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Study of Agung Sleman Mosque Minaret Construction Design: Errors and Solutions

Ala Ali Qasem Alraimi, Muhammad Ikhsan Setiawan, Adi Prawito
Departement of Civil Engineering, Narotama University Surabaya
engala39@gmail.com, ikhsan.setiawan@narotama.ac.id, adi.prawito@narotama.ac.id

Abstract

This study helps to solve the problem at the minaret of Agung Mosque which costs about (Rp16.000.000.000), located in Yogyakarta city, Indonesia, Sleman street, where its high sixty seven meters from the ground and it consists of fifty floors, where analyze and prove the safety of the minaret dome, replace the dome, repair the fallen parts from middle floors, and calculate the total cost of replacing the dome and repairing fallen parts of the minaret. This study proved that the existing design reinforcement of the dome is totally safe, estimated the total cost of solving the minaret problems which (Rp2, 281,873,633.54). Where the total costs of replacing the dome were (Rp2, 073,135,813), the total costs of fixing the damaged “fallen” parts of the middle floors were (Rp1, 294,762.24), and the total of the unexpected costs were (Rp207, 443,057.59)

Keyword:
Design, Dome, High Construction, Minaret

1. Introduction

The minaret in Arabic, it is a word derived from the verb “Adhan". This means a tall tower that is attached to mosques and is designed to convey the sound of the call of prayer people and call them to pray. In English, it’s a tall slender tower, typically part of a mosque, with a balcony from which a muezzin calls Muslims to their prayers.

1.1. History of minaret:

Many different theories about the origin of the minaret and it is historically confirmed that after the completion of the construction of the Almasjid Alnabawii Alsharif, the muezzin of the prophet Bilal bin Rabah had to climb one of the closest and tallest houses near from the mosque to bring his voice to the inhabitants of "Medina", From that moment on all history of Islam, the idea crystallized to expand the scope of this spiritual voice crystallized, the core of the idea was based on the fact the higher the person lifts off the ground, the greater the sound dispersion of his voice. (Ibrahim, 2022)

1.2. The minaret geometrically:

Architectural and engineering composition of the lighthouses is summed up in a square body that rises from the building of the mosque; this style was transferred to the Maghreb and the countries of Andalusia, and it was developed starting from the sixth century hijra and the design of the minarets differed with the passage of time and the different Islamic cities, the minaret, regardless of its location in the mosque, consists of an entrance that is inside the courtyard and then the ascent staircase, which is usually an internal spiral that revolves around the axis of the minaret, and reaches the high balconies that surround the body of the minaret. (Tarchaoui B. , 2017).

This study uses the descriptive approach where data, conclusions, and hypotheses are collected and tested to arrive at engineering solutions that help to solve the problem of the Agung Sleman Mosque minaret, through questions and inquiries, and meetings with both the project manager and supervisors, and the company who build this project which Dinas Pekerjaan Umum, Perumahan, dan Kawasan Permukiman company in Yogyakarta city, Indonesia, and through the database, designs and the blueprints for the project that obtained by the researcher from the construction company that own the minaret project officially.

2. Literature review

This study differs from previous studies many faces, namely in the total project cost of the project, the type and amount of materials used in the construction of the minaret of Agung Sleman Yogyakarta Mosque minaret, The massive weight of the dome, and the high altitude of this minaret that topped by the iron dome, also the time during which the investigation was carried out between 2021 - 2022. The terms of the minaret age, the construction was completed in 2018 and the technical problems and errors appeared in 2021.

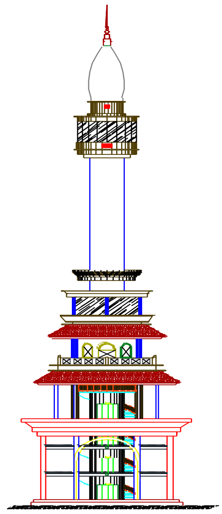

Figure 1. Agung Sleman mosque minaret construction design. (Mulia, 2017)

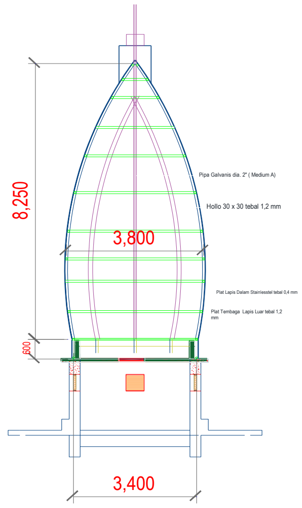

Figure 2. Agung Sleman mosque minaret dome construction design. (Mulia, 2017)

1. Based on (Asaad Alomari et al.2020), Calculate the bearing capacity of Al-Hadba minaret foundation, the elements of the permissible soil bearing capacity of the minaret foundation are analyzed. It is assumed that the foundation rests on the clay layer at a depth of 9 m, the square base is 15 x 15 m, the internal friction angle φ = 29 degrees, and cohesion c = 21 kPa. The stresses were reduced along the southeast corner of the minaret foundation from 761 kPa to 561 kPa for normal soils.
2. Based on (Zerari Sami et al. 2020), highlight the formal and stylistic features of the columns on the basis of the minarets selected in chronological order. The main criterion for classifying minarets according to their morphological features is the formation of the column, whether it is pyramidal, prismatic, and conical or hybrid.
3. Based on (Mohammed Alajmi et al. 2022), analyze the hierarchy of the minaret section according to different design patterns. The tall, towering minarets are often preserved because they are a direct result of the mosque's size. The column and the base are the two most important elements in the architecture of minarets.
4. Based on (Asaad Al-Omari et al. 2021), reconstruction of the missing parts, as the dome was destroyed, but the minaret is still standing. Debris of the original brick material was collected (the dome and part of the cylindrical body of the minaret) near the minaret, reused by crushing and reshaping to create new molds in the same shape as the original bricks.
5. Based on (Wulan Astrini et al. 2019), observation, collection of primary data, to test theories by examining relationships between variables. The minaret of the Sabilillah Malang Mosque is about 45 meters high, the minaret is divided into two parts: The body and the top of the minaret. The body is hexagonal in shape, 38 meters high. In the body there are four rectangular slots on each side and are arranged vertically.

6. Based on (College of fine arts, University of Baghdad, Iraq. 2018), Find the collection of stalactites in the minaret of a mosque (Alkhalafaa). The stalactites of the minaret begin in a decorative line with brick paving where they protrude like a rope twisted between the circle of the basin and the trunk of the minaret.
7. Based on (Muhammad Fatih et al. 2019), the actual function of the minarets and their suitability to the current architecture. The minaret exists only as an aesthetic sight as a unit in the design philosophy of the entire mosque complex and minarets are present in contemporary mosques necessarily to serve functional needs.
8. Based on using a series of 16 small arches to construct the inner dome in the style of "mold". The Kallon Minaret was built in 1127, which is topped by a high dome.
9. Based on (Pinar Usta. 2021), the preserve historical building minarets and pass them on to future generations by performing finite element modeling and linear dynamic structural analyzes of Antalya Kesik Minaret. Antalya Kesik Minaret has the lowest displacement value due to the absence of the upper part of it. Yivli Minaret was the least affected by pressures due to its different thick structure.
10. Based on (Safaeianpour, Ali et al. 2022), modify the dimensions and shapes of the bricks to form trapezoidal shapes. Several tire belt training sessions that contain different gear patterns. This study provided new interpretations regarding practical solutions to implement girih patterns on the curved surface of the Minaret, as reducing the distance between the bricks helped to maintain the engineering integrity to a large extent.
11. Based on (Ashadi, Ashadi. 2021), interpreting the results of the comparison on how the process of architectural acculturation occurs. The construction of the Kudus Minaret is a cultural product between the Hindu culture represented by the building of the temple, and the Javanese culture represented by the crown building, and Islam represents the function of the call to prayer among these three elements.
12. Based on (Mohammad, Arif, Kamal. 2021), Review the different functional aspects of minarets and their evolution in history. Islamic architecture entered northern India who used to construct minarets as symbolic elements in buildings from Persia through Afghanistan via the Turks. The minaret has become a symbol of Islamic architecture, whether used separately or attached to the mosque.
13. Based on (Kimence, Bahattin. 2020), modeling of two types of minarets, similar to the properties and their contrast, according to the height of each, so that the ratio of the thickness of the mortar to the total thickness is 0.6 and 0.2. Period, horizontal displacement of minarets, characteristic model andف he anisotropic models are very close to each other. The anisotropic effect of the solution increases with increasing thickness of the slurry.
14. Based on (Sahar, Diab. 2020), Creating a new function for the minaret to give it a contemporary look in line with contemporary technology. Developing legislation and orientation to modernity and using modern technology to formulate the new features of minaret architecture. Government agencies collaborated with designers to come up with a mature architectural form for mosque architecture, minarets to break out of the traditional design.
15. Based on (Farhana Binti Safar, et al. 2021), analyze the building plan by identifying the entry point and movement pattern. Observe and identify architectural elements that portray the usage of natural elements. The roof is supported by four columns in the middle of the mosque creating a large indoor space - for warm air to ventilate upwards to the upper level. The minaret built of bricks and shaped like a pagoda within the mosque complex.
16. Based on (Holik A.A.R et al. 2017), collecting data on mosque architecture using field observation for mosque architecture. The minaret is designed in harmony with the building, the materials made of Karawangan, the simple design without any frills, and the simple shape, the presence of the minaret expands the sound of the call to prayer.

3. Research Method

Gathering the greatest amount of data and information about the problem, developing hypotheses or questions conjecturing solutions to the problem given it, providing explanations and performing statistical analysis, extracting conclusions and clues, and testing hypotheses to ensure their reliability or not using descriptive method. This study was completed in Yogyakarta city, Indonesia, street of Parasamya, Beran Lor, Tridadi, Kec. Sleman, Kabupaten Sleman, Daerah Istimewa 55511. This study was completed during the years 2021- 2022, starting in December and ending in April.

1. Getting the permission from the director of the masjid Agung Sleman minaret project, during the researcher requests a research permit and a university ethical letter.
2. Field visit to the engineering company specialized in building the minaret and requesting references, books and final reports for the construction of the minaret.
3. The field visit to the minaret project site and request permission from the project supervisors.
4. Obtaining official permission and permits from the engineering company, and the project manager and supervisors.

5. With the help of the project manager, the researcher searches and collects data from records of the construction of minarets in the same city, recording data and observations by age, height, location and materials used in construction.
6. The researcher categorizes the obtained data according to meeting the required criteria.
7. The researcher investigates the appropriateness of the quality of the materials used in the construction of the minaret according to both the American and the Indonesian engineering cod.
8. The researcher is investigating the accuracy of the engineering designs that were used in the construction of the minaret in general and the dome of the minaret in particular.
9. The researcher extracts engineering errors that occurred during the construction process, which are summarized in the weight of the dome of the minaret and the difficulty of lowering it and installing new ones, which prove the safety of the dome, the thickness of dome plate and the fallen parts at the middle floors.
10. The researcher presents the results sequentially and in conformity with the engineering standards.
11. The researcher presents suitable solutions for the restoration and repair of minaret Masjid Agung Sleman Yogyakarta.

4. Finding And Discussion

1. Structural analysis of a concrete plate exposed to the pressure of the dome of the minaret and proof of its safety.

a. calculation of dome plate and the body mass

1) Based on the calculations of dome plate load and the body mass, using the materials, galvanized pipe, hollow steel, stainless plate, and copper plate. Through the calculation of each of density, area, coefficient ratio, thickness and the volume the data was taken from the minaret reports. Results showed that the dome weight (Total body mass) is equal to (1019.13 kg/m^3).

2. The strength of the plate concrete base under the pressure of the dome, through assuming that the data design of the dome plate structure is a rectangle shape each of the following should be calculated:

a. Dome plate concrete dimensions

Based on the (Mulia, 2017), plate dimensions are 4.7m for the length, 2.2mofr the width and 10cm for the thickness.

b. Dome plate concrete strength

Based on the (Mulia, 2017), plate concrete strength is 14.99 Mpa.

c. Dome plate concrete steel type

Based on the (Mulia, 2017), the plate concrete steel type should be (BJ 37).

d. Dome plate concrete moment calculation

Based on the calculations and by dividing (ly/lx). Results showed that (ly/lx) is equal to 2.136363636, where ly is the length and lx is the width of the dome plate concrete. Through the moment calculations in the table of (Mlx) and (Mly) above. Results showed that Mlx equal to 91 and Mly equal to 17, where (Mlx) or indeed (-Mtx) is the moment at join of the plate and (Mly) is the moment in the middle of plate.

e. Dome load

Based on the (Mulia, 2017), the dome load should be equal to 1019.128842 kg/m^2.

f. Dome plate concrete area

Based on (Chair & Secretary, 2018), the formula to find the area is $A = \pi \text{ X } (R^2\text{-}r^2)$. Where (A) is the area, (π) equal to 3.14, (R^2) is the radius of the circle, r^2 is the diameter of the circle. Based on the calculations. Results showed that (A) is equal to 9.550441667 m^2, where(R) is equal to 2.3, (r) is equal to 1.5.

g. Dome plate concrete dead load

Regarding on the (Mulia, 2017), and the soft drawings the plate dead load should be equal to 2400 x 0.1, and it could be 240 kg/m^2.

h. Area load of dome plate

Based on (Chair & Secretary, 2018), 2018, the formula to find the area load of dome plate is (q) and it's equal to (dome weight) $\div \pi \times (R^2\text{-}r^2)$, which actually could be (The load of them / Area), and the load of the dome is equal to 1019.128842 kg/m^2 as the calculation showed before and (Area) where indeed it's $\pi \times (R^2\text{-}r^2)$, and equal to 9.550441667 m^2,as the calculation showed before. Results showed that area load of dome plate is equal to 106.7101269 kg/m^2, and through collecting the area load of the dome plate + Dead load of the plate the, results showed that final area load of dome plate is equal to 346.7101269 kg/m^2.

Regarding to Source: (ITS, 2002), the moment in a rectangular slab table and by calculating (Mlx) where the moment in a rectangular slab of (Mlx) is (0.001) multiplied with the (Area load dome plate) which equal to 346.7101269 kg/m^2, and multiplied with the (width of the dome plate) which equal to (2.2m) and multiplied with the moment in a rectangular slab table of (Mlx) that equal to (0.001) which equal to (91), results showed that (Mlx) is equal to 152.7050083 kgm, and by calculating (My) where the moment in a rectangular slab of (Mly) is (0.001) multiplied with the (Area load dome plate) which equal to 346.7101269 kg/m^2, and multiplied with the (length of the dome plate) which equal to (4.7m) and multiplied with the moment in a rectangular slab table of (Mly) that equal to (0.001) which equal to (17), results showed that (Mly) is equal to 130.200054 kg/m.

i. Reinforcement ratio

Based on (SNI - 1729:2015), the formula to find the ρmin is (ρmin is equal to 1.4/fy), where (fy) is the type of the steel which (BJ37), through the calculation, Results showed that ρmin is equal to 0.005833333.

j. (ρmin) and (ρmax), calculation

Based on (ITS, 2002), the formula to find the (ρmax) is (ρmax) equal to 0.75 multiplied with (β) multiplied (fc') and divided by (240Mpa), multiplied with 0.85, and multiplied with (600) that divided by (600) plus (240Mpa). Where the (ρmax) is equal to 0.75 multiplied with 0.85 which the (ρmin), multiplied with the concrete strength which (fc') and its equal to 14.99, divided by (fy) which the type of the steel which (BJ37), and it's equal to 240Mpa, multiplied with 0.85, multiplied with (600) that divided by (600) plus 240 Mpa. Results showed that the (ρmax) is equal to 0.024174721.

k. (d), calculation

Based on the calculation (d) is the effective height and its equal to (0.07m). Where (d) is equal to (The thickness – the diameter of steel reinforcement – the specification), which would be (10 – 2 – 1) and it's equal to (7cm) and by changing from (cm) to (m) it's going be (0.07m).

l. (b), calculation

Based on the (Mulia, 2017), (b) is the beam width and its equal to 1000mm, and by changing from (mm) to (m) it would be (1m).

m. (***Φ***), calculation

Regarding to the calculation (***Φ***) should be (0.8). Where (***Φ***) equal to the total of (d), which the effective height plus (b), which the beam width and it's going equal to 0.007, and by approximate (0.007) it would be (0.8).

n. Calculate of ultimate moment in the middle of the plate

Based on (PBI-1971 & SNI 2847-2002), where (Mlx) is the moment at join of the plate and (Mly) is the moment in the middle of plate. Mu is equal to (- Mtx) where its means (Mlx) and it's equal to 152.705 kgm. Regarding to the calculation of (Mlx) above where (Mlx) = (- Mtx) = 152.7050083 kgm.

o. (Rn), calculation

Based on (SNI - 1729:2015), where (Rn) is equal to (Mu) divided by Φ which the total of (b) and (d), multiplied with (b) which the beam width, and multiplied with (d^2) which the effective height and through the calculation it's equal to 38955.359 kg/m^2, which actually equal to 0.53 Mpa by changing from kg/m^2, to Mpa.

p. (ω), calculation

Based on (SNI - 1729:2015), where (ω) is equal to 0.58 multiplied with (1 subtracted from the root of 1 subtracted from 2.353 multiplied with (Rn) which equal to 0.53 Mpa and divided by (fc') which equal to 14.99 Mpa. Through the calculation, results showed that (ω) is equal to 0.0361.

q. using ρmin for design

Based on (SNI - 1729:2015), where (ρ) is equal to (ω) which is equal to 0.0361, multiplied with (fc') which is the concrete strength, and divided by (fy) which is the steel type of (BJ37). Through the calculation (ρ) is equal to 0.00226 which is bigger than (ρmin) which is the minimum generator power, where it's equal to 0.00583.

r. Using ρmin for design to calculate (As)

Based on (SNI - 1729:2015), where (As) is equal to (ρmin) which is the minimum generator power, where it's equal to 0.00583, multiplied with (b) which the beam width, and multiplied with (d) which is the effective height and through the calculation. (As) is equal to 0.000408333m^2, and by changing from m^2 to mm^2 it would equal to 408.3333333 mm^2.

3. The existing design is using steel reinforcement diameter 10 mm with distance 150 mm

s. Calculate the existing design using steel reinforcement diameter (10 mm) with distance (150 mm), area of steel diameter (10 mm) which equal to (78.53981634 mm^2), total steel need where it's equal to (5.199061474), distance steel reinforcement which equal to (192.3424074 mm). Through the calculations above the existing design reinforcement is totally safe.

4. Analysis the total cost of replacing the dome of minaret masjid Agung Sleman Yogyakarta and the damaged parts of the middle floors of the minaret.

t. Preparation work

Based on the (Mulia, 2017), the preparation work types that should be done during this study are: clearing the land, mobilization, and disposal. Through the calculation, result showed that the total cost of clearing the land is (Rp2, 000,000), mobilization total cost is (Rp30, 000,000), and disposal total cost is (Rp2, 000,000). Therefore the total cost for preparation work is (Rp34, 000,000).

u. Dome slab concrete work using concrete type of (fc = 14.5 Mpa) for each (1m^3) and labor cost calculation

Based on the (Mulia, 2017), one of the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) that should be done during this study is labor cost which contains collection of works such as: Worker, craftsman, and foreman. Through the calculations, result showed that the total cost for Workers is (Rp25, 928.57), craftsman total cost is (Rp4, 821.43), and foreman total cost is (Rp1, 660.00). Therefore the total cost of labor cost is (Rp32, 410.00).

v. Dome slab concrete work using concrete type of (fc = 14.5 Mpa) for each (1m^3) and material cost calculation

Based on the (Mulia, 2017), one of the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) that should be done during this study is material cost which contains collection of works such as: Ready concrete mix K-175, steel, begistis plate and scaffolding, and unload formwork. Through the calculations, result showed that the total cost of ready concrete mix K-175 is (Rp791, 972), the steel total cost is (Rp737, 820), and begistis plate and scaffolding total cost is (Rp2, 427,210), and unload formwork total cost is (Rp103, 950). Therefore the total cost of the material cost is (Rp4, 060,952).

w. Dome slab concrete work using concrete type of (fc = 14.5 Mpa) for each (1m^3) and equipment cost calculation

Based on the (Mulia, 2017), one of the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) that should be done during this study is equipment cost which contains collection of works such as: Concrete vibrator, concrete pump, and the device. Through the calculations, result showed that the total cost of concrete vibrator is (Rp1, 000,000), concrete pump total cost is (Rp5, 000,000), and (Rp500, 000). Therefore the total cost of the equipment cost is (Rp6, 500,000).\

Based on the calculations for each of labor cost, material cost, and equipment cost, results showed that the total cost for the dome slab concrete work types using concrete type of (fc = 14.5 Mpa) for each (1m^3) is (Rp10,593,362).

x. Dome replacing work

Based on the (Mulia, 2017), the dome replacing work types that should be done are: Crane mobilization and demobilization, crane rental, steel work, and welder. Through the calculation, result showed that the total cost of crane mobilization and demobilization is (Rp8, 000,000), crane rental total cost is (Rp279, 730,000), steel work total cost is (0), and welder total cost is (Rp386, 285.71). Therefore the total cost of dome replacing work is (Rp288, 116,285).

y. Dome lighting and finishing works

Based on the (Mulia, 2017), dome lighting and finishing works types that should be done are: Special panel sport lamp and tovur cable, spotlight high (CR; COB 30 watt 2700K 23 IP65), Lummens (21001m) and cable installation (Zone), Ledstnpught (26 watt/ meter 2700K 90 IP65 24V) and cable installation (Zone 2), Ledstripught (26 watts / meter 2700K 90 IP65 24V) and cable installation (Zone 3), Stripught (24V) Led Driver (320 watt 13.4A IP65) and cable installation (Zone 2&3), Ledspot Rgb (40 Chips-14R, 14G, 128 - 115 watts 15), rgb spot led (40 Chips-14R, 146.128 115 watt 45 IP66 220V) and cable installation (Zone 4), Rgb controller compatible with Led spot rgb (40 Chips-14R, 146.128), led wall washer (20 watt 9x multichip rgbw 30' IP66 220V) and cable installation (Zone 5), rgb controller compatible with led wall washer (20 watt 9xMultichip), led stripught IQ watts/meter rgb (IP68 24V) and cable installation (Zone 6), rgb controller compatable with led stripught (10 watt/ meter), 24V 150 watt IP65 driver + cable installation (Zone 6), Zone 2 and 3 Installation -strip light, Zone 2 & 3 Installation – Driver, (AM724T) Zone 4 Installation, Zone 4 Installation and (CMX), Zone 5 Installation (graze 9Q AM711 CAT), Zone 5 Installation and (CM), Zone 6 strip light rgb Installation, Zone 6 Installation and DMX, Zone 6 Installation and driver, and Old MX custom panel box Installation.

Through the calculation, result showed that the total cost of Special panel sport lamp and tovur cable is (Rp19, 250,000), spotlight high (CR; COB 30 watt 2700K 23 IP65), Lummens (21001m) and cable installation (Zone) total cost is (Rp79, 200,000), Ledstnpught (26 watt/ meter 2700K 90 IP65 24V) and cable installation (Zone 2) total cost is (Rp18,425,000), Ledstripught (26 watts / meter 2700K 90 IP65 24V) and cable installation (Zone 3) total cost is (Rp18,425,000), Stripught (24V) Led Driver (320 watt 13.4A IP65) and cable installation (Zone 2&3) total cost is Rp8,613,000, Ledspot Rgb (40 Chips-14R, 14G, 128 - 115 watts 15) total cost is (Rp230,560,000), rgb spot led (40 Chips-14R, 146.128 115 watt 45 IP66 220V) and cable installation (Zone 4) total cost is (Rp228,800,000), Rgb controller compatible with Led spot rgb (40 Chips-14R, 146.128) total cost is (Rp15,290,000), led wall washer (20 watt 9x multichip rgbw 30' IP66 220V) and cable installation (Zone 5) total cost is (Rp71,016,000), rgb controller compatible with led wall washer (20 watt 9xMultichip) total cost is (Rp7,782,500), led stripught IQ watts/meter rgb (IP68 24V) and cable installation (Zone 6) total cost is (Rp19,580,000), rgb controller compatable with led stripught (10 watt/ meter) total cost is (Rp1,320,000), 24V 150 watt IP65 driver + cable installation (Zone 6) total cost is (Rp5,115,000), Zone 2 and 3 Installation -strip light total cost is (Rp20,676,100), Zone 2 & 3 Installation – Driver total cost is (Rp546,150), (AM724T) Zone 4 Installation total cost is (Rp6,387,648), Zone 4

Installation and (CMX) total cost is (Rp19,680,022), Zone 5 Installation (graze 9Q AM711 CAT) total cost is (Rp2,789,024), Zone 5 Installation and (CM) total cost is (Rp9,584,811), Zone 6 strip light rgb Installation total cost is (Rp827,044,000), Zone 6 Installation and DMX total cost is (Rp9,136,011), Zone 6 Installation and driver total cost is (Rp819,225), old MX custom panel box Installation total cost is (Rp1,200,000). Through the calculations, results showed that the total cost of dome lighting and finishing works is (Rp1, 621,239,491.00).

z. Peel coating finishing work

Based on the (Mulia, 2017), peel coating finishing works types that should be done are: Dome coating finishing, and enamel and galvalume cross 20 - 25. Lightweight steel frame. Through the calculations, results showed that the total cost of enamel and galvalume cross 20 - 25. Lightweight steel frame is (Rp117, 036,675). Therefore the total cost of peel coating finishing works is (Rp117, 036,675).

1. Dome upholstery finishing works

Based on the (Mulia, 2017), dome upholstery finishing works type that should be done is: Finishing of the dome coating of lightweight enameled iron and galvalume cross 20-25 cm. Through the calculations, results showed that the total cost of dome upholstery finishing work is (Rp117, 036,675). Therefore the total cost of dome upholstery finishing work is (Rp2, 073,135,813).

2. Fixing the damaged part of the middle floors Plafond ceiling repair of (IV), and (V) Floors
   1) Based on the (Mulia, 2017), fixing the damaged part of the middle floors plafond of the (IV) floor ceiling repair works type that should be done are: Hollow metal stud ceiling frame, gypsum ceiling 6 mm, kalsi board ceiling 6 mm, and gypsum ceiling paint. Through the calculations, results showed that the total cost of hollow metal stud ceiling frame is (Rp199, 237.50), gypsum ceiling 6 mm total cost is (Rp77, 713.90), kalsi board ceiling 6 mm total cost is (Rp88,124.30), and gypsum ceiling paint total cost is (Rp33,312.68).
   2) Based on the (Mulia, 2017), fixing the damaged part of the middle floors plafond of the (V) floor ceiling repair works type that should be done are: Hollow metal stud ceiling frame, gypsum ceiling 6 mm, kalsi board ceiling, and gypsum ceiling paint. Through the calculations, results showed that the total cost of hollow metal stud ceiling frame is (Rp448, 284.38) gypsum ceiling 6 mm total cost is (Rp174, 856.28), kalsi board ceiling total cost is (Rp198, 279.68), and gypsum ceiling paint total cost is (Rp74, 953.53). Therefore the total cost of fixing the damaged “fallen” parts of the middle floors plafond of the (V) and (IV) floors ceiling repair work is (Rp1, 294,762.24).
   3) This study estimated the total cost of solving the minaret problems which: Structural analysis of a concrete plate exposed to the pressure of the minaret dome and proof of its safety, and analysis the total cost of replacing the dome and the damaged parts of the middle floors of the masjid Agung Sleman minaret. Based on the calculations above, the results showed that the existing design reinforcement of the plate concrete under the dome pressure is totally safe, the total cost of replacing the dome is (Rp2, 073,135,813), the total cost of fixing the damaged “fallen” parts of the middle floors plafond of the (V) and (IV) floors ceiling repair is (Rp1, 294,762.24).
   4) This study estimated the total cost of unexpected costs, through adopting the ratio 10% from total cost of operations that done to solve the minaret problems and it was around (Rp207, 443,057.59). This study proved the safety of the concrete plate under the pressure of the dome where it’s totally safe, estimated the total cost for solving masjid Agung Sleman minaret problems which (Rp2, 281,873,633.54). Based on the engineering company expectations the total cost of solving the minaret problems would be around (3.000.000.000 – 4.000.000.000). This study estimated and the total cost of solving the minaret problems during this study are around (2.000.000.000 – 2.500.000.000).

5. Research Result

This study solved the minaret masjid Agung construction problems that emerged after four years of construction completion, through analyzed two main points. Where prove the minaret dome safety, calculated the total cost of replacing the dome and repairing the middle floors plafond ceiling which the fourth and fifth floors damage “fallen” parts. Several operations are fulling under these points mentioned below:

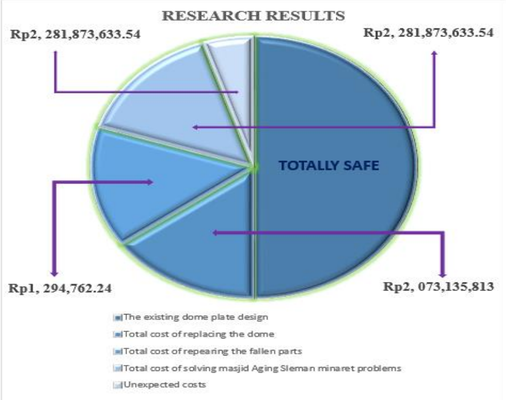

Figure 1. Research Result

1. Dome minaret safety

Based on calculations, in this study the minaret dome safety has been proven. Through analyzing and substantiation the safety of the plate concrete that incur beneath dome pressure through proving that the existing design of concrete plate under the pressure of the dome is totally safe.

2. The total cost of replacing the dome

Based on calculations, this study reached the total cost of replacing the dome from the minaret that rise sixty seven maters from the ground which (Rp2, 073,135,813).

3. The total cost of repairing the middle floors damage “fallen” parts

Based on calculations, this study reached the total cost of repairing the middle floors damage “fallen” parts, where the fourth and fifth floors from the minaret, which (Rp1, 294,762.24).

The chart above in this study shows the size of the discrepancy between the total costs of the Al-minaret project from its establishment until its restoration, where the chart showed that the total costs of the project are around (14.000.000.000 - 16.000.000.000), the total costs of the engineering company expectations are around (3.000.000.000 – 4.000.000.000), and the total cost of solving the minaret problems during this study are around (2.000.000.000 – 2.500.000.000).

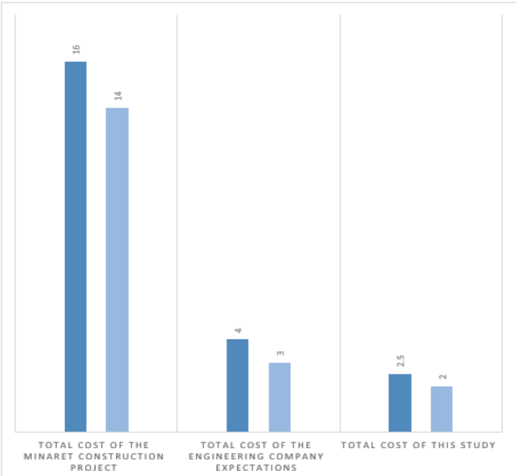

Figure 2. Research Result

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