JURNAL

PLANNING OF CLEAN WATER INSTALLATIONS FOR LUXURY HOMES WITH MODELLING USING AUTODESK REVIT

Diajukan Sebagai Salah Satu Syarat Untuk Memperoleh Gelar Sarjana Teknik Pada Program Studi Teknik Mesin Fakultas Teknik Universitas Muhammadiyah Sumatera Barat

Oleh:

REYHAN STEVANO
20160040

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HALAMAN PENGESAHAN JURNAL

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Planning for clean water installation of luxury homes with modelling using Autodesk Revit

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Abstract

The plumbing system is an integral part of a building. The project in a three-storey luxury house requires the installation of clean water to meet the demands of the occupants of the house. The availability of clean water in luxury homes or multi-storey buildings is needed to help human activities. The luxury house project is located in Sleman, Yogyakarta with a land area of 292 m2. The design process involves several considerations such as choosing a water source, piping layout, and fixture placement to obtain optimal functionality and efficiency. Utilising Autodesk Revit Software is facilitated with advanced design features and functions, enabling proper modelling and visualisation of clean water for installation. This study contributes to the advancement of residential infrastructure planning and design, particularly in luxury residences, by utilising innovative technologies such as Autodesk Revit. Designing the clean water system, it requires the volume capacity of the roof tank and ground tank with the estimation method based on the number of residents. Analysis of clean water installation planning obtained a water demand requirement of 0.039 litres with the need for a Roof Tank with a capacity of 296 Litres and a Ground Tank with a capacity of 1000 litres based on the number of occupants of 8 people.

Keywords : MEP, Plumbing, Luxury House, Water Tank, Autodesk Revit.

1. Introduction

Water is a primary human need. Clean water is one of the main things in need[1]. In the need for water, humans also need a house as a place to live. The types of houses found in Indonesia are Commercial Houses and public Houses. In the world of construction, building modelling, such as BIM (Building information modelling), is a digitalisation mode of building designs and structures. Building information modelling (BIM) is a shared knowledge resource for information about a facility that forms a reliable basis for decision-making[2]. A BIM model containing essential information for all phases of the building cycle enables a seamless transition from design to renovation and provides a reliable place to store and access information[3]. BIM has been widely used in development projects such as housing and high-rise buildings. BIM is divided into several levels, starting from level 0 to level 3. BIM is divided into 3 disciplines Architecture, Structure, and MEP (Mechanical, Electrical Plumbing). Programmes such as BIM have helped many construction workers because they are linked to the coordination of construction project sections[4]. BIM has an efficient and quality infrastructure that can save time, cost and energy[5]. BIM also creates synergies between traditional software methods and algorithm-based approaches for comprehensive energy analysis[6]. In addition, BIM also has the benefit of aiding the integration of architectural, construction, or manufacturing projects[7]. However, the main reason for using the BIM method is the quality assurance of this model[8]. The plumbing system is a system which is like piping with all kinds of accessories, which are needed for a building. Plumbing technology can fulfil needs such as water distribution such as clean water and dirty water[9]. So far, in the planning of clean water installations, there are still many uses of conventional designs that result in very poor planning starting from modelling and analysing calculations manually[10]. MEP is an indispensable consideration during the design and planning process, especially for plumbing. A lot of space in helping the coordination changes from the designer and contractor workers. MEP will be commissioned when the Architect has provided drawings of the plans and visuals provided to facilitate the work[11]. The development spread throughout the country is getting faster and faster, to prevent undesirable things in the planning of plumbing systems. A clear conceptualisation is required.[12]. In making models, of course, many software applications support this work, including Autodesk Revit software. Software made by Autodesk companies such as Revit can create 3D models and plans in detail[13]. In modelling from Autodesk Revit, the simulation of physical characters that appear is very diverse according to their respective disciplines[14]. Revit is divided into several disciplines such as architecture, structural, and MEP. Building information created with Revit, already has a lot of development[15]. Autodesk Revit is a software that can produce details in the form of plans, cuts, perspectives, and scheduling. Revit processes, updates, and documents project designs three-dimensionally in one integrated file[16]. In Revit for the MEP discipline, many functions can be used in manufacturing such as plumbing which builds a system that has high accuracy in a very fast time to make connections or networks for clean water and dirty water, piping with the tools needed based on building needs[17]. The purpose of this planning is to determine the need for water distribution with the existing network system. To facilitate the modelling of luxury homes, it is assisted by Autodesk Revit software so that the planning becomes optimal.

2. The Research Method

In the planning of clean water installations, a calculation method based on building usage is used. This calculation is based on the number of occupants. This calculation is very accurate because the number of occupants has been obtained with exact information. The method of using many occupants is based on the average daily water usage of each occupant of the building.

2.1. Calculation of Clean Water

1. Calculation of water usage in 1 building.

The calculation for one building is calculated in 1 day (Q_d)

$$Q_d \text{ (l/day)} = \text{Number of Users} \times \text{Water usage per person per day} \quad \ldots(1)$$

The number of residents in this project is 8 people, including parents, 3 children, 2 ART, and 1 Security.

To find out the use of building types, following the standards set in the standard (SNI 03-7065-2005)

2. Calculate the value of (Qd) to add the usage of water discharge to cope with emergencies.

$$Q_{d\ Total} = (100\% + \text{Additional water usage}) \times Q_d \quad \ldots(2)$$

3. Calculating average water requirements based on average daily usage (Q_H)

$$Q_H = \frac{Q_d}{t} \quad \ldots(3)$$

Information :
t = water use during working hours.

4. Calculating peak hour water usage. ($Q_{H\ Max}$)

$$Q_{H\ Max} = C1 \times Q_H \quad \ldots(4)$$

C1 has a constant value ranging from 1.5 - 2.0 based on the location and nature of the building.

Table 1. Minimum chilled water usage according to building

No	Building utilisation	Water consumption	Unit
1	Residential House	120	Litres/ Occupant/day
2	Flat House	100	Litres/ Occupant/day
3	Dorms	120	Litres/ Occupant/day
4	Hospital	500	Litres/Patient bed/day
5	Elementary School	40	Litres/Student /day
6	junior high school	50	Litres/Student /day
7	senior high school or higher	80	Litres/Student /day
8	shophouse	100	Litres/residents and staff/day
9	Office/Factory	50	Litres/employee/day
10	Department stores, retail stores	5	Litres/m2
11	Restaurant	15	Litre/Seat
12	Starred Hotels	250	Litres/Bed/Day
13	Jasmine Hotel/Lodging	150	Litres/Bed/day
14	Theatres	10	Litre/Seat
15	Multipurpose Building	25	Litre/Seat
16	Terminal station	3	Litres/Passenger arriving and departing
17	Prayers	5	Litres/person (not with ablution water)

Source: 1) The results of the assessment of the Research Centre for Settlement Development of Dep. Kimpraswil in 2000, 2) Ministry of Health Regulation No: 986/Menkes/Per/XI/1992.

5. Calculating water usage during peak minutes ($Q_{M\,Max}$) .

$$Q_{M\,Max} = C2 \times Q_H \quad \ldots(5)$$

C2 has a constant value between 3.5 - 4.0 based on the location and nature of the building.

2.2 Calculations GWT (Ground Water Tank)

1. Calculating service pipe capacity

$$Q_S = \frac{2}{3} \times Q_H \quad \ldots(6)$$

2. Calculating the volume of GWT

$$\left(Q_S - \left(Q_S \times Q_t\right) \times T\right) \quad \ldots(7)$$

Information :

Q_d = Total water demand per day (m^3 /day)

Q_S = Capacity of service pipeline (m^3/hours)

T = Average usage based on time

3. Determined Ground Reservoir Dimensions

2.3 Calculations RWT (Roof Water Tank)

1. Calculating RWT Volume

$$VE = \left(Q_S - Q_{H\,Max}\right) \times T_P - \left(Q_{PU} \times T_{PU}\right) \quad ..(8)$$

Information :

VE = Volume *Roof Tank* (m^3)

Q_p = Qmmax = Water demand at peak minute (m^3 /minute)

$Q_{H\,Max}$ = Peak hour water demand (m^3 /hours)

2. Roof Reservoir dimensions determined
3. Calculating the Flow Discharge

$$Q = Q_{h\,maks} \ / 3600 \quad \ldots(9)$$

4. Calculating the diameter of clean water pipes from GWT

$$\sqrt[2]{\frac{(4 \times Q)}{v \times n}} \quad \ldots(10)$$

2.3 Flowchart

In planning, the required flow in planning is shown in Figure 1.

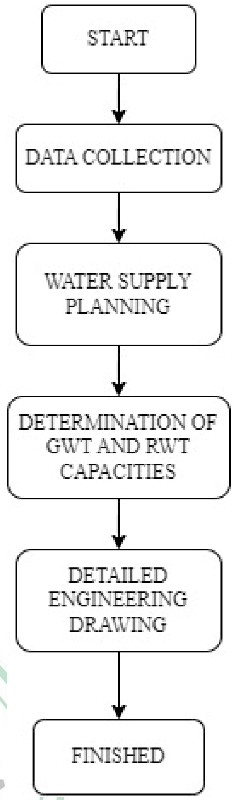


Figure 1. Flowchart

2.4 Equipment and Materials

In the research, the equipment needed is as follows:

1. Computer
   Computer as hardware to do research and work on 3D modelling software.
2. Software Autodesk Revit 2024
   Autodesk Revit is a software from the Autodesk company. Revit has the ability to create accurate 2D models and drawings with powerful visuals. [7].

2.5 Project Area

The research area is located in Salakan, Selomartani Kalasan, Sleman, Yogyakarta.

Figure 2. Project Site Plan

3. Results and Discussion

According to Table 1, it can be determined that the water demand based on occupants is 250 litres per day with a span of 16 hours with a total of 8 occupants.

3.1 Calculation of water demand

1. Calculation of water usage in 1 building. (Q_d)

   Q_d (l/day) = Number of Residents × Individual water consumption per day.

   $Q_d = 8 \times 250$

   = 2000 litre/day = 2 m^3 /day

   From the calculation based on equation 1, the result is 2 m^3 /day.

2. Calculating the value of (Q_d) to add water discharge usage to cope with emergencies

   $Q_{d\ Total}$ = (100% + Additional water consumption) × Q_d

   $Q_{d\ Total}$ = (100% + 30%) × 2 m^3 /day

   = 130 % × 2 m^3 /day

   = 2,6 m^3 /day

   The result of the calculation in emergency usage of 30% is 2,6 m^3 /Day.

3. Determine average water demand based on average daily consumption (Q_h).

   $$Q_h = \frac{Q_d}{t}$$

   $$Q_h = \frac{2600 \text{ L/Day}}{16 \text{ Hours/Day}}$$

   $Q_h = 0{,}1625$ m^3 /hour

   The calculation results show that the average water demand is 0,1625 m^3 /hour because water usage occurs from 6 am to 10 pm.

4. Calculating peak hour water usage $(Q_{h\ maks})$.

   $Q_{h\ maks}$ = C1 × Qh

   $Q_{h\ maks}$ = 1,5 × 162,5 l/hour

   $Q_{h\ maks}$ = 0,24 m3/hour

   Based on the calculation of water usage during peak hours 0,24 m^3 /hour, the constant used for luxury homes is 1.5.

5. Calculating water usage during peak minutes ($Q_{m\ maks}$)

   $Q_{m\ maks}$ = C2 × Qh

   $Q_{m\ maks}$ = (3,0 × 162,5 l/hour) × (1 hour) / 60 Minute

   $Q_{m\ maks}$ = 487,5 l/Hour × (1 hour) / 60 Minute

   $Q_{m\ maks}$ = 0,0078 m^3 /Minute

   The results of the calculation of water usage during peak minutes are 0,0078 m^3 /Minute with the constant used is 3.0.

3.2 GWT (Ground Water Tank) Calculation

The PDAM is considered capable of fulfilling 2/3 of the average daily water demand. This makes it impossible to fulfil the average hourly water demand 100%.

1. Calculating service pipe capacity

   $$Q_s = \frac{2}{3} \times Q_h$$

   $$Q_s = \frac{2}{3} \times 0{,}1625 \text{ m}^3 \text{ / hours}$$

   $$Q_s = 0{,}11 \text{m}^3 \text{ / hours}$$

   The results of the calculation for the service pipe capacity of 0.11 m^3 / hour.

2. Calculating the volume of GWT.

   $$\left(Q_d - (Q_s \times Q_t) \times T\right)$$

   Q_d = 2,6 m^3 /day

Q_s = 0,108 m^3 /Hour

Q_t = 16 hour/day

T = 1 day

Volume Ground Reservoir :

V = $\left(Q_d - \left(Q_s \times Q_t\right) \times T\right)$

V = (2,6 – (0,108 × 16) × 1)

V = 2,6 – 1,733334 × 1

V = 1 m^3

The result of the calculation in determining the GWT (Ground Water Tank) is as follows 1 m^3 or 1000 Litre.

3. Determining Ground Reservoir Dimensions.

After getting the research results, the data obtained for the need for 1000 litres. In the need for GWT (Ground Water Tank), a water reservoir available in the market of 1050 litres is taken.

Spesifications	Connections
Capacity : 1.050 Litre	Inlet : 1 Inch
Thick : 9-11 mm	Inlet : 1 Inch
weight : 26 Kg	Drain : 1 Inch

Figure 3. Water reservoir for GWT needs

The placement of the GWT (Ground Water Tank) on the 1st floor is described as follows.

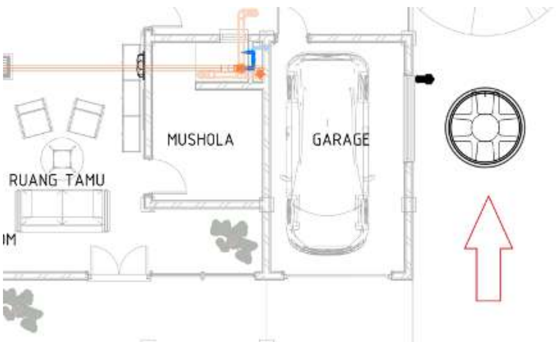


Figure 4. GWT 1st floor plan

3.3 RWT (Roof Water Tank) Calculation

1. Calculating the volume of RWT

$$Q_P = Q_{M\ Maks} = 0,0078\ m^3 / minute$$

$$Q_{H\ Maks} = 0,24375\ m^3 / hour \times \frac{1\ hour}{60\ minute}$$

$$Q_{H\ Maks} = 0,00039 m^3 / minute$$

In the design, the value of Q_{PU} is assumed to be equivalent to Qhmax, which is:

$$Q_{PU} = Q_{H\ Maks}$$

$$= 0,00039 m^3 / minute$$

In addition to this, the system is considered.

T_P = 60 minute

T_{PU} = 30 minute

Based on these data, the effective volume for RWT can then be calculated.

$$V_E = \left(Q_P - Q_{H\ Maks}\right) T_P - \left(Q_{PU} \times T_{PU}\right)$$

$$V_E = \left(0.0078 - 0,00039\right) 60 - \left(0,00039 \times 60\right)$$

$$V_E = 0,4446\ m^3 - 0,0234 m^3$$

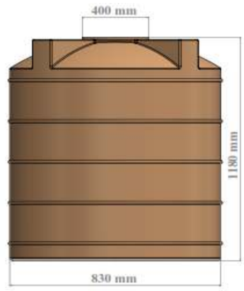
$$V_E = 0,421\ m^3$$

V_E = 421 litres

The result of the calculation for the effective volume requirement of RWT is 0.421 m^3 or 421 litres.

2. Determine the dimensions of the Roof Reservoir.

In this luxury house building, it is planned to use one reservoir for RWT (Roof Water Tank). After being calculated for RWT needs, a result of 421 litres was obtained, but the available use was 520, the water reservoir is depicted in Figure 5.



Spesifications	Connections
Capacity : 520 Litre	Inlet : 3/4 Inch
Thick : 6-9 mm	Outet : 3/4 Inch
weight : 16 Kg	Drain : 3/4 Inch

Figure 5. Water reservoir for RWT needs

3. Calculating flow discharge.

$$Q = \frac{Q_{H\,Maks}}{3600}$$

$$Q = \frac{0,24375}{3600}$$

$$Q = 6,7\ m^3 /\ Second$$

4. Calculating the diameter of the clean water pipe from RWT

$$RWT\ = \sqrt[2]{\frac{(4 \times Q)}{v \times n}}$$

$$RWT\ = \sqrt[2]{\frac{(4 \times 0,000678\ m^3 / Second)}{1\ \times\ 3,14}}$$

$$RWT\ = 0,057\ m$$

$$RWT\ = 57\ mm$$

After getting all the results of the calculation, the three-storey luxury house building, planning the use of pipelines using Rucika pipes for clean water needs. The size obtained from the calculation is 57mm, because the production of pipes with a diameter of 57mm does not exist, then use the nearest size pipe which is 65mm or 2 ½ ‘.

5. Luxury home design modelling

After calculating all the needs of clean water installation planning, a visual house plan is obtained using Autodesk Revit 2024 software as shown in Figure 6.

Figure 6. 3D house with Autodesk Revit 2024

After making a 3D visual model of the house, a clean water system network was made with Autodesk Revit along with plumbing equipment as shown in Figure 7.

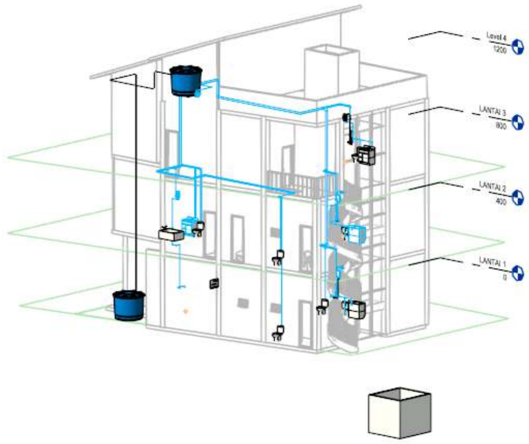


Figure 7. Water supply network system with Autodesk Revit 2024

4. Conclusion

In planning a clean water installation for a 3-storey luxury house located in the Salakan area, Selomartani Kalasan, Sleman, Yogyakarta, with 8 residents, getting a result of 2000 litres/day with GWT needs of 1050 litres, then for RWT needs of 520 litres. By modelling using Autodesk Revit get the results of a clean water system network visually.

Reference list

[1] Asep Gustiawan, Muchlisinalahuddin, dan Rudi Kurniawan Arief, “Analisis Kebutuhan Debit Air dan Menentukan Jenis Pompa Yang Digunakan Untuk Perumahan 13 Raya Permai,” JTTM: Jurnal Terapan Teknik Mesin, Vol. 3, No. 1, pp. 19–26, 2022.

[2] Sarvari, H., Chan, D. W. M., Rakhshanifar, M., Banaitiene, N., & Banaitis, A., “Evaluating the Impact of Building Information Modeling (BIM) on Mass House Building Projects,” Journal of Building, Vol. 10, No. 2, pp. 1–16, 2020.

[3] Yuvita, R. L., dan Budiwirawan, A., “Analysis of the Advantages and Disadvantages of Using Autodesk Revit for the Dean Building of the Faculty of Education, Universitas Negeri Semarang,” Jurnal Teknik Sipil Dan Perencanaan, Vol. 24, No. 2, pp. 91–98, 2022.

[4] Loeh, R., Everett, J. W., Riddell, W. T., & Cleary, D. B., “Enhancing a Building Information Model for an Existing Building with Data from a Sustainable Facility

Management Database," Sustainability, Vol. 13, p. 7014, pp. 1–18, 2021.

[5] Pan, X., Khan, A. M., Eldin, S. M., Aslam, F., Rehman, S. K. U., & Jameel, M., "BIM adoption in sustainability, energy modelling and implementing using ISO 19650: A review," Ain Shams Engineering Journal, Vol. 15, pp. 1–21, 2024.

[6] Tahmasebinia, F., Lin, L., Wu, S., Kang, Y., & Sepesgozar, S., "Advanced Energy Performance Modelling: Case Study of an Engineering and Technology Precinct," Journal of Building, Vol. 14, p. 1774, pp. 1–47, 2024.

[7] Rahimian, F. P., Chavdarova, V., Oliver, S., Chamo, F., & Amobi, L. P., "OpenBIM-Tango integrated virtual showroom for offsite manufactured production of self-build housing," Automation in Construction, Vol. 102, pp. 1–16, 2019.

[8] Valinejadshoubi, M., Moselhi, O., Iordanova, I., Valdivieso, F., Shakibabarough, A., & Bagchi, A., "The Development of an Automated System for a Quality Evaluation of Engineering BIM Models: A Case Study," Journal of Applied Science, Vol. 14, pp. 1–31, 2024.

[9] Jatmika, B., Maulana, I., Al-Faqih, R., Zouda, R. A., dan Maksim Viktorovich, O., "Analysis Of Clean Water And Hot Water Needs Plumbing System In The Building," International Journal of Engineering and Applied Technology (IJEAT), Vol. 4, No. 2, p. 1, 2021.

[10] Rofi, K. A., Hapsari, R. I., Riskijah, S. S., Harsanti, W., Dharmawan, M. A., dan Rahman, T., "Building Information Modelling for clean water and wastewater system in the medium rise school building," IOP Conference Series: Materials Science and Engineering, Vol. 1073, No. 1, p. 012067, 2021.

[11] Lu, Q., dan Wong, Y. H., "A BIM-based approach to automate the design and coordination process of mechanical, electrical, and plumbing systems," HKIE Transactions Hong Kong Institution of Engineers, Vol. 25, No. 4, pp. 273–280, 2018.

[12] Pahpayungi, A., dan Darpito, H., "PERANCANGAN SISTEM PLAMBING PADA BANGUNAN WISMA MESS SEPOLWAN CIPUTAT," Jurnal TechLINK, Vol. 6, No. 2, 2022.

[13] Dyah Ayu, P. P., Indri Hapsari, R., Manajemen Rekayasa Konstruksi, M., Teknik Sipil, J., Negeri Malang, P., dan Jurusan Teknik Sipil, D., "PERENCANAAN SISTEM AIR BERSIH DAN AIR BUANGAN DENGAN BIM PADA PEMBANGUNAN HOTEL GRAND MIAMI KEPANJEN," Vol. 3, Issue 3, 2022.

[14] Shaurya Thareja, M., dan Chand, E. J., "Effective Analysis of Highrise Structure Buildings in Autodesk Revit Bim (Building Data Modeling) vs Autocad," (n.d.).

[15] Ramadhan, M. A., dan Maulana, A., "Pemahaman Konsep BIM melalui Autodesk Revit bagi Guru SMK Teknik Bangunan se-Jabodetabek," Wikrama Parahita: Jurnal Pengabdian Masyarakat, Vol. 4, No. 1, pp. 47–52, 2020.

[16] Pratiwi, S. S., & Budiwirawan, A., "Eksplorasi Pemodelan Gedung Dekanat Fakultas Teknik Universitas Negeri Semarang Menggunakan Software Autodesk Revit," Dinamika Teknik Sipil: Majalah Ilmiah Teknik Sipil, Vol. 15, No. 1, pp. 8–17, Juli 2022.

[17] Teo, Y. H., Yap, J. H., An, H., Yu, S. C. M., Zhang, L., Chang, J., dan Cheong, K. H., "Enhancing the MEP Coordination Process with BIM Technology and Management Strategies," Sensors, Vol. 22, Issue 13, 2022.