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Integrating Ethnomathematics in Architectural Heritage: A Case Study of BAT Buildings in Cirebon

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ABSTRACT

This study is the first to analyze the British American Tobacco (BAT) Building in Cirebon through an ethnomathematical perspective as a means of supporting contextual mathematics learning in Indonesia. The research is driven by the need for innovative approaches that integrate local culture into mathematics education. The main objective is to identify and describe mathematical concepts embedded in the architectural design of the BAT Building. A descriptive qualitative method was employed, with data collected through direct observation, photographic documentation, and literature review. The analysis focused on architectural elements such as roofs, windows, doors, and façades to reveal underlying mathematical concepts. The findings indicate that the BAT Building incorporates diverse geometric representations, including spatial forms (rectangular pyramids and triangular prisms), flat shapes (rectangles and semicircles), symmetry, patterns, proportions, and geometric transformations. These results demonstrate that colonial industrial architecture not only serves as a historical and cultural landmark but also as a rich source of ethnomathematical knowledge. The study concludes that integrating architectural heritage into mathematics learning provides an effective contextual approach to enhance students' understanding of geometry. Furthermore, the findings contribute to the development of culturally based teaching materials and highlight the importance of linking mathematics with history and local wisdom to strengthen meaningful learning experiences.

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1. INTRODUCTION

Indonesia is a country with abundant cultural wealth, reflected in various heritages, both in the form of traditions, arts, and architecture. Cirebon is one of the regions that has many architectural heritages that reflect the confluence of local, colonial, and industrial cultures. One such heritage is the BAT (British American Tobacco) Building, which still stands today and serves as an icon of the city. This building is not only historically valuable, but also holds potential for mathematical studies that have not been widely explored. Integrating cultural heritage into mathematics education is important to make learning more contextual, meaningful, and closely connected to students' daily environments. Thus, exploring architectural heritage like the BAT Building provides not only historical awareness but also educational innovation.

The study of ethnomathematics was first introduced by D'Ambrosio [1] as a study of mathematical practices that grow within a cultural context. Rosa and Orey [2] then emphasized that ethnomathematics plays an important role in understanding the relationship between formal mathematics and cultural practices. In line with this, various studies in Indonesia have applied ethnomathematics to cultural objects, ranging from traditional woven fabric motifs [3], traditional masks [4], or traditional dances [5]. Other research conducted by Ikawati and Wardana [6] studies highlight how mathematical concepts are embedded in local culture and provide resources for contextual learning, yet they remain limited in scope.

In the context of historical buildings, Choirudin et al. [7], [8] examined the Pugung Raharjo Antiquities Site and found a connection between mathematical concepts and several parts of the site, such as stepped pundens, corpse stones, and auspicious pools. This research confirms that historical relics can be used as a source of ethnomathematics studies, while opening up opportunities for exploration at other sites with similar characteristics. Another study by Wulandari et al [9] on the Kasepuhan Cirebon Palace explored philosophical and conceptual mathematical values, including symmetry and patterns in building ornaments. The results of their research emphasize that the culture around us can be used as a source of ethnomathematics-based mathematics learning, while suggesting that future research expand the object of study to other heritage buildings. However, these studies predominantly focus on traditional or ancient sites, while colonial-industrial buildings that also carry mathematical and cultural significance remain understudied.

From these studies, it can be seen that ethnomathematics studies on historical buildings have made an important contribution in connecting mathematics with culture. However, most of the research objects still focus on ancient sites and traditional architecture. Colonial-industrial architecture, such as the Cirebon BAT Building, is rarely used as an object of research, even though this building has a distinctive historical, architectural, and cultural value. Therefore, this research seeks to fill the gap by exploring the mathematical elements of the Cirebon BAT Building as part of a unified cultural heritage. Specifically, this study aims to identify and describe geometric concepts embedded in the BAT Building and to analyze their potential use as contextual resources for mathematics education. By doing so, this research contributes to strengthening the link between mathematics, cultural heritage, and innovative teaching practices.

2. METHOD

The type of research used in this study is descriptive qualitative research. This study aims to describe systematically, factually, and accurately [10] the ethnomathematical elements contained in the architecture of the BAT (British American Tobacco) Cirebon building, which is located on Jalan Pasuketan No. 1, Lemahwungkuk Village, Lemahwungkuk District, Cirebon City. This descriptive method is used because the research is not intended to test a specific hypothesis, but rather to describe the "realistic" conditions of the object being studied. The data collected in this study are in the form of words, pictures, and field notes, not numbers or statistics. The choice of descriptive qualitative design is also intended to allow an in-depth exploration of cultural and mathematical values that are visually represented in architectural forms.

The researcher conducted direct observation of the BAT Cirebon building to document and study the mathematical forms contained in its architectural elements. Data collection is carried out through direct observation, without interviews, because data is obtained visually from the observed object. The researcher focuses on observing geometric shapes, symmetrical patterns, building proportions, and other architectural elements such as roof shapes, columns, doors, windows, walls, and typical building ornaments. In addition to observation, the researcher also uses a documentation method, namely by taking pictures of observed building objects as visual data for further analysis. Each finding is systematically recorded in the field notes, which contain in-depth descriptions of the shape, size, structure, and relationship of the architectural elements to mathematical concepts. To strengthen data validity, the researcher compared visual findings with secondary sources, such as architectural literature and historical documents, as a form of triangulation.

Before data collection was carried out, the researcher had first determined the type of data needed to support ethnomathematical studies, especially those related to the shape and structure of buildings. The research instrument used consisted of an observation sheet to categorize mathematical elements, a digital camera to capture architectural details, and field notes for descriptive records. This ensured systematic and consistent data collection. The collected data is then analyzed by grouping the mathematical patterns found based on specific categories, such as symmetry, geometric shapes, or proportions. The results of this analysis are then presented in a descriptive form that describes the relationship between mathematical elements and local cultural values contained in the architecture of the BAT Cirebon building. The data analysis process followed three main stages: data reduction by selecting relevant observations, data display in tabular and descriptive form, and conclusion drawing [11] to interpret the role of mathematical concepts in the architectural context.

3. RESEARCH RESULTS

3.1. History of BAT Cirebon Building

The British American Tobacco (BAT) building located on Jalan Pasuketan No.1, Lemahwungkuk Village, Lemahwungkuk District, Cirebon City, is one of the architectural relics of the colonial industry built in the early 20th century. Geographically, the location of this building is at the coordinate points of 108° 34' 11.2" East Longitude and 06° 43' 08.1" South Latitude with an altitude of ±6 meters above sea level. The selection of Cirebon as an industrial location is based on its strategic position as a port city and its proximity to tobacco-producing areas, such as Bojonegoro and Temanggung [12]. This strategic positioning not only supported the growth of the tobacco industry but also shaped Cirebon into one of the vital centers of colonial-era trade and production.

This building was originally established in 1917 by the Indo Egyptian Cigarettes Company. However, in 1923, the company was acquired by the British American Tobacco Company, a British multinational company that at that time was expanding its industrial network to the Dutch East Indies. One year later, in 1924, the building underwent a significant renovation by architect F.D. Cuypers & Hulswit. The changes feature an art deco architectural style, known for the use of geometric patterns, symmetry, and a modular design approach that is in harmony with mathematical principles. These renovations not only enhanced the aesthetic and functional aspects of the building but also marked the beginning of its transformation into an industrial and cultural landmark in Cirebon [13].

As a center for white cigarette production, BAT Cirebon developed into one of the largest factories in its time. Products such as Lucky Strike and Pall Mall produced at this facility are not only marketed domestically but also exported to international markets. However, global and national political developments also affect the company's operational continuity. During the Japanese occupation in 1942, the company's operations ceased, and the military government took over its assets. After the end of World War II, BAT resumed operations in 1949 under a new name, British American Tobacco Manufacture (Indonesia) Limited [14]. This fluctuation in operations illustrates how international conflict and political transitions directly influenced industrial activities and ownership structures in Indonesia.

During the Indonesia-Malaysia confrontation in 1963–1964, the Indonesian government took over ownership of BAT because the company was part of a foreign entity. However, with the enactment of Law No. 1 of 1967 concerning Foreign Investment, the company was returned to its original owner. Furthermore, in 1979, the company officially changed its name to PT BAT Indonesia and began offering some of its shares to the public through the Jakarta Stock Exchange. This legal and economic shift reflects Indonesia's changing policies toward foreign investment and highlights the adaptability of BAT in navigating regulatory environments.

The BAT Cirebon building continued to operate until 2010, when the entire production process was moved to Malang, East Java, as part of the business merger with PT Bentoel Internasional Investama. Since then, this building has no longer been used for industrial activities, but it still stands as a historical symbol and becomes a potential object in ethnomathematical studies, especially in studying the application of mathematical concepts in colonial architectural design. Today, the BAT building remains an architectural witness of industrial history and serves as a valuable resource for research that connects mathematics, culture, and heritage preservation.

3.2. Ethnomathematical Concepts in the Architecture of the BAT Building, Cirebon

Based on the results of observation and visual documentation of the British American Tobacco (BAT) Building in Cirebon, various mathematical elements were found that were implicitly embedded in its structure and architectural design. The findings cover seven main categories of mathematical concepts. These elements demonstrate how architecture not only fulfills functional and aesthetic purposes but also inherently reflects mathematical principles that can be identified and analyzed. In this way, the BAT Building becomes a rich medium to understand the intersection of mathematics and cultural heritage.

Table 1. Ethnomathematical Findings on BAT Architecture

No.	Concept	Architectural Evidence
1	Geometry of Building Space	Rectangular pyramid roof; Longitudinal structure in the shape of a triangular prism
2	Flat Plane Geometry	Plaques, rectangular windows, semicircular arches
3	Geometry Transformation	Repeated window pattern (translation), ventilation variation (dilation)
4	Combined Build Area	Curved door (rectangular + 1/2 circle)
5	Symmetry Lipat	Main façade of vertical reflective symmetry
6	Patterns & Blending	Arrangement of tiles and repeated arches
7	Proportions & Ratios	Window spacing, building height–width

The classification in Table 1 provides a systematic overview of how different mathematical concepts appear in specific architectural features. Each category not only illustrates the diversity of geometric applications but also highlights the potential of these elements to be integrated into contextual mathematics learning. Thus, the BAT Building can be regarded as both a cultural artifact and an educational resource.

3.2.1. Spatial Geometry

Ancient buildings are not only a witness to the history of human civilization, but also a tangible manifestation of the application of mathematical concepts in a functional and aesthetic form. In the BAT building, it shows how the shapes of a rectangular pyramid and a triangular prism are used in the structure of the building to create harmony between form and function. This is the concrete form of the geometry of the plane of space that lives in the real world. The definition of spatial geometry is a branch of mathematics that studies three-dimensional shapes that have length, width, and height. Different from flat buildings, spatial buildings have volume and can be calculated in terms of surface area. Examples of building spaces include: cubes, blocks, pyramids, prisms, tubes, and cones. Thus, the study of spatial geometry is not limited to abstract theory in classrooms, but also manifests in real architectural forms that can be observed directly in cultural heritage buildings such as the BAT Cirebon building.

Figure 1. Quadrilateral Pyramid Roof

The top of the BAT building shows the shape of a quadrilateral pyramid roof, which is a roof that tapers upwards and has a square or rectangular base. A quadrilateral pyramid is a spatial structure that has a rectangular base (square or rectangular) and four triangular-shaped upright sides that meet at one apex point. This structural choice not only provides strength against tropical weather conditions but also creates a visual impression of balance and grandeur, reflecting the functional and symbolic role of the building in its historical context.

Figure 2. Triangular Prism Space

Furthermore, in the middle of the building, we can imagine the shape of a triangular prism, especially in the details of the structure and the sides of the building that extend with a fixed height and width. A triangular prism is a space structure with two congruent triangular-shaped bases and the other sides rectangular. The prism shape provides stability and is ideal for elongated parts of buildings such as hallways, corridors, or building wings. In addition, this shape can also be found on roof windows or ornaments on the top of buildings that are triangular in shape. The application of spatial geometry in architecture is not only a matter of engineering, but also of art. The old buildings seen in the pictures show that the shape of the rectangular pyramid and the triangular prism is not only a mathematical concept, but also part of the aesthetics and structure. Through understanding geometry, we can better appreciate how mathematics is the basis of many aspects of life, from the calculation of volume, structure, to design that reflects the identity of an era. Therefore, analyzing these geometric forms in the BAT Building allows us to connect mathematical concepts with historical and cultural values, while at the same time providing concrete examples for contextual mathematics learning.

3.2.2. Plane Geometry

The BAT (British American Tobacco) Cirebon Building is one of the colonial architectural relics that has historical and educational value. Established in 1924, this building is not only a symbol of the development of the tobacco industry during the Dutch colonial period, but also represents the rich value of tropical architecture loaded with geometric principles. In the context of mathematics education, this building can be interpreted as a culture-based learning resource that offers an ethnomathematical approach, namely the study of mathematics in the context of community culture that is relevant and contextual for students. This shows that the architectural design of the BAT Building is not only an industrial product but also a potential medium for teaching mathematics through cultural heritage.

Figure 3. Rectangular Building Structure

One of the dominant forms of flat plane geometry in the BAT Building architecture is the rectangle. This shape is found in various elements, such as the historical plaque that reads "ANNO 1924", rows of windows and main doors, and ventilation holes. Mathematically, rectangles have distinctive properties such as symmetry, right angles, as well as formulas for calculating their area and circumference that can be used in designing the architecture itself. The use of this form in architecture is not solely an aesthetic consideration, but also an efficiency of air circulation and natural light in tropical buildings. Therefore, the rectangle in this building demonstrates how mathematical principles contribute directly to both functional design and environmental adaptation.

In learning, the rectangular shape in the BAT building can be used to teach basic concepts of geometry contextually, introducing an understanding of proportions, sizes, and spatial relationships in real terms. This is in line with the principle of meaningful learning, where students can relate real experiences to the math material learned in class. Such contextualization allows abstract formulas to become concrete experiences, making students more engaged in the process of discovering mathematical concepts.


Figure 4. Semicircular Plane Figure

In addition to the rectangular shape, another geometric element found on this building is a semicircle that appears at the top of the window or entrance in the form of an arch. This form is commonly found in classical European architecture and is used in colonial buildings for structural and aesthetic reasons. From the mathematical side, the semicircle introduces students to the concept of curved shapes. In the context of architecture, the semicircular shape is used because of its ability to distribute pressure from the top of the building to the left and right sides evenly, making it a strong and stable structure. The integration of this knowledge in mathematics learning allows students to understand how geometric concepts are not only relevant in theory but also applied in the design and engineering of buildings. Thus, the ethnomathematical approach implemented through the BAT Building invites students not only to study geometry abstractly but also to appreciate its application in real-world structures, bridging the gap between mathematics, culture, and daily life.

The ethnomathematical approach implemented through observation of the BAT Cirebon building provides a more contextual learning alternative, especially in grounding flat plane geometry material in daily life. Students not only study formulas and definitions abstractly, but are also invited to observe, reason, and analyze geometric shapes in local cultural artifacts. Thus, the learning experience becomes more holistic and meaningful, combining cognitive, affective, and conative aspects simultaneously.

3.2.3. Geometric Transformations

Geometric transformation is a part of mathematics that studies changes in the position, shape, or size of a geometric structure on a flat plane or space. In everyday life, this transformation can be found in various aspects such as art, architecture, graphic design, and digital mapping technology. Its presence in architecture, in particular, demonstrates how mathematical principles are unconsciously applied to achieve both structural efficiency and aesthetic variation.

In general, geometric transformations are divided into two major groups, namely isometric transformations (which maintain the size and shape of the building) and non-isometric transformations (which change the size or shape of the building). In observations at the BAT Building, two types of Geometric Transformation were obtained, namely translation and dilation. These transformations illustrate how repetitive and proportional designs in colonial architecture are grounded in mathematical reasoning, even if not explicitly intended by the original builders.

a. Translation

   Translation is a transformation that shifts a building element in a certain direction by a certain distance without changing its shape or size. For example, windows in the BAT Building arranged horizontally are an application of translation. The repetition of these windows not only ensures regularity and balance but also creates rhythm in the façade, making it an effective illustration of translational symmetry in real architecture.

Figure 5. Translation

b. Dilation

Dilation is a transformation that changes the size of a geometric shape by enlarging or reducing it from a certain central point, while still maintaining its form. In the BAT Building, dilation can be observed in the variations of ventilation openings or decorative elements. This variation produces a dynamic impression on the building's façade, showing that proportional enlargement or reduction is not only a mathematical concept but also a deliberate architectural strategy to enhance visual appeal.

Figure 6. Dilation

3.2.4. Plane Geometry Area

The BAT Building is one of the historical buildings that is famous for its distinctive architecture, especially on the façade, which features a row of curved doors. The unique feature of these doors is their shape, which is a combination of two flat shapes, namely rectangular and semicircle. This shape not only provides high aesthetic value, but also becomes an interesting object to study in mathematics learning, especially in the topic of flat builds. The curved part of the door is a semicircle, while the bottom is a rectangle perpendicular to the ground. By combining these two shapes, we can calculate the total area of a single door unit as the sum of the area of a rectangle and a semicircle. This integration of geometric forms illustrates how architecture can transform abstract mathematical ideas into concrete visual expressions that also serve structural and aesthetic purposes.

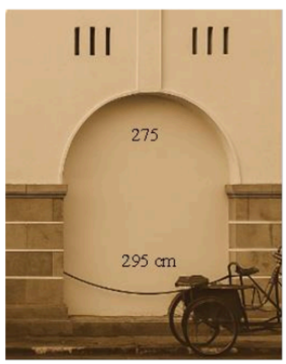

Figure 7. Geometric Area

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From the results of direct measurements at the location, it is known that:

- The width of each door (which is also a semicircular diameter) is 275 cm, and
- The height of the rectangular part of the door is 295 cm.

To calculate the total area of a single door, the following formulas are used:

- Rectangular area = length × width
- Semicircular area = $\frac{1}{2}.\pi.(r^2)$, where r = diameter

By including these values, then:

- Rectangular area: length × width $= 295\ cm \times 275 cm = 81.125 cm^2$
- Semicircular area:
  $\frac{1}{2}.\pi.r^2 = \frac{1}{2} \times 3{,}14 \times (137{,}5)^2 = \frac{1}{2} \times 3{,}14 \times 18.906{,}25 = 29.682{,}81\ cm^2$

Thus, the total area of one door is 81,125 cm^2 + 29,682.81 cm^2 = 110,807.81 cm^2. To obtain the total surface area of all doors on the BAT Building façade, the same calculation can be multiplied by the number of identical doors, since each unit shares uniform dimensions and shape. This example clearly demonstrates how mathematical computation directly relates to architectural measurement and design, making it a powerful medium for contextual mathematics education.

3.2.5. Application of Reflective Symmetry

Architecture is a field that is inseparable from the involvement of mathematical elements, one of which is the concept of symmetry. In many historic buildings, symmetry is often used as a basic principle in the design of shapes and structures to achieve a balanced and harmonious aesthetic impression. The BAT (British American Tobacco) Building, located in Cirebon City, is one of the real representations of the application of the concept of symmetry in an architectural context. The building not only has high historical and cultural value, but it also displays visual regularity that explicitly reflects mathematical principles. This demonstrates that architectural design is not only about functionality, but also about embedding mathematical harmony that enhances the cultural and visual identity of the building.

Through observation of the façade, it is clear that there is a strong symmetry element, both in terms of shape and arrangement of structural elements, making it an interesting example to analyze from a geometric point of view.

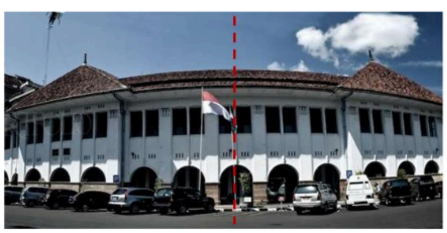

Figure 8. Reflective Symmetry

Based on observations of the front façade of the building, it appears that this building applies reflective symmetry, especially to the vertical axis that divides the building into two balanced parts. If a vertical imaginary line is drawn that passes through the center of the façade, the two sides of the building will appear to reflect each other, indicating a consistent geometric balance. The symmetrical features seen in the BAT Building include the similar placement and number of windows on both sides, the repetition of door arches at the lower level, and the parallel positioning of the roof towers. This regularity creates a visual rhythm that makes the façade appear orderly and proportionate, while at the same time serving as a practical example for teaching reflective symmetry in mathematics learning. In this way, the BAT Building shows how mathematical ideas can be embodied in cultural artifacts and transmitted through architectural design.

3.2.6. Top View

When viewed from the top, the British American Tobacco (BAT) Cirebon Building shows the presence of mathematical elements that are indirectly embedded in its design and structural composition. The building was not only designed to fulfill industrial functions, but also constructed with a sense of spatial order that reflects fundamental principles of geometry and pattern. From this perspective, the top view provides a holistic understanding of how architectural planning involves the systematic arrangement of shapes and proportions, demonstrating the practical application of mathematical reasoning in real contexts.

Figure 9. Top View of the BAT Building

One of the most recognizable things is the symmetry of the building. Overall, the shape of this building has a balance between the left and right sides, especially if you draw an imaginary line from the center of the building. Symmetry like this not only gives a neat and orderly feel, but it also reflects how architectural design makes use of the principle of mirror symmetry to create a visual and functional balance. In addition to symmetry, the repetition of the pattern is also evident, especially in the tiled roof parts that are arranged regularly and repeatedly. This tile pattern is a simple example of the concept of weaving in mathematics. Not only on the roof, the bottom of the building, which has a row of arches, shows a repetitive pattern that shows horizontal alignment of shapes.

In terms of basic shape, the building structure is dominated by rectangular and triangular shapes, both in the building plan and the shape of the roof. The use of these shapes shows that there are mathematical considerations in the design process, especially in adapting the design to the tropical climate so that rainwater can flow properly. In terms of size and comparison, this building also looks built with balanced proportions. The length, width, and height of the building appear to be designed in a measured manner, thus creating a harmonious impression. It shows the utilization of the concepts of scale and comparison, which are commonly used in building planning.

Interestingly, this building also shows geometric transformations, such as the repetition of shifted shapes (translation) and the arrangement of structures that change direction at corners (local rotation). Things like this reflect how mathematics comes naturally in the design process, although it is not always directly referred to as "mathematics".

4. DISCUSSION

This research process began with data collection through direct observation of the structure of the British American Tobacco (BAT) Building in Cirebon and visual documentation of architectural elements. The data obtained is in the form of photographs, field notes, and measurements of certain geometric elements. Furthermore, the data is processed by identifying the categories of emerging mathematical concepts, such as spatial geometry, flat-plane geometry, symmetry, patterns, geometric transformations, combined building areas, and proportions. The results of the identification were then validated with relevant geometric theories in the curriculum, as well as compared with previous research on different cultural objects. For example, the findings of symmetry and proportions in the architecture of the BAT Building are in line with the study by Ikawati & Wardana [6] on the structure of Pari Temple. At the same time, the pattern of bending and repeating the shape of the window reinforces the findings of Hidayatulloh [15] regarding the geometric patterns of the scout tent. This comparison shows that mathematical concepts in industrial colonial architecture have compatibility with ethnomathematical principles in other cultural objects despite their different contexts. Thus, the BAT Building provides evidence that mathematical ideas can transcend cultural boundaries and manifest in both traditional and colonial-industrial heritage, expanding the scope of ethnomathematics beyond commonly studied objects.

In addition to validation with theory and previous research, the discussion also emphasized the relevance of research results to learning [16], [17], [18], [19]. The concepts of geometry found can be integrated into local culture-based learning activities [20], [21], [22], [23], [24], so that students not only learn abstract theories but also relate them to real artifacts in their environment. This approach supports contextual learning as recommended by Khaerani et al. [25]. Thus, the ethnomathematical analysis process in the BAT Building not only produces an inventory of mathematical concepts but also shows how empirical data can be processed, studied theoretically, and reinterpreted as a meaningful learning resource. From an educational perspective, this contributes to the development of culturally responsive teaching materials, helping teachers design lessons that bridge mathematical abstraction and cultural heritage. From a cultural perspective, it reinforces the role of architecture as a living medium for preserving local identity through mathematics.

Nevertheless, this study has certain limitations, particularly because it focuses only on one colonial-industrial building and relies primarily on visual observation without involving expert interviews or advanced measurement techniques. These limitations suggest that future research should expand to other historical sites—both traditional and colonial—to provide a more comprehensive mapping of ethnomathematical practices. In addition, interdisciplinary approaches involving architects, historians, and mathematics educators could enrich the interpretation of findings and strengthen their relevance to both education and cultural preservation.

5. CONCLUSION

This study confirms that the British American Tobacco (BAT) Building in Cirebon contains diverse mathematical concepts embedded in its architectural design, including spatial geometry, flat-plane geometry, symmetry, patterns, proportions, and geometric transformations. These findings demonstrate that colonial-industrial architecture, which is often overlooked in ethnomathematical studies, can also serve as a rich source for exploring the relationship between mathematics and culture.

The integration of these concepts into mathematics learning provides an opportunity to develop contextual and culturally responsive teaching materials. By linking geometric principles to tangible architectural elements, students are able to connect abstract theories with real artifacts in their environment. This not only enriches learning experiences but also highlights architecture as a living medium that preserves cultural identity through mathematics.

However, this research has limitations, as it focuses only on one colonial building and relies primarily on visual observation. Future studies are encouraged to include other heritage sites, both traditional and colonial, as well as interdisciplinary perspectives from historians, architects, and educators. Such approaches will broaden the scope of ethnomathematical exploration and strengthen its relevance to education, cultural preservation, and the development of innovative learning practices.

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