DESIGNING A MECHANICAL ELECTRICAL AND PLUMBING (MEP) INSTALLATION OF HOTEL ACACIA JAJAR

Proposed as one or the requirements to complete the degree of Bachelor of Engineering at Department of Electrical Engineering, Faculty of Engineering

by:

<u>IKA PURYANTO</u>
D 400 122 007

DEPARTMENT OF ELECTRICAL ENGINEERING
FACULTY OF ENGINEERING
UNIVERSITAS MUHAMMADIYAH SURAKARTA
2017

APPROVAL PAGE

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PUBLICATION JOURNAL

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IKA PURYANTO

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This journal has been checked and approved by:

Supervisor

Agus Supardi, S.T., M.T.

NIK.883

AFFIRMATION PAGE

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Has been tested in front of The Council of Examiners
Faculty of Engineering
Universitas Muhammadiyah Surakarta
On 27 July 2017
and affirmed to complete the requirements

The Council of Examiners:

1. **Agus Supardi, S.T., M.T.** (……………..)
   (Ketua Dewan Penguji)
2. **Aris Budiman, S.T., M.T.** (……………..)
   (Anggota I Dewan Penguji)
3. **Ir. Jatmiko, M.T.** (……………..)
   (Anggota II Dewan Penguji)

The Dean of Faculty,

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Ir. Sri Sunarjono, M.T. Ph.D.

NIK. 682

ACKNOWLEDGEMENT

With this acknowledgement I declare that in this final project, by all my knowledge, there is no proposed final project before in same or different university before this journal is being published.

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Surakarta, 24 July 2017

Writer

IKA PURYANTO

D 400 122 007

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Abstract

Hotel Acacia Jajar is one type of accommodation engaged in lodging services, food and beverage providers and other services for the public who are managed commercially. The hotel operates 24 hours a day, without a holiday to serve the general public who want to use hotel services. Dense activity in the hotel resulted in the need for high electrical energy, so the need for a mature planning in the construction of a hotel in order to produce a proper hotel and energy saving. Energy saving is important because the current global energy management paradigm puts energy saving as the first energy source. In this case the researcher doing the installation of Acacia Jajar Hotel building which put forward the reliability and efficiency of electric energy. To be able to produce a reliable electrical installation and energy efficient need careful planning, ranging from the selection of energy-efficient power tools until the right calculation. One example is the use of LED lights for lighting that has an efficiency of up to 80%. This electrical installation plan, includes lights installation, AC (Air Conditioner), water pump, and lifts that will be drawn into AutoCAD Software. And also this research aims to simulate the installation by using DIALux Evo Software. The result of this plan shows that the imaginary power (S) total which is needed is 650568.26 VA/ 650.57 KVA with a main security system such as 1250 A 3-phase MCCB (Molded Case Circuit Breaker) and 4 x 300 mm^2 NYFGbY conductor.

Keywords: AutoCAD, DIALux Evo, electrical installation, energy saving, LED lights

Abstrak

Hotel Acacia Jajar merupakan salah satu jenis akomodasi yang bergerak dalam bidang jasa pelayanan penginapan, penyedia makanan dan minuman serta jasa lainya bagi masyarakat umum yang dikelola secara komersial. Hotel ini beroprasi selama 24 jam sehari, tanpa adanya hari libur guna melayani masyarakat umum yang ingin menggunakan jasa hotel. Padatnya aktifitas didalam hotel mengakibatkan kebutuhan energy listrik yang cukup tinggi, sehingga perlu adanya perencanaan yang matang didalam pembangunan sebuah hotel guna menghasilkan hotel yang tepat guna dan hemat energy. Penghematan energy menjadi penting mengingat paradigma pengelolahan energy global saat ini menempatkan penghematan energy sebagai sumber energy pertama. Dalam hal ini peneliti melakukan perencanaan instalasi gedung Hotel Acacia Jajar yang mengedepankan kehandalan dan efisiensi energy listrik. Untuk dapat menghasilkan instalasi listrik yang handal dan hemat energy perlu perencanaan yang matang, mulai dari pemilihan alat-alat listrik hemat energy hingga perhitungan yang tepat. Salah satu contoh digunakanya lampu LED untuk penerangan yang memiliki efisiensi hingga 80%. Perencanaan listrik ini meliputi, instalasi penerangan, pendingin ruangan *(Air Conditioner)*, pompa air, dan lift yang akan dituangakan kedalam program AutoCAD serta dilengkapi dengan analisis penentuan titik lampu dengan menggunakan program DIALux Evo. Hasil perancangan menunjukan bahwa, total daya semu (S) yang dibutuhkan sebesar 650568.26 VA/ 650.57 KVA dengan pengaman utama MCCB *(Molded Case Circuit Breaker)* 3 fasa sebesar 1250 A dan penghantar utama (2) NYFGbY 4 x 300 mm^2.

Kata kunci: AutoCAD, DIALux Evo, instalasi listrik, hemat energi, lampu LED

1. INTRODUCTION

The need of electrical energy in Indonesia raises in every year, that is because of the technology development in this era. Most of the fields need electricity to operate their machines, so this will cause excessive electricity consumption. The number of electricity consumption affects the production of electricity itself. Which is the most electricity production sources used in Indonesia is fossil, that available in limitation. There are some ways to solve this problem, which one of it is by optimizing the lights placement of rooms (Miroslav Badida, et al. 2011).

Almost all buildings need lights, and this fact forces government to provide electricity. So, to save the energy, we need to plan the building construction to be efficient in the terms of lights placement. To produce an efficient building, we need a good plan to consider all aspects. One of the aspect is considering the electrical devices. The electrical devices choice will push the total amount of energy that is used in the building. Since LED Lamp was founded in 1990s, LED Lamp gave the solution as low-energy-consuming light source until today. With high energy efficiency, LED Lamp also provides maximum illumination and also durability more than the normal lamp (Ana Serrano, et al. 2015).

The hotel is one of a building that need plan to have good efficiency in all aspects to provide security and pleasure to the costumers. And Hotel Acacia Jajar is one of the buildings that consumes a lot of electrical energy. To get the maximum light design, we need to simulate the illumination, so the calculation will be more accurate and suitable to the user. To do this illumination design, digital lab is needed. Because this kind of lab provides the easiest to design than physical labs (Prasasto Satwiko, 2011). The commonly used software that support this illumination design simulation is DIALux Evo. Deluxe Evo also supports the electrical installation plan. Then this software will be used to compare the difference between manual calculation and simulative calculation. This software also can be used to retrofitting from old lamps to the new LED technology (Roberto FARANDA, et al. 2011).

Electricity needs in a building is not only laid on lamp installation, but also covers many aspects. The electrical energy plan of a building is usually called MEP, this method covers electrical installation, Air Conditioner, water pump, and lift. Which is in each component need a good calculation and plan to get the best building construction design. Because of that, we need a good formula to reach that goal. These are the formula and the components that are needed to finish this research:

1.1 Current Rate Nominal

Considerating the Current Rate Nominal is to decide the ability of MCB or security component that will be used.

For one phase load:

$$Ia = \frac{P}{V_{L-N}.Cos\varphi} \tag{1}$$

For three phases load :

$$Ia = \frac{P}{\sqrt{3}.V_{L-L}.Cos\varphi} \tag{2}$$

Which :

Ia	= Arus nominal (A).
VL-N	= Phase-neutral voltage (V).
VL-L	= Phase-phase voltage (V).
P	= Output power of load (W).
Cos φ	= Power factor.

1.2 Current and Voltage

If in an electrical circuit consist current (I), voltage (V) and resistance (R), then Ohm Law (Ω) is applied in that circuit.

$$I = \frac{V}{R}\ , \qquad R = \frac{V}{I}\ , \qquad V = IxR \tag{3}$$

Which:

I	= Current (ampere).
V	= Voltage (volt).
R	= Resistance (ohm).

1.3 Armature Placement

This is how we determine the placement of the armature in a room:

a. The first step that we need to do is calculating the kind of the lamp/armature and how many lamps that will be used in every point.

b. Determining the reflection factors (including rp, rw, and rm) of the rooms according to the floor color, wall, and palate.

c. Calculating the room index (k), which the formula is described below:

$$k = \frac{lxw}{h(l+w)} \tag{4}$$

Which :

P	= Length of a room (m).
l	= Width of a room (m).
h	= Height between lamp and floor (m).

d. After determining the reflection factor and room index, then the room efficiency (η) can be known from “Tabellen Voor Verrlichting” by Philips.

e. Illumination Intensity (E) that is needed, determined according to the room function by considering the Indonesian National Standard (SNI 03-6575-2001). For instance, Court room and ballroom, according to the SNI, the both rooms use the illumination intensity at 200 lux.

f. Flux of the light that is needed in a room can be known from the formula below:

$$\Phi o = \frac{ExA}{\eta} \text{ (new product)} \tag{5}$$

or

$$\Phi o = \frac{ExA}{\eta x d} \quad \text{(old/second product)} \tag{6}$$

So the total number of lamp or armature (n) can be determined by the following formula:

$$n = \frac{\Phi o}{\Phi lamp} \tag{7}$$

1.4 Power

a. Real power

$$P = VICos\varphi \tag{8}$$

b. Apparent power

$$S = VI \tag{9}$$

c. Reactive power

$$Q = VISin\varphi \tag{10}$$

d. Power Factor and triangle power

$$\mathrm{Cos}\,\varphi = \frac{\mathrm{P}}{\mathrm{S}} \tag{11}$$

Which:

P = Active power (W)

S = Apparent power (VA)

Q = Reactive power (Var)

From the above equation graphically can be described as follows:

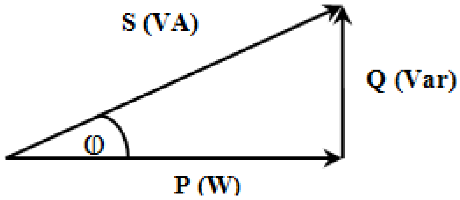

Figure 1. Power triangle diagram.

1.5 Electrical Installation components

On electrical installation, we need to prepare the components that are needed. And the components must be considered by the rule of *Peraturan Umum Instalasi Listrik* (PUIL 2000).

a. Cable
b. Switches
c. Lamp Fittings
d. Plug Terminal
e. MCB & MCCB

1.6 AC capacity calculation

This is the method of how to calculate the AC capacity that is needed in a room:

(L x W x H x I x E) / 60 = Need BTU (13)

Which:

L = Room Length (feet).

W = Room width (feet).

H = Room height(feet).

I = The value is 10 if the room is insulated (located on bottom or between rooms);
The value is 18 if the room is not insulated (located on the top of a building).

E = The value is 16 if the longest wall faces north;
The value is 17 if faces east;
The value is 18 if faces south;
The value is 20 if faces west.

1.7 Lift capacity calculation

These are the steps of how to calculate the lift capacity:

a. Determine the building population
b. Determine the pHC (Handling Capacity Percentage)
c. Determine the HC (Handling Capacity)
   = pHC x Building Population (14)
d. Determine the lift specification
e. Determine the RT (Round Trip)
f. Determine the Car Passenger Capacity (P)
g. Determine the Lift needs:

$$h = \frac{300xp}{RT} \tag{15}$$

$$N = \frac{Hc}{h} \tag{16}$$

Which:

N = Total amount of lift
Hc = Handling Capacity
h = The capacity of lift at one lifting

1.8 Grounding System

A grounding system installation plan is very important in tall buildings. Because this system is a protection of a building from lightning thunder. Good placement of a grounding system can reduce the risk of destruction from thunder.

1.9 Clean water needs

In daily life, human being cannot live without clean water. From drinking needs, cooking, taking a bath, and washing, all of those activities cannot be acquired without clean water. So, we need a plan to get the clean water to reach the goal to provide a good environment in a building.

The making of this final project aims to design a MEP that is equipped with DIALux Evo simulation for determining the placement of lamps to acquire the optimum illumination. So this research can be a reference for Electrical Engineering students on understanding the MEP design. Otherwise, this research can describe the benefits of lamps placement optimization, despite the benefit of DIALux Evo itself. And also to realize the importance of pushing the consumption behavior that is related to electrical energy through this illumination optimization method.

2. METHOD

Method is importance part of a research, this part will decide whether the goal is going to be reached or not. The first step that is needed to be done is study of literature, by collecting data, to be the fundamental theories to support this research. This data can be acquired through books and scientific journals. Beside basic theories, the thing that we must have is Hotel Acacia Jajar layout picture, AutoCAD software, and DIALux Evo software that make up the whole research process.

After the data has been collected, then is conducting a manual calculation of electrical needs on the building. The next step is taking a sample in a room of the building by calculating the lamp point with DIALux Evo software. And we can analyze the two data results from conducting those two methods. And the final step is putting the calculations into the Hotel Acacia Jajar layout picture.

3. RESULTS

3.1 Lamps Placement Calculation

3.1.1 Large Meeting Room Manual Calculation

This room length is 15 m x 11 m width, the area is 165 m^2, and the height of light source of the room from the floor is 2.4 m. We use 1 x LED Bulb 13 Watt, with 1300 lumen. According to the SNI standard, this room needs 200 lux of illumination intensity. To determine the total number of lamps, we need to concern on illumination efficiency (η). This illumination efficiency is affected by the room index (*k*) and reflection factor. Reflection factor in this room is; rp=7, rw=5, and rm=1. And the room index (*k*) can be found with this formula:

$$k = \frac{lxw}{h(l+w)} = \frac{15x11}{2.4(15x11)} = 2.64$$

After finding the room index and the reflection factor, so the value of illumination efficiency (η) can be found with this formula:

k = 2.5 : η= 0.59

k = 3 : η= 0.61

for k = 2.64 then:

$$\eta = 0.59 + \frac{2.6-2.5}{3-2.6}(0.61-0.59) = 0.60$$

So for the value of k = 2.8 the illumination efficiency is 0.60

To find the value of the light flux is:

$$\Phi o = \frac{ExA}{\eta} = \frac{200x165}{0.60} = 55000 \quad lumen$$

To illuminate the large meeting room, we need 55000 lumen of light. So, the total lamp that we need is:

$$n = \frac{\Phi o}{\Phi lamp} = \frac{55000}{1300} = 42.31 \quad lamps$$

So the total lamp that we need in the room is 42 lamps.

3.1.2 Large Meeting Room DIALux Evo Analysis

For the calculation of lamp using DIALux Evo can be done by designing the room that is going to be calculated. So the DIALux Evo can provide the estimation of the total number of lamp that we need automatically. The placement of lamps can be done automatically with software or according to what the owner wants. We can see the result of illumination visually from the software. So when the light is not matched with our need, we can manipulate it again.

By using DIALux Evo software the Large Meeting Room only requires 35 lamps, more efficient than manual calculation. And this figure is showing us the Large Meeting Room DIALux Evo analysis.

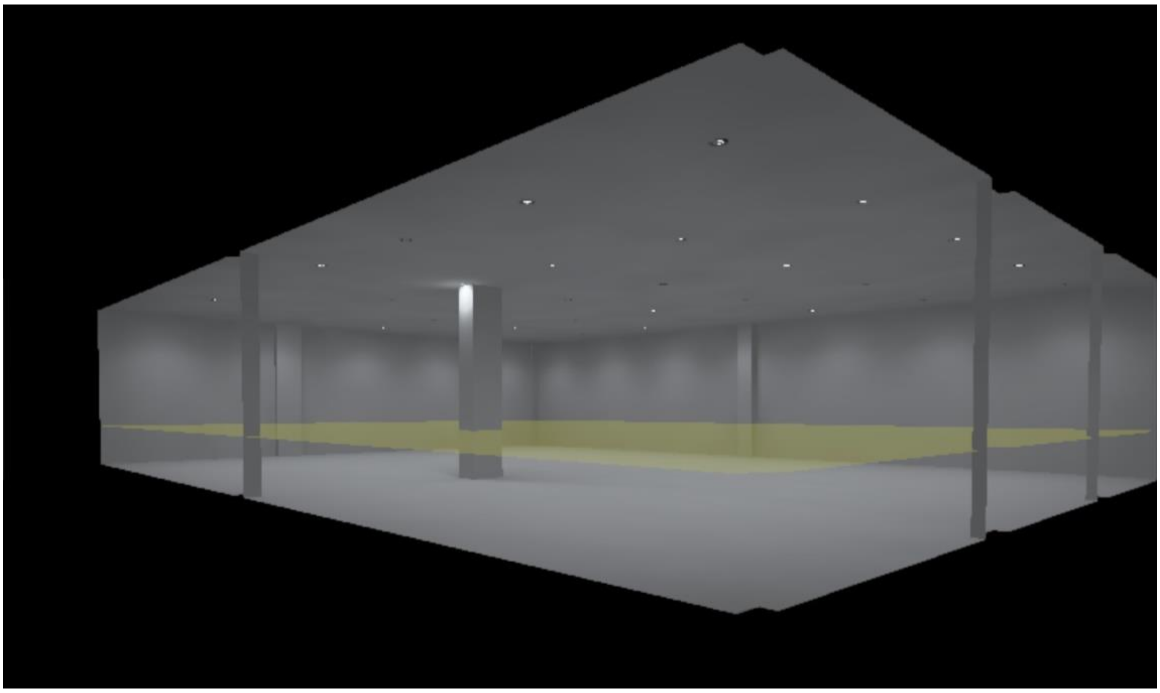

Figure2. Large Meeting Room DIALux Evo analysis in 3D view.

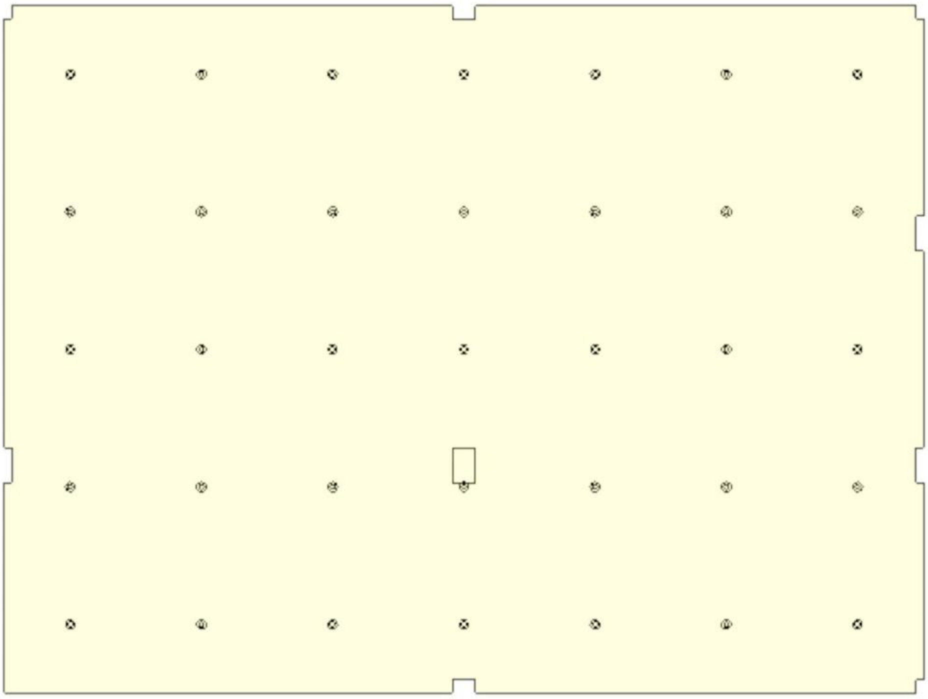

Figure 3. Large Meeting Room DIALux Evo analysis in 2D view.

3.1.3 Other Rooms

For other rooms light placement, we use the similar method in large meeting room. The further explanation can be seen on the appendix 1 and 2.

3.2 AC Capacity

AC (Air Conditioner) length, width, and height parameters calculation should not be in meter unit, we need to convert it to feet unit, which 1 meter feet is equal to 3.28 feet.

1. Large Meeting Room

This room length (L) is 49.2 feet, the width (W) is 36.1 feet, and the height (H) is 10.5 feet. With those parameters, this room insulation (I) is 10 and the value of E is 16, so the need of AC can be found with this way:

$$(L \times W \times H \times I \times E)/60 = (49.2 \times 36.1 \times 10.5 \times 10 \times 16)/60 = 49684.9 \text{ BTU}$$

Then in this room, we need AC that produce 49684.9 BTU. So 7 units of AC split with 1 PK (9000 BTU) are needed. For the other rooms, we can calculate with the same way above.

2. The complete calculation can be seen on appendix 1 and 2.

3.3 Water Pump

To supply clean water, this building uses 1 ground tank with capacity 100 m^3 and 4 roof thanks with total capacity 24 m^3. Because of that we need a water pump that is able to supply the water need on each water tank. To supply clean water at ground tank, we use 2.2 kW deepweel pump that can handle 8 m^3/hour with maximum 70 m range of height. So, by using this deepweel pump, the ground tank will be full of water in 12.5 hours. To supply water to the roof tank, we use 2x1.13 kW transfer pump that can handle 8 m^3/hour with maximum 54 meters range of height. By using this transfer pump, we can make the roof tank full in 3 hours.

In this building, 0.37 kW booster pump is also used to supply water in each bathroom. This aims to make the water presssure on floor 9, 8, and 7 more balanced and the water supply on roof tank to be stable.

3.4 Distribution of Electrical Power

3.4.1 2nd Basement Floor

Lamp + Exhaust Fan, Terminal plug, Split AC, and Central AC

a. Phase R = 3.89 + 20 + 2.27+ 0 = 26.15
b. Phase S = 4.23 + 20 + 4.55+ 0 = 28.77
c. Phase T = 4.16 + 20 + 0 + 0 = 24.16

The total capacity of power (S) at SDP (Sub Distribution Panel) on 2nd Basement Floor is 79.08 A x 220 V = 17398.75 VA. For the security system, we use 32 A 3-phase MCCB (Molded Case Circuit Breaker) and 4 x 4 mm^2 NYY conductor that handle 44 A.

3.4.2 1st Basement Floor

Lamp + Exhaust Fan, Terminal plug, Split AC, and Central AC

a. Phase R = 6.77 + 30 + 0 + 34.43 = 71.19
b. Phase S = 7.11 + 30 + 0 + 34.43 = 71.54
c. Phase T = 7.02 + 30 + 0 + 34.43 = 71.44

The total capacity of power (S) at SDP (Sub Distribution Panel) on 1st Basement Floor is 214.17 A x 220 V = 47118.25 VA. For the security system, we use 80 A 3-phase MCCB (Molded Case Circuit Breaker) and 4 x 16 mm^2 NYFGbY conductor that handle 98 A.

3.4.3 1st Floor Lamp

Lamp + Exhaust Fan, Terminal plug, Split AC, Central AC

a. Phase R = 13.81 + 40 + 4.55 + 113.27 = 171.63
b. Phase S = 13.66 + 40 + 3.41 + 113.27 = 170.35
c. Phase T = 14.09 + 40 + 3.41 + 113.27 = 170.77

The total capacity of power (S) at SDP (Sub Distribution Panel) on 1st Floor is 512.74 A x 220 V = 112803.76 VA. For the security system, we use 200 A 3-phase MCCB (Molded Case Circuit Breaker) and 4 x 70 mm^2 NYFGbY conductor that handle 228 A.

3.4.4 2nd Floor

Lamp + Exhaust Fan, Terminal plug, Split AC, and Central AC

a. Phase R = 8.20 + 30 + 43.18 + 44.1 = 125.48
b. Phase S = 7.98 + 30 + 46.59 + 44.1 = 128.67
c. Phase T = 7.76 + 30 + 46.59 + 44.1 = 128.45

The total capacity of power (S) at SDP (Sub Distribution Panel) on 2nd Floor is 382.6 A x 220 V = 84173.5 VA. For the security system, we use 250 A 3-phase MCCB (Molded Case Circuit Breaker) and 4 x 95 mm^2 NYFGbY conductor that handle 271 A.

3.4.5 3rd -9th Floor

Lamp + Exhaust Fan, Terminal plug, Split AC, and Central AC

a. Phase R = 48.74 + 10 + 0 + 12.64 = 71.38
b. Phase S = 48.59 + 10 + 0 + 12.64 = 71.23
c. Phase T = 43.48 + 10 + 0 + 12.64 = 66.12

The total capacity of power (S) at SDP (Sub Distribution Panel) on 3rd – 9th Floor is 208.73 A x 220 V = 45921.49 VA. For the security system, we use 200A 3-phase MCCB (Molded Case Circuit Breaker) and 4 x 16 mm^2 NYFGbY conductor that handle 98 A.

3.4.6 Lift Panel

This building uses 3 lifts, each lift has 15 kW of power capacity

$$Ia = \frac{P}{\sqrt{3}.V_{L-L}.Cos\varphi} = \frac{15000}{\sqrt{3}.380.0,8} = 28,4A$$

Added at current phase R 0.05 A of lamp load and phase T 2.27 A of AC load. The total power (S) capacity at SDP (Sub Distribution Panel) per lift is 87.52 A x 220 V = 19753.8 VA. For the security, 32 A 3-phase MCCB (Molded Case Circuit Breaker) is used and 4 x 4 mm^2 NYY conductor that can handle 44 A of current.

3.4.7 Water Pump Panel

1. 2.2 kW 3-phase Deepweel pump

$$Ia = \frac{P}{\sqrt{3}.V_{L-L}.Cos\varphi} = \frac{2200}{\sqrt{3}x380x0.8} = 4.178A$$

10 A 3-phase MCCB and 4 x 2.5 mm^2 NYM conductor are used.

2. 1.13 kw 3-phase Transfer pump

$$Ia = \frac{P}{\sqrt{3}.V_{L-L}.Cos\varphi} = \frac{1130}{\sqrt{3}x380x0.8} = 2.15A$$

10 A 3-phase MCCB and 4 x 2,5 mm^2 NYM conductor are used.

3. 0,37 kW 1 phase Booster pump

$$Ia = \frac{P}{V_{L-N}.Cos\varphi} = \frac{370}{220x0.8} = 2.1A$$

10 A 1 phase MCB and 3 x 2,5 mm^2 NYM conductor are used..

Total loads :

a. Load R = 4.178 + (2 x 2.15) + (2 x 2.1) = 12.674 A
b. Load S = 4.178 + (2 x 2.15) + (2 x 2.1) = 12.674 A
c. Load T = 4.178 + (2 x 2.15) + (2 x 2.1) = 12.674 A

The total capacity of power (S) at water pump SDP is 38.02 A x 220 V = 8364.8 VA. For the security, we use 16 A 3-phase MCCB and 4 x 2.5 mm^2 NYY conductor that can handle 25 A of current.

After we know the power usage of each floor, then we need to know the total power that is already installed on Building Hotel Acacia Jajar:

The total power of 2nd Basement Floor + The total power of 1st Basement Floor + The total power of 1st Floor + The total power of 2nd Floor + The total power of 3rd – 9th Floor + The total of power of 3 lifts + The total of power of water pump.

Total = 17398.75 VA + 47118.25 VA + 112803.76 VA + 84173.5 VA + (7 x 45921.49 VA) + (3 x 19753.8) + 8364.8 VA

= 650568.26 VA

$$Ia = \frac{S}{\sqrt{3}xV_{L-L.}} = \frac{650568.26}{\sqrt{3}x380} = 989.6A$$

MDP (Main Distribution Panel) is a place that consists a mian security system, or we can say as main panel. The security that is inside the MDP must be able to handle the whole loads on basement floor 2, basement floor 1, floor 1, floor 2, floor 3-9, lifts, and water pumps. In the main security, 1250 A 3-phase MCCB (Molded Case Circuit breaker) and 4 x 300 mm^2 NYFGbY that can handle 600 A are installed in parallel.

3.5 Grounding System

The Building Hotel Acacia Jajar has 85 m of length, 50 m of width, 46 m of height, and 4250 m^2 of area. So this building needs a grounding system that can protect itself from thunder. And an electrostatic grounding system is used, because this kind of grounding system is a modern grounding system that uses E.S.E (Early Streamer Emission). E.S.E system works actively by releasing huge amounts of ion into the air before the thunder strike. By releasing ions to the air will automatically will make a way to break through directly to the metal of the grounding system. With this E.S.E system, the thunder protection will cover more area than the conventional one.

The ionizing method of lightning protection came from the inspiration of J. B. Szillard, who presented his idea in a paper read to the Academy of Sciences in Paris on March 9, 1914. Gustav P. Carpart, who was also a colleague of Madame Curie, patented the first ionizing lightning method in 1931(Donald W. Zipse, 1994).

4. CONCLUSION

According to the conducted analysis of the Building Hotel Acacia Jajar electricity installation, so we can conclude:

a. DIALux application is very helpful to plan a lamp installation, and in the analysis we can choose some kinds of lamp that are being used, the spread of light that is produced by the lamps and easily simulate the illuminance and 3-D virtual.
b. The power needed for this building reaches 650568.26 VA / 650.57 KVA by using 1250 A 3-phase MCCB and 4 x 300 mm^2 NYFGbY conductors that can handle 600 A Which are installed in parallel.
c. This building uses 800 KVA of PLN power source and 800 KVA from power generator (when PLN power supply goes down).

ACKNOWLEDGEMENT

Praise be to Allah *Azza wa Jalla*, Who always guide my heart and hand, So I can finish my final project journal. Peace be upon Prophet Muhammad *Shallaullahu 'Alaihi Wasalam* and His companion. Thanks to my parents, who always support me in any situation. Thanks to all my friends, who always accompany me while in hard condition. Also the honorable, Mr. Agus Supardi, as my supervisor in this final project, even me doing some mistakes in this process.

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