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StatMat
Jurnal Statistika dan Matematika

STATMAT (Jurnal Statistika dan Matematika)
P-ISSN: 2655-3724 E-ISSN: 2720-9881
Vol. 8, No. 2, August 2026
11th article, Pages: 320 – 334
DOI: https://doi.org/10.32493/sm.v8i2.59668

# Exploration of Ethnomathematics in Historic Architecture in The Old Town Area of Surabaya

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## *ABSTRACT*

This study explores ethnomathematics in the architectural elements of historical buildings in the Kota Lama Surabaya area, which contains rich geometric features from the colonial period. The research applies a qualitative method with an ethnographic approach to document and identify geometric patterns found in facades, windows, columns, roofs, and decorative ornaments. The analysis reveals that these architectural elements embody mathematical concepts such as symmetry, proportion, congruence, and geometric transformations. The findings show the presence of various plane figures including squares, rectangles, circles, triangles, and trapezoids and solid shapes such as cylinders, cones, and spheres. These elements serve structural and aesthetic purposes while reflecting philosophical meanings related to balance, continuity, stability, and harmony in colonial architectural design. The study demonstrates that ethnomathematics can bridge mathematics learning with local cultural heritage in a meaningful and contextual manner. The results contribute to the development of ethnomathematics in Indonesia and highlight the educational potential of historical architecture as a culturally relevant medium for teaching geometry.

**Keywords: Ethnomathematics, Colonial Architecture, Geometry, Cultural Heritage, Contextual Learning.**

| ARTICLE INFO | |
|---|---|
| Submission received: 21 April 2026 | Accepted: 31 August 2026 |
| Revised: 13 August 2026 | Published: 31 August 2026 |
| Available on: https://doi.org/10.32493/sm.v8i2.59668 | |



## INTRODUCTION

Mathematics is one of the fundamental sciences that plays an important role in the development of science and technology (Safitri & Siregar, 2023). An understanding of mathematics is necessary in developing logical, analytical, critical, and creative thinking skills. Mathematics is the foundation for various fields such as engineering, science, economics, and information technology. Its role is not only as an academic subject, but also as an essential skill in facing the challenges of the 21st century (Indrawati, 2023). Behind this urgency, there are many problems in the learning process. Many students view mathematics as a difficult and abstract subject (Tindaon et al., 2025). This perception arises

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because of teaching methods that tend to be conventional, fail to relate the material to real-life contexts, and lack activities that connect mathematics to the surrounding environment. This situation leads to low motivation and poor learning outcomes, resulting in mathematics often being considered a frightening subject that is irrelevant to everyday life (Rizky & Nasution, 2024).

In improving the quality of the learning process, an approach that connects mathematical concepts with real-world situations is needed. Contextual teaching and learning (CTL) offers a solution by focusing on the relevance of lessons to the experiences, environment, and culture of learners (Armiati & Hidayati, 2023). Through this approach, learners can understand that mathematics is present in various aspects of life, making the material taught more meaningful. Contextual learning also encourages students to actively explore and observe real phenomena around them, making it an innovative learning alternative (Tiara Medyasari & Wardono, 2024). Ethnomathematics is the study of mathematics that discusses the relationship between mathematical concepts and the culture, traditions, and artifacts of a particular community. This approach reveals that mathematical concepts actually exist in various cultural practices such as traditional architecture, batik, art, and daily life patterns. Through ethnomathematics, mathematics learning becomes closer to students because it departs from the local cultural context so that this approach not only strengthens understanding of mathematical concepts but also fosters students' appreciation of cultural heritage and strengthens local identity (Mufida & Wildan, 2025). In the context of historical architecture, ethnomathematics can be used to explore elements of geometry, symmetry, proportion, and building patterns that represent the cultural values of the past (Fitriyana & Mariana, 2022).

The Old Town area of Surabaya was chosen as the subject of ethnomathematics research for a number of compelling and relevant reasons, both scientific and practical. From an academic perspective, the Old Town has many old buildings with colonial architecture featuring numerous geometric shapes, such as symmetrical facades, arched windows, and decorative ornaments. This provides an opportunity to study mathematics through a cultural context by analyzing flat and spatial shapes. Historically, this area was the center of economic, trade, and social activities during the Dutch colonial period and is classified as a cultural heritage area protected by the government, giving it significant cultural and historical value as a research background. In the context of ethnomathematics, colonial buildings in Kota Lama contain European and local cultural symbols that link mathematical concepts to the original cultural context, thereby enriching the understanding of mathematics through a cultural approach. The practical reason for choosing Kota Lama is its location, which is easy to observe directly and has various angles and buildings that allow for the collection of visual data such as photographs to analyze geometric shapes comprehensively, thereby supporting the validity of ethnomathematics research. This reason makes Old Town Surabaya the right and suitable location for research that connects colonial architectural culture with mathematical concepts in the field of ethnomathematics (Solikah, 2023a).

Old Town Surabaya is located in North Surabaya, covering several streets such as Jembatan Merah, Kembang Jepun, Veteran, and Rajawali in the Krembangan District. This area is a former Dutch colonial building that was once a very important center for ports, trade, and economic activities, built in the 19th century to the early 20th century (Solikah, 2023b). The buildings here feature colonial architecture that combines art deco, neoclassical, and Indische styles, with distinctive features such as symmetrical facades, arched windows, large pillars, and high roofs. Currently, Old Town Surabaya has been designated as a cultural heritage area that is maintained and protected by the Surabaya city government, so that the

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authenticity and function of the buildings are preserved. The function of this area has changed into a place for historical tourism, culinary, trade, museums, SMEs, and various cultural activities that make the atmosphere of the area more lively as a public space that can learn and develop creatively economically. Scientific research also shows that this area has great historical value and high potential in the fields of education and cultural preservation through its various functions (Pemerintah Kota Lama, 2024).

The Old Town area of Surabaya has various colonial architectural elements that contain various geometrical shapes that can be explained mathematically. The buildings in this area feature symmetrical facades, arched windows, geometrical ornaments, and proportional buildings that are characteristic of neoclassical and Indische architecture. This is clearly seen in the facades of buildings that use geometric shapes, such as triangles, rectangles, circles, and symmetrical patterns. These patterns are characteristic of colonial architecture in Surabaya, according to research on colonial buildings in the Rajawali Street Corridor, which examined the elements on the front of buildings and the basic shapes of buildings in Surabaya's Old Town. The study shows that the front of colonial buildings in the Rajawali corridor uses simple geometric shapes, such as rectangular planes on doors, windows, and front panels of buildings, as well as curved sections forming semicircles on windows and main doors. The gable and multi-level roof shapes also form a visually strong triangular composition, supporting the analysis that colonial buildings in this area have many representations of flat shapes and spatial forms that can be interpreted in the context of geometry and ethnomathematics (Wikantiyoso & Suhartono, 2024).

Flat buildings in the center of Surabaya with colonial structures show how buildings adapt to the tropical climate. Their shape uses long elements such as beams, rows of columns at the front of the building, as well as windows and protruding roofs. This helps protect against bright sunlight and heavy rain. Real examples of this can be seen in the Bank Indonesia Museum and the Balai Pemuda Building. Both buildings have designs that allow cross ventilation and help cool the rooms, which is in line with research on how colonial architecture in Surabaya adapts to the local climate (Shalimar & Winarto, 2024). This diversity of mathematical elements is in line with ethnomathematics studies that explore geometric patterns in historical buildings and their mathematical interpretations, as done in the analysis of traditional architecture for context-based mathematics learning. This shows that Surabaya's Old Town not only has historical and cultural value, but also has high potential for the development of culture-based mathematics learning (ethnomathematics), as explained in efforts to preserve cultural heritage areas in Surabaya that prioritize mathematical and aesthetic values in architecture (Dinarti et al., 2024).

Research on ethnomathematics has been conducted on various cultural objects, such as traditional games, historical buildings, and places of worship. An example is the research conducted by Nabila, who attempted to find mathematical concepts in the traditional game of congklak and discovered elements of circles, squares, rectangles, and the use of number operations in game strategy (Nabilah et al., n.d.). Another study by Fitriyana and Mariana analyzed the historical building of the Kanjeng Sepuh Sidayu Grand Mosque and identified various geometric shapes, such as squares, triangles, circles, and trapezoids in flat shapes, as well as cubes, blocks, tubes, and pyramids in spatial shapes, which can be used as a source of mathematics learning at the elementary school level (Fitriyana & Mariana, 2022). The results of this study show that buildings or cultural objects contain geometric elements that can be utilized in the learning process and demonstrate the benefits of ethnomathematics in increasing the relevance and mastery of mathematical concepts. Research on the cultural heritage site of Alun-Alun Surabaya shows that colonial architecture has geometric elements

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that can be integrated into learning materials such as symmetry, flat shapes, and spatial proportions (Yuliati et al., 2024). These findings reinforce that local culture is a rich and contextual learning resource. Ethnomathematics research to date has mostly focused on objects such as mosques, museums, traditional houses, traditional games, or other iconic buildings, but there has been no research specifically examining geometric elements in historic buildings in the Old Town area of Surabaya. This research plays an important role in filling this gap in the study and contributing new insights to the development of ethnomathematics based on Surabaya's colonial heritage area.

This study aims to identify various forms of flat and spatial structures found in buildings in the Old Town area of Surabaya, as well as to explain the concept of ethnomathematics that emerges from these geometric elements. This study also analyzes the relationship between the culture seen in colonial architecture and the mathematical concepts used in designing and constructing these buildings. Thus, this study not only deepens the understanding of the relationship between mathematics and culture in the context of colonial architecture, but also provides a valuable contribution both theoretically and practically. Theoretically, this study enriches the study of ethnomathematics, especially in terms of geometry based on local culture, particularly in the context of architectural heritage in Surabaya. The practical benefit is as teaching material for mathematics that is relevant to the local and cultural context, helping lecturers teach geometric concepts through real examples that are familiar to students, thereby increasing their interest and motivation to learn mathematics. Mathematics learning is not only focused on theoretical aspects, but also relates to local cultural and historical values, making mathematics more meaningful and relevant to students' lives.

## MATERIAL AND METHODS

This research uses qualitative methods to examine the relationship between culture and mathematical structures in historic architecture in the Old Town area. This method allows researchers to understand the meaning, patterns, and geometric concepts that emerge in the visual elements of the buildings. The Old Town area was chosen because of its high historical value and is listed by the Ministry of Education and Culture as an area with over 105 cultural heritage buildings that still retain colonial architectural features. These characteristics make this area relevant for analysis using an ethnomathematical approach(Putra et al., 2021).

An ethnographic approach was applied in this research to gain an in-depth understanding of the form and function of architectural elements. Direct observation was used to examine the visual characteristics of the buildings and identify geometric structures that appear in the buildings, windows, columns, and roofs. This approach enabled researchers to uncover the mathematical structures inherent in the rectangular shapes of the windows, the cylindrical contours of the columns, and the variations in the triangular roofs. Each element was recorded and analyzed to identify the mathematical regularities that consistently emerge(Pradhan & Orey, 2021).

Data collection was conducted through field observations focusing on building elements containing mathematical forms. Researchers identified recurring building form patterns, visible proportions within buildings, basic plane shapes, and spatial structures seen in colonial architecture. Photographic documentation was used to strengthen the observation results and support the visual analysis process. Literature studies complemented the observation activities by reviewing references on ethnomathematics, the geometry of historic buildings, and official government reports regarding the preservation of the Old City area.

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This demonstrated its important role as a living cultural space that can be studied mathematically (Wijaya et al., 2025). The flow of the research process is as follows:

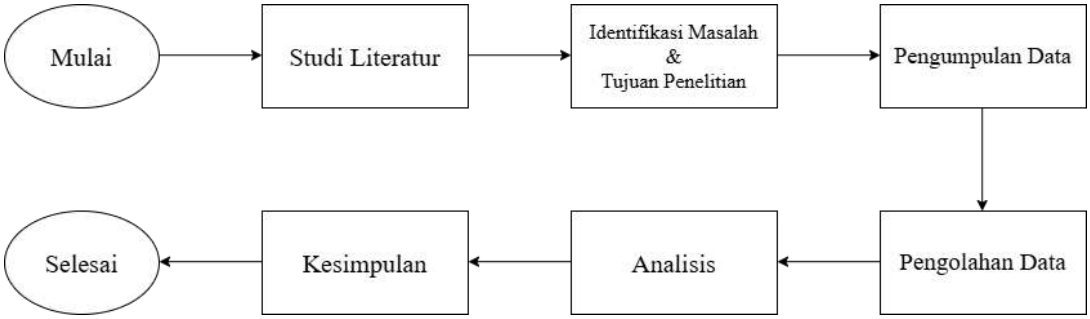


**Figure 1**. Algorithm Flow

Data analysis was carried out through a series of procedures that include data reduction processes, systematic data presentation, and drawing conclusions as the final stage of research interpretation. This researcher through observation data based on its relevance to the concept of geometry, then presents the findings in the form of systematic descriptions to facilitate the interpretation process. Conclusions are built by integrating visual data and ethnomathematics theory so that a comprehensive understanding of the relationship between colonial architectural elements and the mathematical structures they contain is obtained. The Old City area is proven to have a rich visual character and stores geometric patterns that can be used as a cultural-based learning resource.

## RESULTS AND DISCUSSION

### History of the Development of Surabaya's Old City

The Old Town area of Surabaya is one of the oldest colonial areas that has developed since the Dutch occupation in the 17th century. During the VOC era, this area became the center of trade operations and colonial government, marked by the establishment of important offices such as the International Building, De Javasche Bank, and other European trading companies (Rachmawati, 2025). These buildings have magnificent European-style architecture and are seen by the colonial side as a symbol of their power and economic glory in Surabaya (Febrianto, 2024). However, for local communities, these buildings reflect social inequality as indigenous access is strictly restricted; locals are only allowed to enter the area if they work as European-owned laborers, shopkeepers, or office staff (Chawari et al., 2023). In addition to being an administrative and trade center, this area also serves as an entertainment center for the Dutch people with the presence of social buildings, restaurants, and exclusive shopping centers that cannot be freely accessed by indigenous people (Suci, 2024). The spatial layout and architectural design of this area was deliberately designed to show the political and economic superiority of the colonial government, so that the Old City became a space full of symbols of Dutch domination over the people of Surabaya.

The Old Town area was also an important location ahead of Indonesia's independence. In October 1945, the International Building in this area became the site of the initial clashes between Surabaya youth and Allied forces which then triggered the outbreak of November 10, 1945. The great battle established Surabaya as a city nicknamed the "City of Heroes", while the colonial-style buildings in the Old City area bear witness to the history of the

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struggle of the people of Surabaya in an effort to defend independence. After Indonesia's independence, the function of the Old City area changed along with the development of the city, but its historical value and colonial architectural heritage were still maintained. The Surabaya City Government designated this area as a cultural heritage through the Decree of the Mayor of Surabaya No. 188.45/251/402.1.04/1996. In recent years, the government has carried out a massive revitalization to maintain the authenticity of the façade of colonial buildings and revive the atmosphere of the Old City as a historical tourist destination, public space, and center for art and cultural activities (Pemerintah Kota Surabaya, 2024). With its architectural heritage and long historical journey, the Surabaya Old Town area is now an important representation of the city's identity from the colonial period to the modern era.

**Overview of Surabaya Old Town Area**

The Old City of Surabaya is administratively located in the Cantikan and Krembangan Customs Districts, with a scope that includes the Red Bridge corridor, Rajawali Street, Veteran Street, Rubber Street, the Japanese Flower area, to the historical settlement area of Peneleh. Morphologically, the area shows a distinctive colonial spatial pattern, characterized by a building arrangement that follows a grid pattern and a road orientation that leads to an old trading center along the Kalimas River.

To provide a more comprehensive understanding of the boundaries of the area, the distribution of historical buildings, and their spatial patterns, this study includes a map of the Surabaya Old Town area shown in Figure 2. The map shows the locations of the buildings of the study objects such as the International Building, the Kebonrojo Post Office, and the Bank Indonesia Building, along with the main corridor that connects the surrounding historical areas.


**Figure 2**. Surabaya Old Town Area Map

Visually, the character of colonial buildings in this region can be recognized through the use of thick brick materials, high walls, large window openings with wooden or metal lattices, and the shape of the limas and mansard roofs that characterize the adaptation of

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European architecture to the tropical climate. The existence of a row of buildings with symmetrical facades and a repetitive rhythm of windows also strengthens the architectural character of the area as a center of colonial activity in the late 19th to early 20th centuries.

The function of buildings in the colonial period shows a clear differentiation. The Internatio Building acted as a trading office for foreign companies that managed export-import activities, the Kebonrojo Post Office functioned as a distribution center for letters and telegraphs, the Bank Indonesia Building (formerly De Javasche Bank) became a colonial financial center, while the Peneleh area developed as an elite settlement and national movement figures, including the house of HOS Tjokroaminoto which is now a cultural heritage.

The diversity of functions and forms of the building makes the Old City of Surabaya relevant as an object of ethnomathematical study. The geometric structure of buildings—both flat building elements and spatial buildings—is present clearly and authentically, making it easier for students to identify geometric concepts through cultural contexts and real environments.

## The Concept of Building Flat and Its Philosophy in the Cultural Heritage of Surabaya's Old City

Based on the results of observations on various colonial buildings in the Old City area of Surabaya, it was found that a number of architectural elements were formed by a variety of flat buildings that were arranged proportionally and repeatatively. Geometric shapes such as rectangles, triangles, circles, and other variations are evident in the building's façade, window patterns, vents, ornaments, and other construction details. The existence of this flat building is not only related to structural function and lighting or air circulation needs, but also reflects the aesthetics of colonial architecture that prioritizes order, symmetry, and rationality of form. Therefore, the next analysis will systematically describe the types of flat buildings and their application to building elements in the Old City area of Surabaya.

1) Square

   A square shape is a flat plane that has four sides of identical length and four perpendicular corners. This element appears in some of the architectural details of colonial buildings in the Old City of Surabaya, especially in decorative elements and repetitive patterns that require balanced proportions. This use of squares reflects the regularity and symmetry that are common characteristics of colonial architecture.

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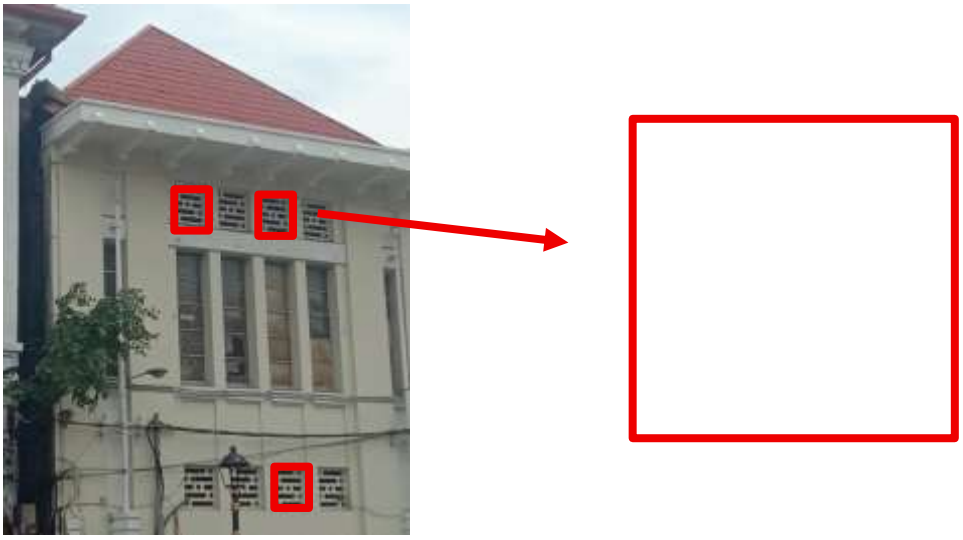

**Figure 3.** Square

Formulas used:

Area

$$L = s^2 \quad (1)$$

Perimeter

$$K = 4 \times s \quad (2)$$

In the colonial building, the square shape is seen in the windows that are neatly arranged with a uniform size. The presence of this square pattern shows the application of geometric concepts, especially in maintaining the proportions, order, and symmetry of the building. This repetitive pattern of square windows shows how the principle of flat building is used in architecture to create visual balance and structural stability.

2) Triangle

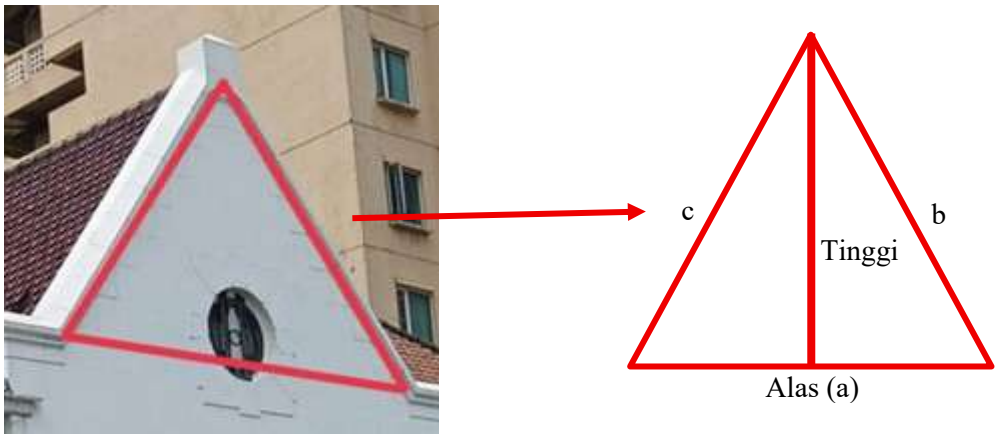


**Figure 4.** Triangles

Figure 4 shows a flat triangular structure. In the context of historical architecture in Surabaya's Old Town, triangles have special significance. The meaning of

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triangles is often associated with the balance between humans, nature, and God. The base of the triangle represents human life as God's creation, while the two sides pointing upwards symbolize the glory of God Almighty. In Dutch colonial architecture, the triangular shape on the front facade of a building is a characteristic of Neo-Renaissance design, which was widely applied to government buildings and important buildings, as seen in the gabled roofs of buildings in the Old Town area. A triangle is a two-dimensional geometric configuration characterized by three sides and three angles. There are several classifications of triangles, including equilateral triangles with all sides of equal length, isosceles triangles with two sides of equal length, and scalene triangles with all sides of different lengths.

Formulas used:

Area

$$L = \frac{1}{2} \times Alas \times Tinggi \tag{3}$$

Perimeter

$$K = a + b + c \tag{4}$$

3) Circle

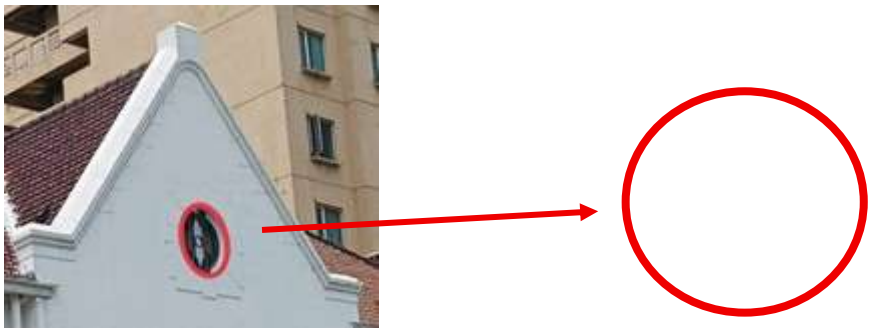

**Figure 5.** Circle

In Figure 5, we can see the concept of a flat shape, namely a circle. Circles in historic buildings usually appear in the form of ventilation or small windows, as seen in colonial buildings in Surabaya's Old Town. Philosophically, circles symbolize perfection, wholeness, and continuity, because they have no end and no beginning. In Dutch architecture, the circle is used as a classical ornament to provide a harmonious visual accent. A circle is a flat surface composed of a collection of points equidistant from a central point, known as the radius. This shape has only one curved side.

Formulas used:

Area

$$L = \pi \times r^2 \tag{5}$$

Circumference

$$K = 2 \times \pi \times r \tag{6}$$

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4) Rectangle

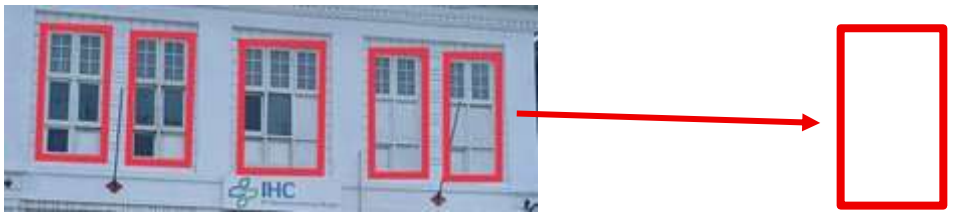

**Figure 6.** Rectangle

In Figure 6, we can see the concept of a flat shape, namely a rectangle, which can be seen in the shape of the windows of colonial buildings. Rectangles symbolize order, neatness, and balance, in line with Dutch architectural philosophy, which is synonymous with neat geometric shapes. A rectangle is a flat shape with two pairs of parallel sides, each pair having equal lengths. This shape is commonly used in window design because it provides optimal lighting and air circulation.

Formulas used:

Area

$$L = p \times l \tag{7}$$

Perimeter

$$K = 2(p + l) \tag{8}$$

5) Trapezoid


**Figure 7.** Trapezoid

In Figure 7, we can see the concept of a flat shape, namely a trapezoid, which can be seen on the roof of the building. A trapezoid has one pair of parallel sides. In colonial architecture, the trapezoidal shape of the roof is used to expand the shade area, thereby protecting the walls from rain and sunlight. Philosophically, a trapezoid symbolizes stability and protection, because its wider base gives an impression of sturdiness.

Formulas used:

Area

$$L = \frac{1}{2}(a + b) \times t \tag{9}$$

Perimeter

$$K = a + b + c + d \tag{10}$$

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6) Semicircle

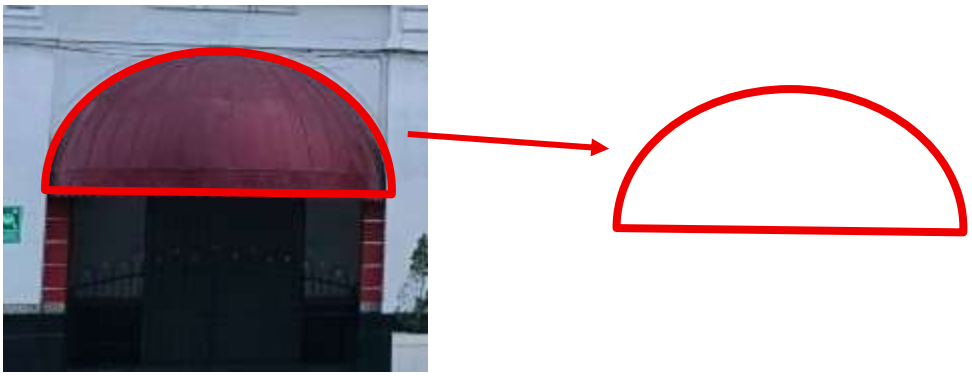

**Figure 8.** Semicircle

In Figure 8, we can see the concept of a flat structure, namely a semicircle, which can be seen in the shape of the roof of colonial buildings. Semicircles are curved shapes that are often used in Dutch colonial architecture, especially on roofs, bovenlicht windows, and door arches to give an elegant and balanced aesthetic impression. Philosophically, the semicircle symbolizes divided perfection, harmony, and balance between strength (diameter) and softness (curve). This shape also serves to help drain rainwater well to both sides of the building. A semicircle has one straight side in the form of a diameter and one curved side in the form of an arc.

Formulas used:

Area

$$L = \pi \times r \tag{11}$$

Circumference

$$K = \frac{1}{2} \times \pi \times r^2 + 2 \times r \tag{12}$$

**The Concept of Building Space and Its Philosophy in the Cultural Heritage of Old Surabaya**

1) Cone


**Figure 9.** Cone

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In Figure 9, we can observe the concept of a cone shape in the form of towers and roof ornaments of colonial buildings. Cones are one of the geometric shapes that were widely used in Dutch colonial architecture, especially in watchtowers, pointed roofs, and building corner covers to give a strong yet elegant vertical impression. Philosophically, the cone symbolizes a focused direction—from a wide base to a single peak—which can be interpreted as a symbol of firmness, stability, and purpose. Functionally, the conical shape helps rainwater flow more quickly from the top while reducing structural load due to its aerodynamic properties. The cone has a circular base and a curved surface that meets at a single apex, making it a harmonious spatial form between flat and curved surfaces.

Formulas used:

Surface Area

$$LP = \pi \times r \times (r + s) \tag{13}$$

Volume

$$V = \frac{1}{3}\pi \times r^2 \times t \tag{14}$$

2) Tube

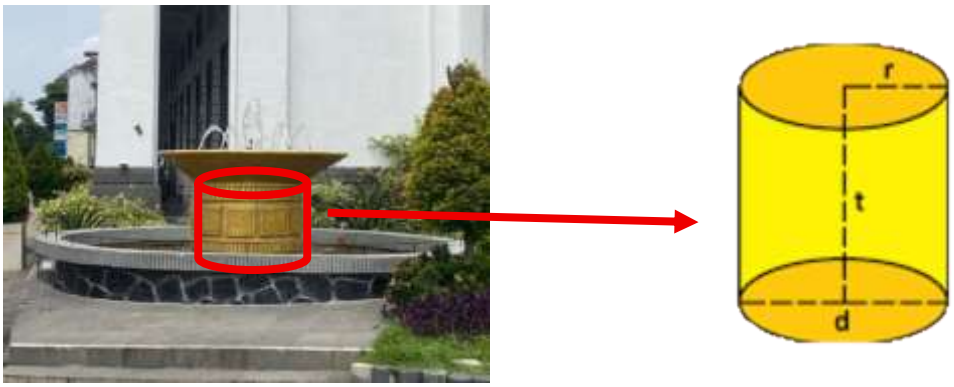


**Figure 10.** Tube

Figure 10 shows the cylindrical shape of the fountain structure. A cylinder is a three-dimensional shape with two parallel circular bases connected by a curved side. In architecture, cylindrical shapes are often used to give an impression of strength, stability, and proportionality. Philosophically, cylinders symbolize continuity and balance because they have a symmetrical shape that repeats from top to bottom.

In terms of function, the cylindrical shape is ideal for holding and channeling water because its walls can withstand pressure evenly. In addition, the cylindrical structure allows for stable load distribution, making it suitable for fountain elements that require both strength and aesthetics. The combination of curved surfaces and circles in the cylinder creates a harmonious shape that blends well with the design of public spaces.

Formulas used:

Surface Area

$$LP = 2 \times \pi \times r \times (r + t) \tag{15}$$

Volume

$$V = \pi \times r^2 \times t \tag{16}$$

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P-ISSN: 2655-3724 E-ISSN: 2720-9881
Vol. 8, No. 2, August 2026
11th article, Pages: 320 – 334
DOI: https://doi.org/10.32493/sm.v8i2.59668

3) Sphere

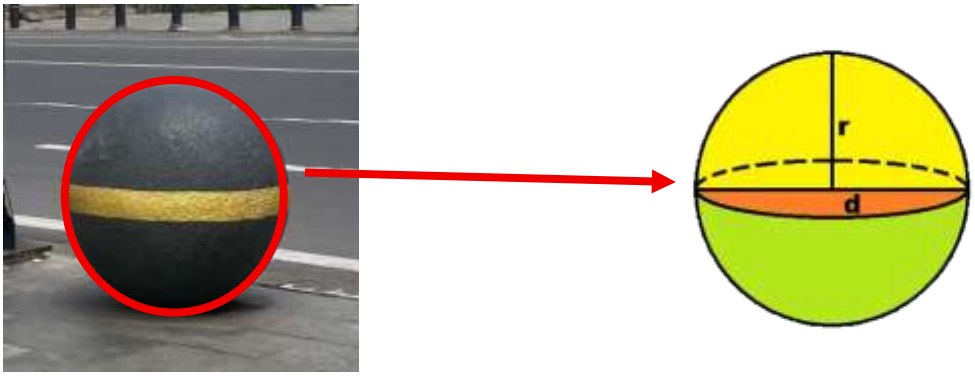


**Figure 11.** Sphere

Figure 11 shows a spherical shape used as a barrier element and public space decoration. A sphere is a three-dimensional shape in which all points on its surface are equidistant from the center point, creating a perfect, whole, and symmetrical impression. In urban design, spherical shapes are often chosen because they have no sharp corners, making them safe for pedestrians and aesthetically pleasing.

Philosophically, spheres symbolize unity and harmony because their shape is endless, resembling unbroken continuity. Functionally, spheres serve as effective area dividers because their symmetrical structure allows them to withstand pressure from various directions. Additionally, the spherical shape provides a bold yet soft visual, making it a harmonious element in beautifying sidewalks and surrounding public spaces.

Formulas used:

Surface Area

$$LP = 4 \times \pi \times r^2, \tag{17}$$

Volume

$$V = \frac{4}{3} \times \pi \times r^3, \tag{18}$$

## CONCLUSION

This study shows that the Old Town area of Surabaya is a cultural space rich in historical value and full of mathematical concepts, particularly in the flat and spatial elements inherent in its colonial architecture. Through an ethnomathematics approach, various building elements such as symmetrical facades, arched windows, tubular pillars, triangular roofs, circular ornaments, and conical and spherical structures can be identified as real representations of geometric concepts that have been taught abstractly in classrooms.

The results of observation and documentation show that colonial buildings in Kota Lama not only display geometric shapes as an aesthetic aspect, but also reflect structural functions and cultural philosophy during the colonial period. Each shape has a symbolic meaning—triangles as a symbol of balance, circles as perfection, tubes as stability, cones as a firm direction, and spheres as unity and harmony. This proves that mathematics lives in the cultural and architectural practices of society and plays a major role in building the visual identity of this historic area.

From an educational perspective, these findings confirm that ethnomathematics can be an

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effective contextual approach to improving students' understanding, motivation, and engagement in learning geometry. The buildings in Surabaya's Old Town can be used as concrete learning resources that are close to students' lives and relevant to the local context. Thus, this research not only contributes to the study of ethnomathematics but also provides a more meaningful learning alternative through the use of cultural heritage as an educational medium.

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