to obtain data that affect the efficiency of clean water use related to water conservation strategies. Where this research aims to design office buildings that can streamline the use of clean water, by recycle water from rainwater and greywater.

The results of data analysis are obtained that refer to the office design criteria through water conservation and output in the form of numbers. The analysis carried out is related to the calculation of the required discharge - water discharge and the percentage resulting from water conservation efforts, namely rainwater harvesting and recycle greywater. This will later have an effect and become a reference for the design of the mass of the building, the space requirements for the building and the landscape.

3. Result and discussion
3.1 Mass compositions
From the site data in section 1. Introduction above, the requirements for the building can be calculated, which is in the Table 3 below.

| Num | Parameter | Koef. | Calculation         | Result  |
|-----|-----------|------|---------------------|---------|
| 1.  | BCR (KDB) | 40%  | 40% x 4812m²        | 1924m²  |
| 2.  | GBC (KDH) | 30%  | 30% x 4812m²        | 1443m²  |
| 3.  | GFA (KLB) | 5%   | 5 x 4812m²          | 24060m² |
| 4.  | BFR (KTB) | 55%  | 55% x 4812m²        | 2646m²  |

(Source: Personal Analysis)

Based on the table above, in order to obtain an estimate of the area of each floor, which is used for water conservation calculations, is in the following Table 4.

| Num | Parameter                      | Calculation                                      | Result      |
|-----|--------------------------------|-------------------------------------------------|-------------|
| 1.  | Estimation Area of Each Floor  | GFA ÷ floor total plan = 24060 ÷ 21 floors       | 1145.7m²    |
| 2.  | Estimation l x w floor (mass  | √estimation floor area = √1145.7 = 33.8          | 33 x 33 m²  |
|     | form assumption = square)      |                                                 |             |

(Source: Personal Analysis)

From the above calculations, we get the mass composition assumptions in the following figure. Where the temporary catchment area for rainwater is located on the roof, it can be seen in the Figure 5 below.
3.2 Water conservation analysis
Through calculations related to building area based on assumptions from the calculation of site data regulations in the previous sub-section (3.1 Mass compositions), it can be calculated through formulas related to water conservation and the result of calculations are in Table 5 below.

| Num | Formula | Calculation |
|-----|---------|-------------|
| 1   | Num of Occupant = area (m2) x 80% x occupancy standard (prsn/m2) [7] | Num of Occupant = (33 x 33) x 80% x (0.015 + 0.0015) = 144 Person /floor |
|     | Temporary Floor Area = 33 m x 33 m | Total of occupant = 3019 Person |
|     | Occupancy standard = 0.015 for employees | For 1st floor until 21 st floor |
|     | Occupancy standard = 0.0015 for visitors | |
| 2   | Need of Clean Water (Qd) Qd = Number of occupants x standard of water usage [8] | Qd = 144 ppl/floor x 50 litre/person/day = 7187 Litre/day |
|     | Water usage standards = 50 litre/person/day [9] | For 1st floor |
|     | From the use of this Qd produces liquid waste in the form of; Black Water 24 % and Grey Water 76% [7] | Total of Qd = 150935 litre/day |
|     | For 1st floor until 21 st floor | Q_month = 3471514 litre/month |
|     | Black Water = 833163 litre/month | |
|     | Grey Water = 2638351 litre/month | For January: 23 working day |
| 3   | Ton Refrigerant (TR) TR_{building} = \left[\frac{1.5 \text{ to 2 TR}}{100 \text{ m}^3}\right] \times \text{building volume} [7] | TR_{building} = \left[\frac{1.5}{100 \text{ m}^3}\right] \times (33 \times 33 \times 4) = 65 \text{ Ton Refrigerant} |
|     | Building Vol. = 33m x 33 m x H | For 1st floor |
|     | H = Height | TR_{building} = \left[\frac{1.5}{100 \text{ m}^3}\right] \times (33 \times 33 \times 3) = 49 \text{ Ton Refrigerant} |
|     | H = 4 m for 1 st floor until 3 rd floor | For 4th floor |
|     | H = 3 m for floor 4th until 21 st floor | Total TR_{building} = 1078 |
|     | | For 1st floor until 21 st floor |
| 4   | Circulating water volume (discharge) V_{circulating water} = 8 s/d 13 \times TR_{building} (litre/minute) [7] | V_{circulating water} = 8 \times 65 \times 60 \times 10 \text{ litre/day} |
|     | Operating Hour: 10 hours / day, and 22 until 23 day/month | V_{circulating water} = 313632 litre/day |
|     | For 1st floor | V_{circulating water} = 8 \times 49 \times 60 \times 10 \text{ litre/day} |
|     | | V_{circulating water} = 235224 litre/day |
|     | For 4th floor | Total V_{circulating water} = 5174928 litre/day |
|     | | For 1st floor until 21 st floor |
Table 5 Water conservation formula and calculation (continued)

| Num | Formula | Calculation |
|-----|---------|-------------|
| 5   | Cooling water volume (discharge) | \[ V_{\text{cooling water}} = 0.015 \times 313632 \text{ litre/day} \]  
For 1st floor | \[ V_{\text{cooling water}} = 0.015 \times 235224 \text{ litre/day} \]  
For 4th floor | \[ V_{\text{cooling water}} = 1.5 \times 2\% \times V_{\text{circulating water}} \]  
(litre/minute) [7]  
\[ = 4704 \text{ litre/day} \]  
\[ = 3528 \text{ litre/day} \]  
Total \[ V_{\text{cooling water}} = 77624 \text{ litre/day} \]  
For 1st floor until 21st floor | \[ = 1785350 \text{ litre/month} \]  
For 23 working day of January | \[ = 20880834 \text{ litre/year} \]  
\[ = 20881 \text{ m}^3 \text{/year} \]  
For one year |
| 6   | Primary Water (PW) = Grey Water | Primary water = 0.76 x 341514 litre/month  
(because the product from primary water is gray water) | \[ = 259551 \text{ litre/month} \]  
For 23 working day of January | \[ = 30857233 \text{ litre/year} \]  
\[ = 30857 \text{ m}^3 \text{/year} \]  
For one year |
| 7   | Secondary water (SW) = Water (Cooling Tower) + Water (urinal & flushing) | SW = 1785350 + 0.24 x \[ 3471514 \text{ litre/month} \]  
Water for urinal & flushing = black water = 24% of Qd | \[ = 2618514 \text{ litre/month} \]  
Water for cooling tower = \[ V_{\text{cooling water}} \]  
\[ = 30625224 \text{ litre/year} \]  
\[ = 30625 \text{ m}^3 \text{/year} \]  
For one year |
| 8   | Rainwater Harvesting | \[ Q_{\text{rain-mean}} = 358 \times 33 \times 33 \times 0.9 \text{ litre/month} \]  
\[ = 350876 \text{ litre/month} \]  
Where: | \[ Q_{\text{rain}} = 1843568 \text{ litre/year} \]  
\[ = 1844 \text{ m}^3 \text{/year} \]  
\[ C = \text{flow coefficient / run-off coefficient (0.9)} \]  
\[ I = \text{monthly rainfall (mm)} \]  
\[ A = \text{cathment area (33x33 m}^2) \]  
\[ \text{For January} \]  
\[ \text{For one year} \]  
\[ \text{Water conservation efforts = amount of water recycle + rainwater harvesting} \]  
\[ \text{Water conservation efforts = SW + } Q_{\text{rain}} \]  
\[ = 32469 \text{ m}^3 \text{/year} \]  
\[ = 30625 + 1844 \text{ m}^3 \text{/year} \]  
\[ \text{Water conservation efforts = } 30625 + 1844 \text{ m}^3 \text{/year} \]  
\[ = 32469 \text{ m}^3 \text{/year} \] |
Table 5 Water conservation formula and calculation (continued)

| Num | Formula | Calculation |
|-----|---------|-------------|
| 10  | \( \text{Percentage (\%)} = \frac{\text{Water conservation efforts}}{\text{Total needs of clean water}} \times 100\% \) | \( \frac{32469}{61482} \times 100\% = 52.8\% \) |

Clean water is primary water and secondary water.

3.3 Conclusion of result and discussion

From the water conservation efforts in this project which include rainwater harvesting and gray water harvesting as discussed above, the percentage of water conservation is obtained at 52.8\%. For the use of both primary and secondary water, a reservoir tank with a capacity of 400 m\(^3\) is required. From the entire water cycle in this project, the daily water looping can be described as shown in Figure 7 and the monthly water looping as shown in Figure 8 below.

![Figure 6 Daily water looping](Source: Personal Analysis)

![Figure 7 Yearly water looping](Source: Personal Analysis)

From the water looping above, it can be seen that not all gray water is converted to secondary water because it depends on the amount of secondary water utilization needed.
4. Concluding remarks
The efforts of water conservation implementation in buildings are very important due to the Increasingly crisis water conditions. Through the application of water conservation from rain water harvesting and recycle gray water, it can save water by 52.8% only with the shape of the building based on temporary assumptions which can be seen in Figure 5. If the building is designed with a shape that adapts to surrounding conditions and maximizes the catchment area rainwater harvesting, the effort to save water can increase higher than before.

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