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Accuracy Test of Qibla Direction of Qowiyuddin Mosque Jagir Wonokromo Surabaya

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Abstract: *This study was conducted to examine the accuracy of the Qibla direction of Masjid Qowiyuddin in Jagir Wonokromo, which is a crucial aspect of performing prayers (shalat) for Muslims. The instruments used in this research included the Mizwala Qibla Finder, Right-Angled Triangle, and Theodolite, each serving to ensure the precise measurement of the Qibla direction. Using a descriptive qualitative approach, the researcher collected primary data through interviews and direct field measurements, as well as secondary data from various literature references. The results showed a deviation in the Qibla direction by 23°49'12" to the north from the mosque's current orientation, indicating the need for an immediate correction to ensure accurate alignment for worship. The urgency of this accuracy test is high, as the correct Qibla direction is a requirement for the validity of prayers. Therefore, it is recommended that the mosque's management adjust the Qibla direction based on these findings and regularly verify its accuracy to avoid errors that could affect the quality of worship for the congregation.*
Keywords: *Qibla Direction, Mosque, Mizwala Qibla Finder, Right Triangle, Theodolite.*

Abstrak: *Penelitian ini dilakukan untuk menguji akurasi arah kiblat Masjid Qowiyuddin di Jagir Wonokromo, yang merupakan salah satu aspek penting dalam pelaksanaan ibadah shalat bagi umat Muslim. Instrumen yang digunakan dalam penelitian ini meliputi Mizwala Qibla Finder, Segitiga Siku-Siku, dan Theodolit, yang masing-masing berfungsi untuk memastikan ketepatan pengukuran arah kiblat. Dengan menggunakan pendekatan kualitatif deskriptif, penulis mengumpulkan data primer melalui wawancara dan pengukuran langsung di lapangan, serta data sekunder dari berbagai referensi literatur. Hasil penelitian menunjukkan adanya penyimpangan arah kiblat sebesar 23°49'12" ke arah utara dari arah bangunan masjid 270°13'48" ke arah azimuth kiblat 294° 3' 00'', yang menunjukkan bahwa koreksi arah kiblat perlu segera dilakukan untuk memastikan keakuratan dalam pelaksanaan ibadah. Urgensi dari pengujian ini sangat tinggi karena arah kiblat yang benar merupakan syarat sahnya shalat. Oleh karena itu, disarankan agar pengurus masjid melakukan penyesuaian arah kiblat berdasarkan hasil pengukuran ini dan secara berkala memeriksa akurasi arah kiblat untuk menghindari kesalahan yang dapat mempengaruhi kualitas ibadah jamaah.*
Kata Kunci: *Arah Kiblat, Masjid, Mizwala Qibla Finder, Segitiga Siku-Siku, Theodolit.*

A. Introduction

Qibla, which linguistically means 'facing,' is the direction Muslims should point to when praying, namely to the Kaaba in Mecca. (Anaam et al., 2023) Those who are close to the Kaaba should face it directly, while those who are far away should simply point in its direction. (Amir, 2020) Mosques, Muslim places of worship, often experience changes in Qibla direction over time due to various factors, such as geographical changes or building modifications. Ancient mosques in Indonesia, which are hundreds of years old, used to determine the Qibla direction based solely on natural observations, before the existence of more precise calculation techniques. (Ridha, 2023, p. 57). Apart from these reasons, usually ancient mosques were built with the important direction of the building facing west due to Indonesia's position east of the ka'bah. (Utami & Awaludin, 2021, p. 79)

The author is interested in researching the Qowiyuddin Mosque in Surabaya, which was founded in 1786 by Mbah Qowiyuddin, a descendant of Sunan Gunung Jati. This mosque, located on Jagir Street, Wonokromo, is one of the historical mosques that has an important value, both in terms of culture and religion. Given the urgency of the importance of accurate Qibla direction in the performance of prayers, there has been no similar study that specifically evaluates the Qibla direction of this mosque, even though it has been operating for more than two centuries. This is an academic gap that underlies the importance of testing the Qibla accuracy of the Qowiyuddin Mosque, especially because the wrong Qibla direction can affect the validity of worship.

This study aims to test the accuracy of the mosque's Qibla direction using three measurement methods: Mizwala Qibla Finder, Right Triangle, and Theodolite. These tools were chosen because each has specific advantages in measuring Qibla direction with high accuracy. The Mizwala Qibla Finder is known as a practical tool in direct Qibla direction measurement, while the Right Triangle is used to determine precise angles in geometric calculations. Theodolites, which are often used in topographic surveys, play an important role in ensuring that Qibla direction measurements are made with great accuracy.

The purpose of this research is to make a real contribution to the community, especially the congregation of Qowiyuddin Mosque, by ensuring that their Qibla direction is in accordance with the correct standard. In addition, the results of this study are expected to be a reference for other researchers who are interested in conducting similar tests in other mosques, especially those with historical value. Thus, this research not only provides practical solutions, but also strengthens academic studies in the field of Qibla direction measurement.

B. Method

Seeing the object of research studied by the author in the form of testing the accuracy of the Qibla direction of the mosque building, the type of method that is suitable for conducting this research is by using field research methods. This method requires the researcher to come directly to the location of the research object in order to obtain and collect data about the situation / state of the place referred to in the research discussion (Sugiyono, 2021). In the context of the approach, the author uses a descriptive qualitative approach. Qualitative was chosen because it allows the author to understand the context and in-depth details about the object of research (Setiawan, 2018). In the case of the Qibla direction accuracy test, this approach allows researchers to explore contextual factors that may affect the accuracy of Qibla direction, such as the history of Qibla direction determination. Descriptive is between data and facts that have been obtained and then elaborated in the form of a narrative (Setiawan, 2018). The description in this study includes the history of the construction of the mosque, the method used when initially determining the facing of the mosque building, the direction data of the Qowiyuddin mosque building, the data on the results of the Qibla azimuth, and the data facts resulting from the accuracy of the Qibla direction.

There are two sources of research data. 1. Primary data source. 2. Secondary data sources. Primary data sources are interviews with Mr M. Amir Hamzah as the takmir of the Qowiyuddin mosque and the results of the accuracy of the Qibla direction at the Qowiyuddin mosque. While the secondary data sources include supporting references related to the discussion about Qibla direction and the methods/instruments used in the accuracy of Qibla direction such as those taken from 'the book *Falak Science: The Basics of Practical Hisab* by Akh. Mukarram' and "The book of *Falak Science From History to Theory and Application* by Siti Tatmainul Qulub", "Mizwala Qibla Finder" a falak instrument by Hendro Setyanto as well as sources from books, websites, and the results of scientific papers that complement the author's writing. The data collection techniques that the author uses are 3: 1) Interview with the takmir of the Qowiyuddin mosque to explore the history of the Qowiyuddin Mosque. 2) Observation of the Qowiyuddin mosque and measuring the Qibla direction to determine the accuracy of the direction of the building against the results of measuring the Qibla direction. 3) Documentation of references from books, websites, and the results of scientific papers that contain information on the author's writing. Furthermore, in analysing the data, the author chose to use descriptive analysis, namely describing the data on the direction of the Qowiyuddin mosque building which was then matched with the results of the Qibla direction accuracy to answer the accuracy of the Qibla direction of the Qowiyuddin mosque.

C. Results and Discussion

1. Brief Description of the Qowiyuddin Mosque

a. Profile and History of the Qowiyuddin Mosque

Qowiyuddin Mosque, located on Jagir Street, Wonokromo, Surabaya, is one of the oldest mosques in the city. Founded in 1786 by Mbah Qowiyuddin, the seventh descendant of Sunan Gunung Jati, the mosque measures 117 x 9 metres with an area of about 13 square metres. As the oldest mosque in the South Surabaya area, it was built long before Indonesia's independence. (Ahmad, 2023)

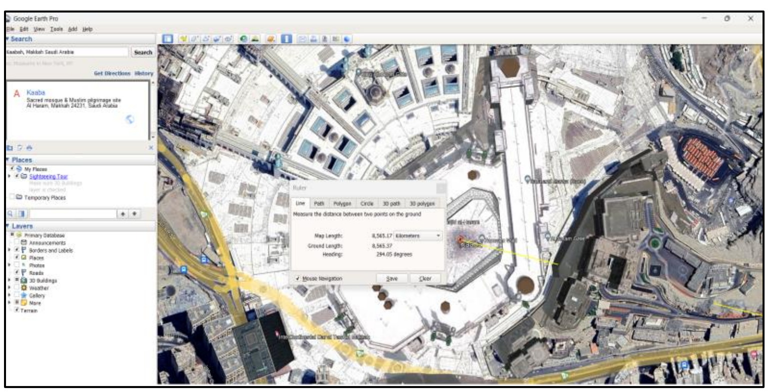
The management of the Qowiyuddin Mosque is currently carried out by Mbah Qowiyuddin's great-grandson who is accommodated in a Qowiyuddin Mosque Foundation, including the support system of the mosque Takmir in carrying out various activities. This foundation also organises educational facilities, both in the form of formal and non-formal ones, namely in the form of 'YAMASQO' Kindergarten, TPQ 'Qowiyuddin', and building Diniyah Schools. Due to its strategic location, it is located in a position that is circled by Wonokromo Terminal, Wonokromo Station, and Wonokromo Market (DTC), so the Qowiyuddin mosque has become quite popular around the area. (Ahmad, 2023).

According to local residents, the beginning of the Qowiyuddin Mosque dates back to the Dutch colonial era, when Mbah Qowiyuddin was targeted for arrest because of his prowess in war tactics. He escaped by anchoring a piece of wood to the sea and following the flow of the wood until it stopped at the Brantas River (Rolag) Surabaya, which is now known as the Jagir sluice gate. After successfully avoiding the pursuit of the Dutch, Mbah Qowiyuddin built a mosque where the wood stopped. Initially, the mosque was built in the Brantas Rolag River, but was later moved to its current location in Jagir due to a waterway construction project carried out by the Dutch colonisers. Mbah Qowiyuddin himself moved the mosque by the necessity of Allah Swt. (Ahmad, 2023).

Qowiyuddin Mosque has been renovated three times since its establishment, in 1904, between 1971-1974, and most recently in 2005-2007. The renovations included the expansion of the courtyard, wall repairs, and repainting. However, some of the original parts of the mosque, especially the interior, were retained. For example, the 8-metre-long wooden pillars that support the building are still original, brought from Cirebon by Mbah Qowiyuddin by sea. The ancient yellow tiles inside the mosque have also been preserved since the beginning. (Ahmad, 2023).

b. Geographical Location of the Qowiyuddin Mosque

Qowiyuddin Mosque is located at Jalan Jagir, Jagir Village, Wonokromo District, Surabaya City, East Java Province. Its location in a dense and crowded area makes this mosque easily accessible and quite famous in the South Surabaya area. Astronomically, the Qowiyuddin Mosque is precisely located at coordinates 7°18'03.4' LS and 122°44'17.9' East. Qibla azimuth data generated using Google earth is 294°3'0.00 '(USBT). While the azimuth of the direction of the Qowiyuddin Mosque building leads to 270°13'48' (USBT). Then the results of these measurements obtained the value of the inclination of the Qowiyuddin Mosque of 23 ° 49'12.00 'less to the north



c. Determination of the Qibla direction of the Qowiyuddin mosque

According to Mr M. Amir Hamzah, as the takmir of the Qowiyuddin Mosque, the determination of the Qibla direction of the mosque in the past is not specifically known. He explained that the determination of the direction of the Qibla mosque building at the time of construction used a classic tool called 'bencet.'

2. Theory of Calculation and Determination pf Qibla Direction

Qibla direction determination can be done using spherical trigonometry, a method of measuring angles on the spherical surface of the earth, first developed by Muslim scientists such as Al Battani and Al Khawarizmi. Spherical trigonometry is not only used to determine the Qibla direction, but also to calculate the shortest distance between two points on the earth's surface. (SUHARLI, 2022)

Over time, the method of determining the Qibla direction has evolved from the traditional way to the use of modern technology such as GPS and Google Earth. The principles of trigonometry, such as sine, cosine, tangent and cotangent, developed by Muslim scientists, play an important role in astronomical observations and Qibla calculations. Qibla direction is calculated based on the shortest line to the Kaaba, which produces a large arc on the earth's surface due to its spherical shape. This angle measurement is done using tools such as calculators or calculating machines. (Mustaqim, 2021)

The calculation procedure using the following formula: (Akh. Mukarram, 2017)

a. Side price (a) = 90 - φ place
b. Side price (b)= 90 - φ of the Kaaba.
c. The price of angle C = λ of the place - λ of the Kaaba.

There are three determination methods that the author uses to measure Qibla direction 1) Mizwala Qibla Finder. 2) Right Triangle 3) Theodolite

a. Mizwala Qibla Finder

Mizwala Qibla Finder is a tool modified from a*sundial* and an istiwa' stick that serves specifically to determine the Qibla direction. The word ‘Mizwala’ comes from the Arabic word meaning to go or operate, while in this context it means a sundial. In contrast, ‘Qibla Finder’ comes from the English word meaning qibla finder.

Like a *sundial*, it has a dial plane that receives sunlight from a gnomon or wand. However, in the Mizwala Qibla Finder, the gnomon is set perpendicular to the dial plane, similar to a typical istiwa' stick. This Mizwala tool is practical, accurate, and easy to use. By entering latitude, longitude, and measurement time data into the Mizwala Qibla Finder programme provided in the package, users can obtain calculation results without a calculator. The results of this calculation allow users to measure the Qibla direction in accordance with the Mizwala Qibla Finder usage guide. However, Mizwala can only be used during the day with sufficient sunlight, because this tool depends on sunlight, just like a *sundial*. (Qulub, 2017)

b. The Right Triangle

The right triangle is a geometric tool that is useful in various measurements, including determining the Qibla direction, which is the direction towards the Kaaba in Makkah. In astrology, the right triangle is used practically by utilising the shadow of the sun as a reference to calculate the Qibla angle. With tools such as gnomons, rulers, clocks, GPS, and calculators, the right triangle is designed to ensure that tools such as the Mizwala Qibla Finder are in the correct horizontal position.

This method utilises the 90-degree angle of the right triangle to ensure the gnomon is perpendicular to the plane of the dial. This triangle is also used to calculate the Qibla azimuth and other astronomical data using trigonometric formulae. The use of a right triangle is proven to be accurate, as it allows for precise measurements and periodic adjustment of the measuring instrument, thus maintaining the consistency and accuracy of the Qibla direction. (Hambali, 2013)

c. Theodolite

A theodolite is a tool used to measure the vertical (altitude) and horizontal (azimuth) angles of an object, as well as create straight lines and flat planes on the ground. It is often used in land surveying, forestry, meteorology, rocket launching and map making. In addition, theodolites can also determine geographical positions by the transit method, through observing the position of the sun from a location. Theodolite is also an accurate method, due to the accuracy of the calculation of the second arc of an angle.

In Indonesia, theodolites are used by falak experts for rukyatul hilal, which is the observation of the crescent moon to determine the beginning of the lunar month. With the ability to measure altitude and azimuth, theodolites are used to track the movement of the moon, as well as determine the Qibla direction with high accuracy through the identification of True North and Qibla azimuth. (Qulub, 2017)

3. Accuracy of Qibla Direction of Qowiyuddin Jagir Wonokromo Mosque

a. Calculation of Qibla Direction Angle of Qowiyuddin Jagir Wonokromo Mosque

Measuring the Qibla direction from a distance that cannot see the physical ka'bah can be done by using the trigonometric formula. This is because the shape of the planet Earth is not flat, but round. So that with the help of the trigonometric formula, the angular value of the Qibla direction in a place can be found and calculated. Then the results of the calculation are used as data to measure the Qibla direction using several methods of measuring the Qibla direction.

Based on the trigonometric formula that has been described in point c.2 and the data on the geographical location of the Qowiyuddin Jagir Wonokromo Surabaya mosque which has been explained in point c.1.b, it can be seen the process of calculating the Qibla direction angle using the trigonometric formula as follows:

Required coordinate data:

1) Latitude of Qowiyuddin mosque: -7°18‘03.4’ LS
2) Longitude of the Qowiyuddin mosque: 112°44‘17.9’ WEST
3) Latitude of the Kaaba: 21°25‘21’ N
4) Longitude of the Kaaba: 39°49‘34’ EAST

Calculation process:

1) Side a: 90 - (-7°18'03.4‘) = 97° 18’ 03‘’
2) Side b: 90 - 21°25'15" = 68°34‘39"
3) Angle C: 112°44'17.9‘ - 39° 49’ 40‘ = 72° 54’ 44‘’

After finding the results of the calculation of the side and angle data, the next step is to enter the cotan B formula to find the Qibla angle. The process of calculating the Qibla angle is as follows:

How to input the calculation in the calculator as below:

cotan B = 1/tan 68°34‘39’‘ x sin 97° 18’ 03‘’ : sin 72° 54‘ 44’‘ - cos 97° 18’ 03‘’ : 1/tan 72° 54‘ 44’' = $^{x-1}$ = shift tan ans= B = 65° 57‘ 11.76’' (U-B) (result on calculator) = 24° 02‘ 48.24’' (B-U) = 294° 02‘ 48'' (UTSB)

Based on the calculation of the cotan B formula that the author has calculated, it can be seen that the angle of the Qibla direction of the Qowiyuddin Jagir Wonokromo Surabaya mosque is 65° 57‘11.76'' (U-B). (U-B) means North to West, meaning that the value is calculated in quadrants from the true north to the true west. While 24° 02‘ 48.24'' (B-U) is the value of the Qibla direction angle in quadrants from the true west point to the true north. The value is obtained by calculating 90 - 65° 57‘ 11.76‘’ (U-B) = 24° 02’ 48.24‘’ (B-U). Finally, the resulting value of 294° 02‘ 48’' (UTSB) is the azimuth value of the Qibla direction of the Qowiyuddin Jagir Wonokromo Surabaya mosque. Azimut is an angle measured from true north towards a certain direction in a clockwise direction in the horizontal plane. In determining the Qibla direction, azimuth refers to the angle between north and the direction towards the Kaaba in Mecca, which is measured clockwise through the order of north, east, south, and west, or commonly referred to by the abbreviation UTSB.

b. Qibla Direction Accuracy of Qowiyuddin Jagir Wonokromo Mosque

1) Accuracy using Mizwala Qibla Finder

Mizwala is a practical and efficient instrument for measuring Qibla direction. Practical because it is easy to carry anywhere without difficulty, thanks to its rectangular design and its container in the form of a backpack so it is comfortable to carry. Efficient because its use is fast and does not take much time, so users do not need to take a long time to determine the Qibla direction in a place or test the accuracy of the Qibla direction of an existing mosque building. What needs to be underlined is that the use of mizwala requires sunlight as the main data reference to find true north.

In preparation for the measurement, the author opens the mizwala box and then installs the gnomon first which functions as a shadow shaper, after that looping the thread / rope on the gnomon which functions as a line puller to be straight and precise in the desired azimuthal direction. Measurement of the Qibla direction of the Qowiyuddin Jagir Wonokromo Surabaya mosque with mizwala is carried out in the courtyard of the Qowiyuddin mosque, the courtyard of this mosque has an area of about 7.5 x 7.5 m^2 as a parking lot for the congregation who pray at the Qowiyuddin mosque. Almost in the middle of the courtyard, 3.5 metres from the end of the mosque to the courtyard, stands a bencet that was once used as a tool to determine the time of the duhur and asr prayers. In connection with the courtyard of the mosque which is not flat even though the courtyard has used paving, so to make it easier and ensure that the mizwala is in a flat position the author uses a small table as a base as well as a height where the mizwala is placed.

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The author adjusts the mizwala to be in a flat state by rotating 3 black roundabouts that function as tripods. These 3 roundabouts can function to raise or lower the dial of the mizwala.To know that the mizwala is really flat or horizontal, the author balances the mizwala using the help of a waterpass tool.The waterpass is placed at the end of the mizwala dial plane on three different sides in turn to make sure everything is completely flat.Justifying the mizwala to be in a flat state is very important, because if there is a tilt, it will affect the inaccuracy of the direction of the gnomon shadow to the azimuthal value in the mizwala dial field.

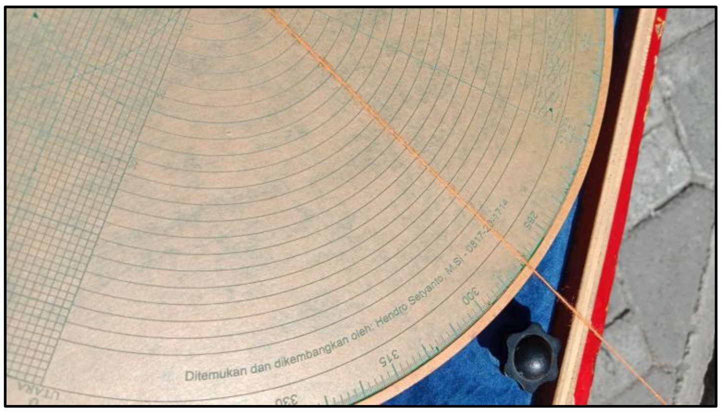
After ensuring that the entire plane of the mizwala dial is flat, the author makes observations to find true north by utilising the sun as a celestial object that appears throughout the day.To easily find out the azimuth value of the sun, the author uses the Stellarium application which is set in real-time according to the latitude and longitude of the place of observation and the local time that continues to run.Observations were made on Monday, 20 May 2024 at 12:19:46 WIB, and the solar azimuth listed on the Stellarium application was 334° 17‘ 3.1’' (rounded to 334°).The author then pulled and placed the thread according to the direction of the shadow produced from the gnomon.

Furthermore, because this mizwala is a Qibla finder tool by utilising the shadow formed on a gnomon, then to adjust the dial plane of the mizwala so that the tip that shows 0° can face true north, depending on the conditions of the measurement time. Firstly, if the measurement is made between the morning and before the sun culminates, then the value of the solar azimuth is added to 180°.Secondly, if it is done between after culmination and before sunset, then the value of the solar azimuth is subtracted by 180°.The reason for subtracting and adding 180° is because the shadow produced by the gnomon (the pointing stick on the mizwala) is always formed in the opposite direction to the position of the sun.Therefore, to get the correct direction, we have to adjust by adding or subtracting 180° from the solar azimuth.Since the observations were made at noon (after sun culmination), the step taken was to follow the guidelines appropriate for the conditions.

Thus, the solar azimuth is 334° minus 180°, giving 154°. Turn the plane of the mizwala dial and place the end indicating 154° exactly towards the position of the gnomon shadow. Straighten the string against the shadow to ensure that 154° points to the shadow of the gnomon. Once the dial plane is straight, it is pointing towards true north, meaning that the 0° value on the mizwala dial plane is pointing towards true north.

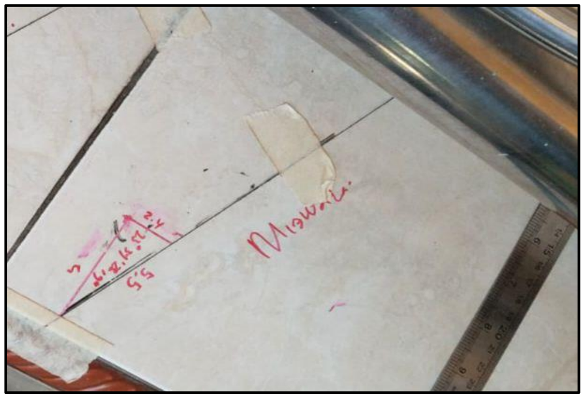
Next, the author pulled the thread in the direction of the Qibla azimuth calculated in point 4.a, which is 294° 02‘ 48’' (rounded to 294°). The thread was pulled to the Qowiyuddin Mosque ceramics, while still paying attention to the straightness of the thread against the 294° azimuth line on the mizwala dial plane. The thread is then attached to the ceramic and given tape at the end, and the back of the thread that is still touching the ceramic is also taped. After the thread was taped at the front and back, the author cut the remaining thread that had been pulled towards the Qowiyuddin Mosque ceramics.

The thread that has been taped is then outlined using a small marker by the author. The resulting line is the correct azimuth of the Qibla direction of the Qowiyuddin Mosque. However, the line is not straight or in accordance with the direction of the Qowiyuddin Mosque building. The azimuth line of the Qibla direction intersects the line of the mosque ceramics in the direction of the mosque building with an intersection pointing north. Because the direction of the Qowiyuddin Mosque building is not in line with the calculated azimuthal line of Qibla direction, it means that the direction of the mosque building has deviated from the actual Qibla direction. Therefore, the author continued the measurement to find out how much the mosque was deviated from the true qibla azimuth.



To measure how much the Qowiyuddin Mosque is tilted, the author uses the trigonometric formula. The author chose the trigonometric formula because it is more detailed than measuring with an arc. The arc can only calculate the amount of tilt in degrees, while the trigonometric formula can calculate up to minutes and seconds. Because it uses trigonometry, the author needs to form a triangular image in order to run the formula. It is known that the hypotenuse has been formed from the azimuthal line of the actual Qibla direction, then additional side and front side lines are needed to be able to calculate using the trigonometric formula. The author takes a length of 10 cm from the direction of the Qowiyuddin mosque building as the side, then unites the two lines that have formed the angle by completing it as the front side. It is known that the front side is 2.4 cm and the hypotenuse is 5.5 cm. Furthermore, the author entered the calculation data into the formula as follows: **shift tan (front side : hypotenuse) = shift tan (2.4 : 5.5) = 23° 34‘ 28.29’'**

Based on these calculations, it can be seen that the Qowiyuddin mosque has a deviation of 23° 34‘ 28.29’' less to the north.



2) Accuracy using The Right Triangle

This measurement theoretically requires a courtyard to draw a triangle. However, in this measurement the author did not directly use the courtyard as a place to make a triangle, but instead used a small table as a place to take measurements. The reason is because the first step in using this method is to draw a line for the shadow produced by an object that is standing perpendicularly to find true north. The author uses the mizwala gnomon that has been removed and then placed on the table to draw a line for the shadow produced by the gnomon. The author drew the shadow produced by the gnomon at exactly 12:50:33 WIB. By looking at the Stellarium application that has been set according to the latitude and longitude of the Qowiyuddin Jagir Wonokromo Surabaya mosque and the appropriate time in reality, the solar azimuth at that time can be known as 323 ° 1 '39.3" (rounded to 323 °). The results of the shadow shape that the author has drawn are helper lines to find the direction of true north. In finding true north, here you also have to pay attention to the conditions at the time when the measurement was taken.

The theory of the condition is the same as what has been explained in the measurement using mizwala. but the difference is in the practical part of how to find true north. If the measurement is done in the morning until before the sun culminates, then to find true north the formula is True North = the size of the sun's azimuth. Use a bow to the left to make an angle equal to the value of the sun's azimuth, for example the azimuth in the morning is 30°. So, form an angle to the left of 30°, mark the angle and make a straight line. The line is the direction that shows the north-south direction. If the observation is done when the sun has culminated until before sunset, then the formula for finding true north is True North = 360 - the size of the sun's azimuth. Then the result is made an angle by using a bow to the right. Since the author made the measurement during the day, the condition is included in the second part. So the calculation of the formula is 360-323° (the sun's azimuth at the time of observation) = 37°. The author makes an angle to the right of 37° by using a bow as a medium for making the angle. The number indicating 37 is given a dot, then the author draws a straight line from that point. The line that was just produced is a line that shows the north and south directions.

To do the next step, which is to make a line along the north-south direction with a length of so many cm and so on until finding the direction of the qibla as explained in the procedure for using the right triangle method, the author here has a more practical and efficient way without having to do it at the measurement site, but it has been prepared the day before the measurement.

The author has made the triangle shape first from paper that has been cut. Actually, the shape and size of the triangle are up to us who want to make it as big or small as possible. The author here first makes a paper regarding the length of the north-south line of 10 cm. After that, to find the length of the line to the west, the Tan calculation is carried out (Qibla direction angle U-B x North-south length). According to the existing data, the author's calculation is Tan (65° 57' 11.76"x10 cm) = ... From these results, the author then draws a straight line upwards as the orientation from the west along ... cm. The rest is to combine the lines from the two points as the shape of the hypotenuse. The right triangle shape that the author has made on paper has become a medium that can be used when measuring. The author then cuts the triangle shape neatly according to the size shape that he has drawn. So that when measuring, the author only needs to put it straight with the north-south line that he has made. The direction indicated by a hypotenuse of the triangle is the direction indicating the qibla.

The author taped the triangle shape so that it would not move and shift. Then also attached a thread to pull straight towards the porch of the Qowiyuddin Jagir Wonokromo Surabaya mosque. The thread was pulled towards the mosque while still paying attention that the thread was still straight according to the direction of the hypotenuse of the triangle. After it felt straight, then the author taped the thread at the front end and a little at the back that still touched the porch of the mosque. The author then cut the thread that was not needed. The direction of the thread formed from the measurement intersected the line from the direction of the Qowiyuddin mosque building to the north.

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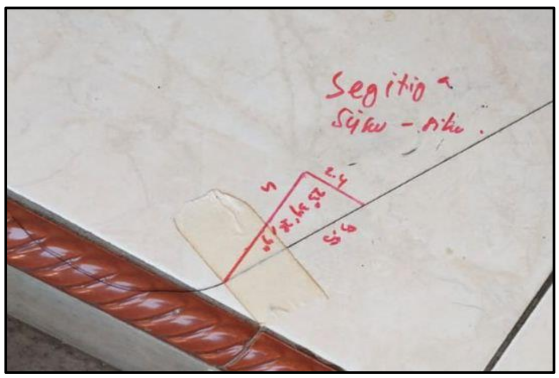
The author measures the deviation with the same formula as in the measurement above using the mizwala qibla finder. The author takes a 10 cm long line for the side, namely the straight direction according to the mosque building, then makes a line, then connects from two directions (the direction of the qibla and the direction of the building) as the front side. It is known that the front side is 2.4 cm long and the sloping side is 5.5 cm long. The data is entered in the calculation as follows: Shift tan (2.4: 5.5) = 23 ° 34 '28.29 ". So from the calculation of the measurement of the direction of the qibla of the Qowiyuddin Jagir Wonokromo Mosque using the right triangle method, it was found that the direction of the mosque building had a deviation with a value of 23 ° 34 '28.29 " less to the north to face the actual direction of the qibla.



3) Accuracy using Theodolite

In the world of Astronomy, theodolites are also used to measure the direction of the Qibla. This utilization lies in its telescope which is used to aim at an object in the sky and its ability to calculate very accurately up to the accuracy per second. Therefore, theodolite can be said to be a tool that has a high level of accuracy in determining the direction of the Qibla. Here is the accuracy that the author did

First, the author prepared a theodolite tripod by spreading its three legs with a span that was not too wide, the tripod legs can be raised according to the height of the measurers. According to the author, the ideal height is from the chest to the neck of the observer. The reason is so that the observer does not bow too much and shortens his legs when the object being observed is in a very high position. Conversely, so that the observer does not tiptoe if the position of the object being observed is in a position that is not high.

After the tripod is raised to a height that suits the author, then the tripod is measured with a waterpass to ensure its flatness. The measurement of flatness is done by placing the waterpass on the top of the tripod which forms a triangle in turns. After one side is flat, move it to the other side, after it is also flat, move it to the other side, when it is flat, make sure again one more time by placing the waterpass alternately from the three sides, if all are flat then the theodolite is ready to be installed, if there is one that is not flat again, then fix it again until all are flat.

Next, the author installs the theodolite on the tripod by inserting the lock on the back of the tripod, tightening it against the theodolite hole with the aim that the theodolite does not shift and keeps the theodolite from falling when it is bumped. After the theodolite is placed on the tripod, the author adjusts the flatness of the theodolite which also has three leveling screws aka tripods that are integrated with the theodolite which can be rotated to raise or raise the theodolite tripod.

By looking at the circular waterpass bubble which is positioned above one of the screws, the author then rotates the nuts one by one to balance the waterpass bubble so that it is in the middle position. After the waterpass bubble is in the middle position, look at the position of the rectangular waterpass bubble above the calculation indicator screen. The bubble will also shift itself towards the middle, if it is not right, it means that the position of the circular bubble is not completely in the middle position. Therefore, adjust one of the screws while looking at the rectangular waterpass bubble until it is in the middle position.

After the waterpass bubble is in the middle position, the theodolite means it can be used and is ready to be used to determine the direction of the Qibla. The next step to find true north, the author points the telescope at an object that is easily visible during the day, namely the sun. Because during the day the object that is easy to see is the sun, the author does not use his eyes to look at it. Because in this case the author avoids direct eye contact with the sun which can be dangerous to the eyes. Therefore, the author uses paper as a means to ensure that sunlight has entered the telescope hole, if the light has entered the telescope hole then on the paper placed in the place of the observation hole the eye will see a light in the shape of a circle. If the circle light is still not perfect or still not bright enough, then correct the position of the telescope until it gets brighter light with a more perfect circle shape. If the position is correct, then lock the horizontal movement of the theodolite and turn on the on button, then press "0 set" twice.

The author's sun shooting was done exactly at 13:11:09 WIB. To find out the sun's azimuth easily, the author used a stellarium with settings that had been set according to the observer's latitude and longitude and adjusted to the current clock. The sun's azimuth listed on the stellarium was 317 ° 0' 6 " (rounded to 317 °). Because the research was conducted during the day, to find true north the formula used was like the second condition in the explanation using the right-angle method, namely 360 - sun azimuth. 360 - 317 = 43. So to face true north from the sun's azimuth that the author had shot, which was less to the right by 43 °. The author then pressed the R / L button and selected "R" which means right to tell the theodolite to start its calculation from the right.

The author released the theodolite's horizontal movement lock and moved it to the right by 43 ° 00' 00 ". When the theodolite movement is approaching the target calculation value, the author locks the horizontal movement of the theodolite and rotates the theodolite with a rotating tool with a more micro movement. After the theodolite calculation position shows a value of 43 ° 00' 00 ". The author presses the "0 set" button again twice and presses the R / L button to change it to L which means left. Namely, the theodolite calculation will start from the left.

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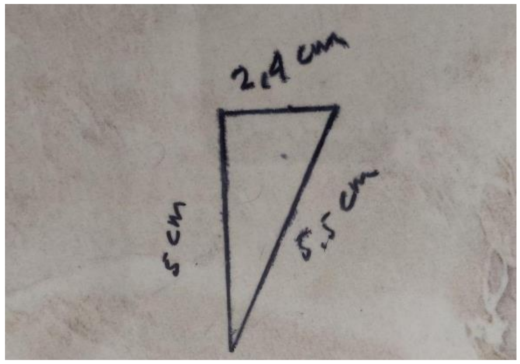
The author loosens the horizontal lock of the theodolite and rotates it to the left by the angle of the Qibla direction in U-B which the author has calculated in point 4.a. which is 65° 57' 11.76" (rounded to 65° 57' 12"). After the theodolite shows a number of 65° 57' 12" the author locks the movement of the theodolite and turns on the laser located above the telescope in the middle. The author then directs the laser to the mosque porch while adjusting the point to focus on the laser. The goal is that the laser point that falls on the mosque porch remains clearly visible in detail and its shape does not fade. The author marks the laser point that falls on the mosque porch with a marker, then marks another mark from the laser beam by moving the theodolite telescope back or forward. Then the author connects the two marks by drawing a straight line using a ruler. The line looks diagonal to the direction of the mosque building which matches the position of the ceramics. The oblique direction cuts towards the direction of the Qowiyuddin mosque ceramics.

Finally, the author then calculates the direction of the deviation of the Qowiyuddin mosque building from the actual qibla direction line using the trigonometric formula. The length of the side side is taken by the author as 5 cm. Then the author combines two points in different directions, namely the direction of the qibla and the direction of the building by drawing a straight line so that a triangle is formed. The length of the front side is found to be 2.4 cm and the length of the hypotenuse is found to be 5.5 cm. The formula for finding the difference in deviation is then entered by the author according to the data that has been obtained. Shift tan (2.4: 5.5) = 23 ° 34 '28.29 "

So from the calculation of the measurement of the direction of the qibla of the Qowiyuddin Jagir Wonokromo Mosque using the theodolite method, it was found that the direction of the mosque building has a deviation with a value of 23 ° 34 '28.29 " less to the north to face the actual direction of the qibla.



c. Analysis of the Accuracy of the Qibla Direction of the Qowiyuddin Jagir Wonokromo Mosque

The Qowiyuddin Mosque is an ancient mosque that has been standing since the 18th century, precisely in 1786, explained by Amir Hamzah as the head of the mosque's management when the author interviewed him. The head of the management also informed that before the mosque was built, an instrument to indicate the time for the Dhuhur and Asr prayers or better known as a bencet tool had already existed. When interviewed, the author asked how the direction of the Qibla was determined at that time at the Qowiyuddin Mosque. The head of the management replied that he did not know in detail how the direction of the Qibla was measured in ancient times at the Qowiyuddin Mosque. He only assumed that with the bencet that had existed before the mosque, it was possible that the direction of the Qibla was determined using a bencet tool. After conducting several measurements of the direction of the Qibla of the Qowiyuddin Mosque in Jagir Wonokromo Surabaya using different methods, the author collected the results of the measurement data for the direction of the Qibla of the Qowiyuddin Mosque in the form of a table as follows:

Metode	Jam Pengamatan	Az Matahari	Kemelencengan	Arah Kemelencengan
Mizwala Qibla Finder	12:19:46 wib	334° 17' 3,1"	23° 34' 28,29"	Kurang ke Utara
Segitiga Siku-Siku	12:50:33 wib	323° 1' 39,3"	23° 34' 28,29"	Kurang ke Utara
Theodolite	13:11:09 wib	317° 0' 6"	23°34' 28,29"	Kurang ke Utara

The results of the Mizwala Qibla Finder method and the Right Triangle method show the same deviation value, which is both 23 ° 34' 28.29 ". Then the author strengthened the two results of determining the direction of the Qibla using the most precise tool, namely the theodolite and the results showed the same deviation value.

According to the author's analysis, the occurrence of similar deviation values resulting from measurements using Mizwala and Right Triangle is due to the similarity in finding true north, namely by utilizing the shape of the shadow of sunlight produced by a gnomon that is erected perpendicularly. Although the procedure for finding true north is slightly different between the two, both have an easy way to face true north. Mizwala just adds or subtracts 180° from the sun's azimuth at the time of observation, then the result of the subtraction or addition is used to rotate the mizwala dial plane and put the number listed at the end of the mizwala dial plane exactly in line with the direction of the shadow produced by the gnomon. While the right triangle, if the observation is carried out during the day until before sunset, then just add the value of the sun's azimuth at the time of observation to the deficiency to reach 360°, simply 360 - Sun azimuth of observation. Then just use an arc to the right as much as the calculated value and draw a straight line. If the observation is carried out in the morning until before noon, then the result of the shadow from the gnomon that has been drawn, then just use an arc to the left as much as the value of the sun's azimuth at the time of observation and draw a straight line. From the procedures in both methods, the author can analyze that both have the same first step using the sun's shadow so that the direction produced to indicate true north can be the same. Since the true north direction already points in the same direction, the direction indicated to draw the azimuth of the Qibla direction of the Jagir Wonokromo Mosque in Surabaya is also the same, as a result, the deviation obtained from these two methods shows the same value.

Furthermore, the author's analysis of the measurement of the Qibla direction using a theodolite, the author found differences in the procedure for finding true north. The way the Theodolite works does not utilize the shadow of the sun, but must aim at the sun itself. From the results of the sun's shooting, it is then followed up as the way it works to measure the direction of the Qibla using the right triangle method. Because what is being targeted is the sun, the position of the theodolite telescope must be exactly facing the sun, otherwise it will result in an inaccurate indication of true north because the accuracy of the theodolite calculation is capable of reaching arc seconds of a direction, if the true north direction is not accurate then it will also affect the indication of the azimuth of the Qibla direction. The challenge of difficulty in aiming at the sun accurately can be encountered when the measurement is carried out during the day, because the position of the sun is still quite high so that the telescope must be raised upwards to aim at the sun. Meanwhile, if the telescope is facing too high, the observation post will be close to the base of the theodolite, making it difficult to know whether the theodolite telescope is in the right position with the sun.

According to the author, the logic of finding true north by drawing a shadow line is more certain than by aiming at the sun directly. Because by drawing a line, the line is indirectly in accordance with the sun's azimuth value. Meanwhile, by aiming at the sun directly, our own equipment must adjust the sun to get the sun's azimuth value when at the time of observation.

The results of the deviation obtained through the measurements of the three methods are compared with the difference between the azimuth of the direction of the Qibla of the Qowiyuddin Mosque and the azimuth value of the building in the direction of the Qibla reviewed by Google Earth measurements. The data obtained are as follows:

Google Earth	
Azimut Arah Bangunan	270° 13' 48"
Azimut Arah Kiblat	294° 3' 00"
Kemelencengan	23° 49' 12"
Arah Kemelencengan	Kurang ke Utara

Metode	Kemelencengan	Selisih dengan Google Earth
Mizwala Qibla Finder	23°34'28,29"	0°14'43,71"
Segitiga siku-siku	23°34'28,29"	0°14'43,71"
Theodolite	23°34'28,29"	0°14'43,71"

The deviation shown by the Mizwala Qibla Finder and Right Triangle methods and theodolite with Google Earth is only slight, which is less than 1 degree, precisely 0 ° 14'43.71 ". From this alignment, the author concludes that the use of the Mizwala Qibla Finder and Right Triangle is correct. namely with the validation of the theodolite as the most accurate instrument between the two.

The author also wants to criticize the determination of the direction of the Qowiyuddin mosque during the construction of the past in 1786. According to the head of the Qowiyuddin mosque, M. Amir Hamzah, the determination of the direction of the mosque's qibla could have been determined using a bencet, the reason being that this bencet had existed since before the Qowiyuddin mosque was built, so that the determination of the direction of the Qowiyuddin mosque when it was first built in the past was possible using a bencet clock in determining the direction of the qibla. When viewed from Google Earth, the direction of the Qowiyuddin Mosque building is at an azimuth of 270° 13' 48", which tends to face true west rather than facing the actual azimuth of the Qibla. This difference can be seen if facing the actual azimuth of the Qibla is still 23° 49' 12" short of the north, while facing the true west is only 0° 13' 48" short of the south.

According to the author's analysis, it is possible that Mbah Qowiyuddin when determining the direction of the Qibla of the Qowiyuddin Mosque still had the understanding that the Qibla from Indonesia is to the east of the Kaaba, so the direction of the Qibla faces west. This understanding may still be simple, without considering in detail the astronomical coordinates such as the latitude and longitude of the Qowiyuddin Mosque and the Kaaba.

If Mbah Qowiyuddin in determining the actual direction of the Qibla is still far off, and is more dominant in facing true west. So it could be true that Mbah Qowiyuddin determined his mosque to face exactly to the true west. This can be seen from the very small difference between the azimuth direction of his building and the true west, which is 0 ° 13' 48 " to the south. If it is true, then this is what makes the author curious about how Mbah Qowiyuddin knew how to determine the direction of his mosque building to the true west. If according to the chairman of the mosque's management, it is determined using a bencet tool, then the main media used to determine the direction of the mosque is certainly by utilizing the sun. If utilizing the sun, there are 2 possible choices. First, Rashdul Qibla Global. Second, Vernal Equinox or autumnal equinox. If using Rashdul Kiblat Global, then the direction of the shadow produced by the bencet should have pointed exactly to the true azimuth of the qibla, because this event can only occur when the sun's declination value is the same or almost the same as the latitude of the Kaaba. Precisely occurred on May 27-28 and July 15-16. So the possibility of using a global Qibla compass is rejected. The second possibility is that Mbah Qowiyuddin determines it at the time of the Vernal Equinox or Autumnal Equinox. That is, an event where the sun is at the Aries point or its turning point so that it will rise exactly in the direction of true east and likewise at sunset.

The direction of the sun at sunrise is at an azimuth of 90 degrees so that it will produce a shadow in the direction of 270 degrees while at sunset it is in the opposite position. This is the analysis that the author can provide in the research on the accuracy test of the Qowiyuddin Jagir Wonokromo mosque. In reviewing the accuracy of the direction of the Qibla of the Qowiyuddin Mosque after being tested using the method of determining the direction of the Qibla that exists today, the measurement results show that there is a difference between the azimuth of the Qibla determined in the past and the results of modern measurements. Based on measurement data carried out using various methods, such as the Mizwala Qibla Finder, Right Triangle, and theodolite, it is known that the mosque has a deviation of 23° 34' 28.29" to the north of the actual azimuth of the qibla, as indicated by modern tools such as Google Earth. When viewed from the tolerance limits of the direction of the qibla that have been set by experts, it can be said that the deviation that is considered acceptable or tolerable is around 1° from the actual direction of the qibla (Nur, 2023). In this case, although measurements using the Mizwala Qibla Finder and Right Triangle show results that are quite close to the results from Google Earth (only deviating 0°14'43.71"), the results of measurements of the direction of the mosque's qibla historically show a significant deviation, which is more than 23° to the north.

Thus, the current direction of the Qibla of the Qowiyuddin Mosque, after being tested using modern methods, can be said to be inconsistent with the established tolerance limit, because it deviates far from the actual direction of the Qibla. This deviation of more than 23° clearly exceeds the permitted tolerance threshold. The author also suggests that corrections be made to the direction of the Qibla and prayer rows to match the Qibla which should face directly towards the Kaaba in Mecca.

D. Conclusion

Qowiyuddin Mosque, Jagir Wonokromo, Surabaya, based on research results, experienced a deviation of the direction of the qibla by 23 ° 34'28.29 " to the north from the direction of the mosque building. This study used three modern measurement methods, namely the Mizwala Qibla Finder, Right Triangle, and Theodolite. Each method was chosen because it provides a high level of accuracy in measuring the direction of the qibla. From the accuracy test using the three tools, it can be seen that the direction of the qibla of the Qowiyuddin mosque determined in the past cannot be said to be accurate. Meanwhile, by reviewing the tolerance limit for the deviation of the direction of the qibla, which is a maximum of 1 degree, the Qowiyuddin mosque cannot accept this tolerance. this is because the deviation of the mosque exceeds the maximum tolerance limit.

E. Suggestions

1. The management of the Qowiyuddin Mosque needs to immediately correct the direction of the Qibla and the rows to ensure the accuracy of the direction of the Qibla.
2. It is recommended to routinely check the direction of the Qibla with modern tools such as Theodolite and Mizwala Qibla Finder to prevent deviations in the direction of the Qibla.
3. Other historic mosques need to be tested for the accuracy of the direction of the Qibla using the same method to ensure the correctness of the direction of the Qibla.

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