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DETERMINANTS OF THE OPTICAL ILLUSIONS EFFECT ON THE DALEM AGENG PRABAYEKSA ROOF, DALEM MANGKUBUMEN AREA, YOGYAKARTA

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ABSTRACT

Javanese buildings can be understood both physically and non-physically, one of them is the Dalem Ageng Prabayeksa which is in the Dalem Mangkubumen complex. This building has the most important and sacred position in the complex with the uniqueness of the hip roof *(limasan),* which cannot be found in other hip roof buildings. This study focuses on optical illusions that occur on the roof of the building in front (south) and rear (north) views using explorative descriptive methods. Optical illusions that affect visual perception occur because of the imaginary perspective lines formed from the diagonals of the roof of the building so that an illusion is created that make the roof of the building look wider and taller than it should be. The roof of the building is also formed from proportions that are in accordance with the reference for the building as a house and the building as a place of worship (temples) which supports how optical illusions can occur so that a visual perspective and meaning behind the design of the roof appears which makes sense and is in line with the position of the Dalem Ageng Prabayeksa building as the most important and sacred building in the Dalem Mangkubumen complex.

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1. Introduction

Javanese buildings, including houses, were formed from the culture and civilization of the Javanese people hundreds of years ago. These buildings can be understood both physically and non-physically, which is interesting to study. House for the Javanese is not just a place to shelter or live, but more than that. The house is an entity considered to have a soul that gives power to its owner (Budiwiyanto, 2013). With this power or energy, it is hoped that the house will provide harmony, comfort, and peace (Sumardiyanto, 2019) for its inhabitants where this power or energy arises from the construction process and when the building has been completed with full philosophy, calculations, and strict rules so that this raises sacred values inherent in Javanese society.

Tacid knowledge regarding Javanese architectural buildings from previous generations of Javanese people is a challenge for researchers to be able to reveal and explain them in accordance with existing truths. The values of Javanese buildings need to be discussed from a physical perspective and a philosophical point of view (Prakoso and Willianto, 2020). Between physical and non-physical (philosophical), both cannot be separated. Both are connected and influence each other. It includes human perception when visually looking at the building so that other people will see how the building will look, as is the case with Javanese keris. There is what is called the *pamor* of a *keris* which aims to be aesthetically pleasing to look beautiful and has a symbolic function that has meaning and depicts hopes and prayers embodied in the form of a keris pamor. Both of them have things in common as the physical and non-physical are inseparable things in the life of the Javanese people. This perception can be formed from optical illusions that occur in the human eye. In fact, this technique has long been used to enhance the aesthetic perception of works of art or architectural structures, where traditional Javanese society itself refers to the teachings of the *Kejawen* philosophy. It intuitively understands reality, limited to its physical form and philosophy (Prakoso and Willianto, 2020).

This study aims to explore optical illusions on the roofs of buildings facing the mountains (north) and sea (south), which will affect human visual perception in seeing traditional Javanese buildings, in this case, the Dalem Ageng Prabayeksa building located in Dalem Mangkubumen. The reason this research focuses on the roof is that there are several factors, namely, (1) it has the most dominant part of the building facade; (2) it has the largest proportion and scale of building form compared to the body and foot of the building; (3) having the most

visually accessible part of the building so that it becomes a point of interest. The findings regarding optical illusions that affect visual perception can later be used as new knowledge of how we view a traditional Javanese building, especially Dalem Ageng Prabayeksa, which is closer to the impression that the maker/owner wants to convey regarding its function, which is so sacred to the building.

2. Literature Review

2.1 Dalem Ageng Prabayeksa

Dalem Ageng Prabayeksa is the most important building in the Dalem Mangkubumen complex, where Dalem Mangkubumen itself is the residence area of Prince Adipati Anom, who is the heir to the royal throne of the Kraton Ngayogyakarta Hadiningrat with the title Sri Sultan Hamengku Buwono VII. Within the Dalem Mangkubumen complex, Dalem Ageng Prabayeksa is a *gedhong pusoko* (a place to store heirlooms), a place of worship, and a residence for the Prince's family. Like its function as a *gedhong pusoko* and worshipping transcendental authorities in the Dalem Mangkubumen complex, Dalem Ageng Prabayeksa has transcendent properties and powers so that it becomes a transcendental center in the Dalem Mangkubumen complex (Wibowo and Murti, 2020). Meanwhile, the transcendentality of the Javanese king's house is found in the Prabayeksa Kraton Yogyakarta, with *'sang tani'* as its spiritual ruler (Mangunwijaya, 1988) and as a bright light that guides the human soul to heaven as well as a place for ritual worship activities related to fertility (Wardani, 2011).

Based on the result of research published in the Kraton Ngayogyakarta Hadiningrat, Dalem Ageng Prabayeksa and Dalem Mangkubumen complex were specifically designed to support and help the crown prince become a king; and by requiring that Dalem Mangkubumen complex be made the same as the Kraton Ngayogyakarta Hadiningrat in terms of architecture and state administration. From the architectural side, placed in Dalem Ageng Prabayeksa is made the same as Prabayeksa in the Kraton Ngayogyakarta Hadiningrat (Wibowo and Murti, 2020).

2.2 Kraton Yogyakarta Javenese-Hindu Art Style

According to Wardani (2011), Sri Sultan Hamengku Buwana I managed to increase cultural, artistic, and philosophical values through the spatial configuration of the Yogyakarta Palace. This spatial configuration is the best idea for realizing an artistic expression consisting of form and content influenced by religious aspects so that it is not just considering aesthetic aspects. Sri Sultan Hamengku Buwana I embodied his expressions, feelings, and thoughts in the spatial configuration of the Kraton Yogyakarta by combining the micro and macro universes harmoniously, making it a reflection of the pre-Hindu and Hindu periods in central Java. The room configuration of the Kraton Yogyakarta refers to the Vasthusastra originating from India and then processed and readjusted for its use based on the socio-cultural and religious life of the Javanese people at that time. This change occurred as a form of cultural acculturation between the original culture of central Java and Hinduism.

The Kraton Yogyakarta retains traditional building art with various types of Javanese (especially DIY) houses. Most of the buildings in the Kraton are *joglo* and *limasan*, which are supported by four to eight *saka gurus*. In Hindu building systems, this roof refers to the shape of the *meru* on the roof, namely the shape of the roof that rises high in the middle and is called the *brunjung* roof. The principle of Hindu-Javanese cosmology is that the world is divided into three layers called the *Triloka*, namely the *Jagad Atas* (*svarloka*), the *Jagad Tengah* (*bhuvarloka*), and the *Jagad Bawah* (*bhurloka*). The *Jagad Atas* and *Bawah* are *adam makdum* (emptiness). In *Jitapsara* it is called the *Jagad sunya-ruri*, the realm of the jinn, as well as all creatures with spiritual bodies. The *Jagad Atas* is the abode of the gods and supreme beings, the *Jagad Tengah* is the realm of the world, where humans and all creatures with physical bodies live, while the *Jagad Bawah* represents evil forces in nature (Ronggowarsito, 2001, p. 39, 85). It represents the composition of the universe (macrocosm) in the form of Mount Mahameru (India), and the king is seen as a god-king who reigns at its peak. By applying the *meru* shape to the building, the divine light enters the building through the *meru*-shaped rooftop (Ambarwati, 2009, p. 127).

2.3 Optical Illusion

Witabora (2012) states that, in general, there are three kinds of optical illusions, namely: (1) literal optical illusion, where the optical illusion that occurs will cause the object to have a different impression from the actual one; (2) psychological optical illusion, a condition in which the eyes and brain are given excessive stimulation, such as size, color and position; (3) cognitive optical illusion, an optical illusion that results from processing information from the subconscious/out of control.

2.4 Distorting/Geometrical-Optical Illusions/Anamorphosis

Distorting/Geometrical-Optical Illusions/Anamorphosis itself falls into the category of cognitive optical illusions. It is a distortion that occurs in 2D geometric shapes. This optical illusion is usually found in depth, distance, or size that has been distorted.

a. The Muller-Lyer illusion states that lines of the same size will appear to differ in length if the ends of the lines are given arrows in opposite directions.

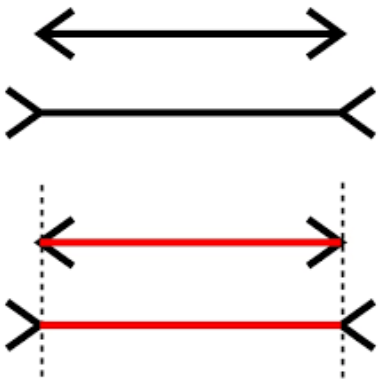


Figure 1. Muller Lyer Illusion
Source: Brainstuff (2019)

b. The vertical-horizontal illusion explains that we tend to see vertical lines as longer than horizontal lines when in fact, they have the same line length, such as

in an experiment conducted by Roger Shepard, where there are two tables with the same size but different orientations, vertical and horizontally, causing the illusion of sizes that look distinctly different.

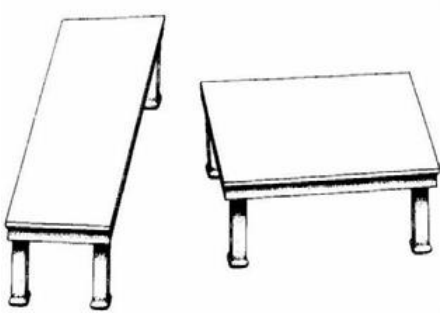


Figure 2. Vertical-Horizontal Illusion
Source: Roger Shepard, as cited in Wibora (2012)

c. The Ponzo illusion states that humans determine the size of objects based on their surroundings so that objects that have the same size if placed away from a background that imagines perspective lines or lines leading to vanishing points, such as railroads and tunnels, can appear longer or larger (Witabora, 2012).

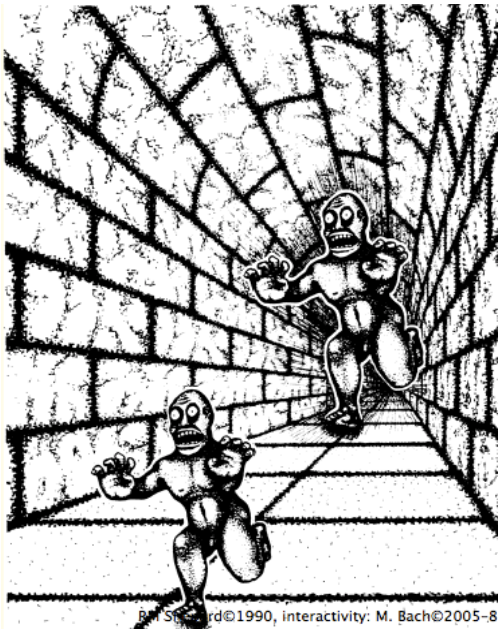


Figure 3. Ponzo Illusion
Source: Roger Shepard, as cited in Wibora (2012)

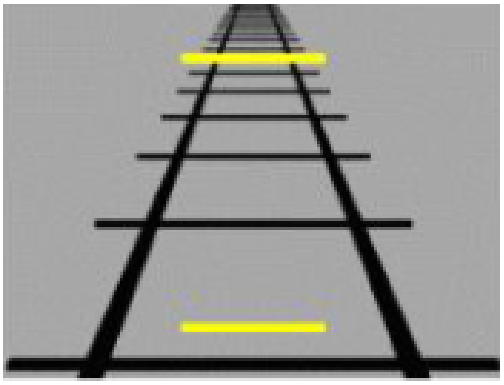


Figure 4. Ilusi Ponzo
Source: LaBerge (2019)

2.5 Roof Width in *Manusyalayacandrika*

Manusyalayacandrika is a writing that summarizes various classical or ancient Hindu literature relating to the art of building construction. The summary is also related to a more detailed explanation of this classical literature with systematic procedures related to planning, design, and construction, so it is expected to provide convenience in understanding them in this era.

According to Achyuthan and Prabhu (1998), the length of the rafters is calculated by drawing a right-angled triangle on a flat board, usually with a scale of 1:8 representing half of the roof truss. The base of the triangle is a half span, and the height of the triangle represents the height of the roof above the wall slab, while the slanted side represents straight rafters.

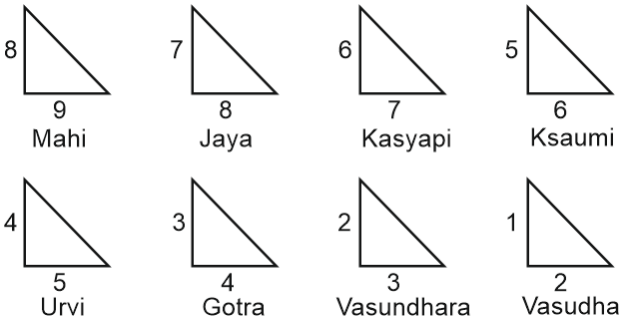


Figure 5. Name of Roof Slobe for House
Source: Modified from Achyuthan dan Prabhu (1998)

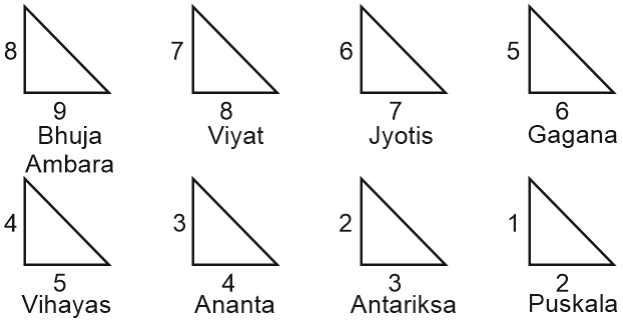


Figure 6. Name of Roof Slobe for Temple
Source: Modified from Achyuthan dan Prabhu (1998)

3. Research Method

This research is descriptive exploratory research, with output in the form of facts with a quantitative or qualitative approach. Research that is descriptive in nature aims to provide an overview of something that was ongoing when this research was conducted and examine the causes of certain symptoms (Umar, 2011). Explorative-descriptive research is a method for describing or exploring a phenomenon without intending to test hypotheses, only describing what a variable, symptom, or condition is (Arikunto, 2002).

The research process begins with presenting data in the field related to photographs, the size of which is then converted into proportions and the creation of 2D images. This study focuses on the front/south (sea) and rear/north (mountains) views of the roof of the Dalem Ageng Prabayeksa building. Measurements in the field using a laser meter and assisted by using drones to get the height of the roof of the building due to the limitations of the researchers and the condition of the building, which is

quite vulnerable to being on top of the roof. After obtaining a 2D re-image using the Sketchup software, an exploratory analysis was carried out by applying the optical illusion example presented in Chapter 2 (review of the literature) so that it would explain how the shape of the roof on the Dalem Ageng Prabayeksa building gives an optical illusion effect to humans which has an impact on visual perception intentionally and unintentionally presented by the owner or builder of the building in relation to the function of the building.

4. Results and Discussions

Dalem Ageng Prabayeksa is the most important and sacred building in the structure of the Dalem Mangkubumen complex, Yogyakarta, which is located west of the Kraton Yogyakarta. This building is located in the northern part of the complex. Currently, the building is an empty building with no activities in it (Figure 7).

Figure 7. Position of Dalem Ageng Prabayeksa (marked in red) on the Dalem Mangkubumen Complex
Source: Yuniastuti et al. (2014)

Dalem Ageng Prabayeksa has an orientation towards the south with the Javanese architecture of the *limasan sinom lambang gantung*. *Limasan* generally has a main face or entrance that is at the longest position of the building, but in the Dalem Ageng Prabayeksa building, the main front or entrance is at a shorter position than the building (Figure 8 and 9).

Redrawing the building in 2D is done to be able to get the proportions of the building. In addition to getting proportions, the purpose of redrawing is also a medium to facilitate exploration activities.

The roof section is divided based on the horizontal size of roof A (top roof) and the outer side of the roof of the building, which is then pulled vertically so that the roof below is divided into three, namely B, C, and D as shown in Figure 10.

Figure 8. Front and Back View of Dalem Ageng Prabayeksa
Source: Survey (2022)

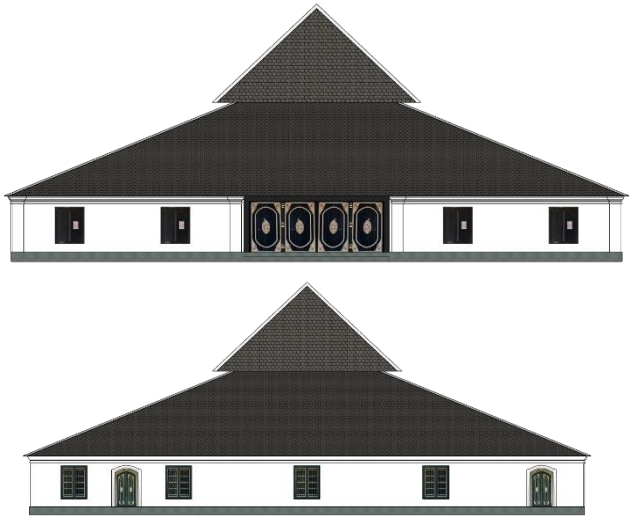


Figure 9. Front (South) and Back (North) View of Dalem Ageng Prabayeksa
Source: Researcher (2022)

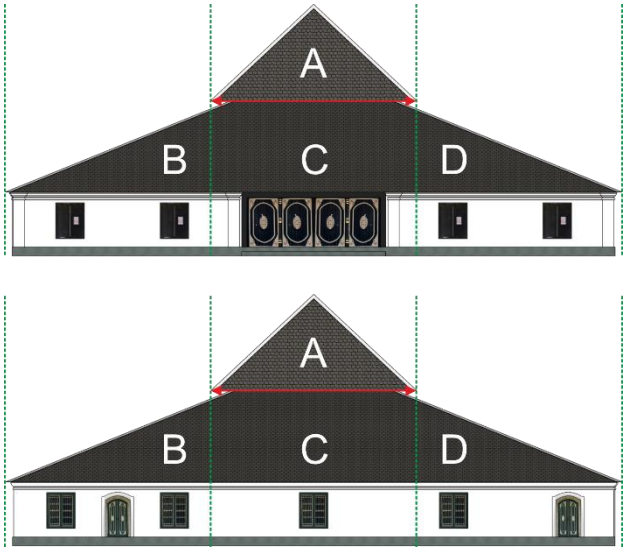


Figure 10. Vertical Triple Division
Source: Researcher (2022)

After the division is carried out, the next is the measurement of the proportion formed from the division made on the roof of the building turns out that the length of the A/C roof has similarities to B and D, so the proportion of the horizontal size of the roof becomes; A: B: C : D = 1: 1: 1: 1 as shown in Figure 11.

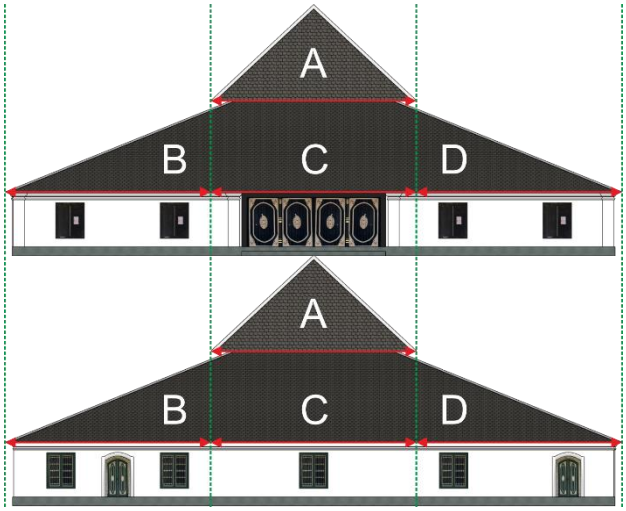


Figure 11. A: B: C: D Proportion
Source: Researcher (2022)

In this research, we observed whether there is an optical illusion that occurs by looking at the diagonal lines B and D, which point towards the horizontal line A. It showed two blue lines intersecting the red line A (Figure 12). It is as described in the Ponzo optical illusion, where objects of the same size are placed as if moving away from a background that imagines perspective lines or lines towards a vanishing point that will appear bigger or longer.

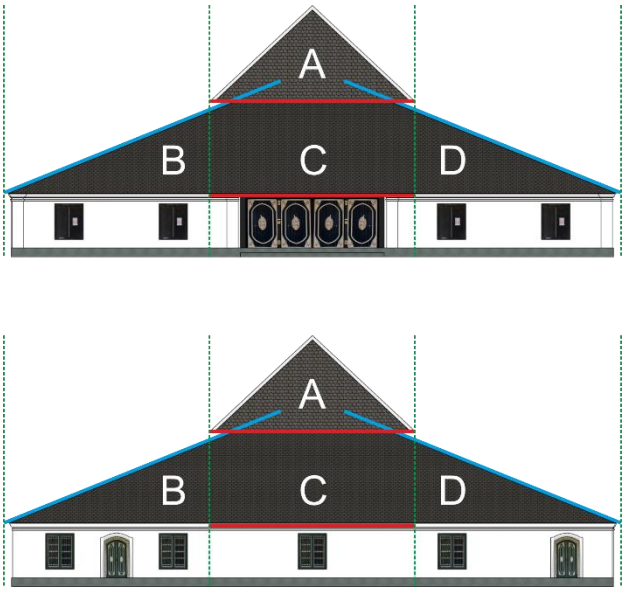


Figure 12. The Illusion that Happened at Dalem Ageng Prabayeksa
Source: Researcher (2022)

Lines A and C have the same length, but because line A is cut by an imaginary perspective line (diagonals B and D), it causes line A to appear longer than line C (Figure 13), with the illusion that it occurs on the roof of the building, of course, it will affect human visual perception both consciously and unconsciously for those who see it, especially the roof which is the top and most striking part.

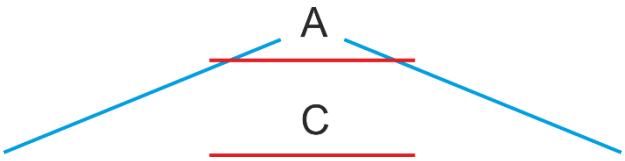
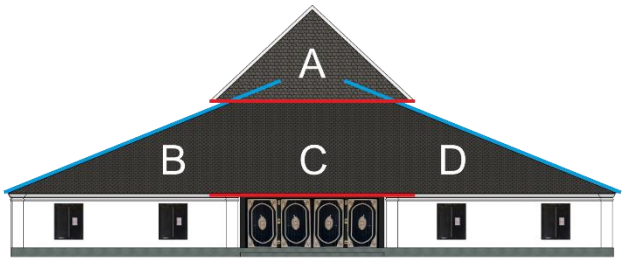


Figure 13. The Illusion that Happened at Dalem Ageng Prabayeksa
Source: Researcher (2022)

The illusion line that is formed results in a partial view as if it is seen that the horizontal line of roof A has the impression that its width extends to the horizontal lines B and D because the illusion causes the horizontal line A to look wider than it is (Figure 14), this is just an illusion because in reality, the horizontal line A is the same as C, so physically its width does not enter the area of the horizontal lines B and D.



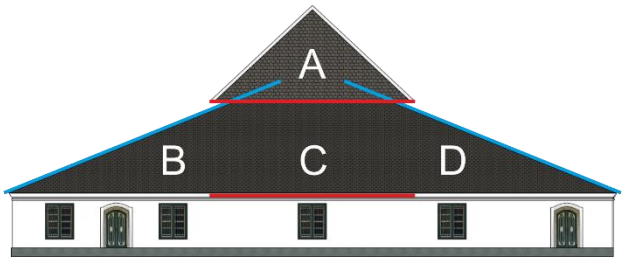


Figure 14. The Illusion that Happened at Dalem Ageng Prabayeksa
Source: Researcher (2022)

The picture above (Figure 14) has deliberately removed the green vertical line that divides the roof into three parts so that by removing the vertical line, the aim is that the horizontal lines A and C do not have boundaries that can hinder the optical illusion from working.

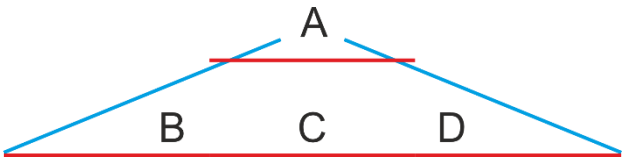


Figure 15. The Illusion that Happened at Dalem Ageng Prabayeksa
Source: Researcher (2022)

When there are horizontal lines B and D joined with horizontal line C, a different optical illusion will occur (Figure 15). The illusion occurs because there is a perspective effect that plays a role in it. It can be seen that the horizontal line BCD is indeed longer than line A, but because there is a perspective effect that makes it appear as if it is a BCD line so long that the roof of the building feels wider than it should be.

Apart from making it look wider than it should be, this perspective effect gives the impression of being far from the roof of the building, giving rise to the perception that the roof of this building feels higher than it should be. We can also find this perspective effect in the temple architecture, which makes the temple look taller than it should be.

After discussing the optical illusion that occurs, the determining factor of how the roof can be formed is also a topic to be discussed. Based on Manusyalayacandrika, in determining the roof ratio, a right-angled triangle is used, which represents the height and half of the roof width (Figures 5 and 6), where different names are divided based on size and use. In terms of its use, it is divided into 2 (two), namely for houses consisting of *mahi, jaya, kasyapi, ksaumi, urvi, gotra,* Vasundhara and *vasudha* and for worship consisting of *bhuja ambara, viyat, jyotis, gagana, vihayas, ananta, antariksa* and *vuskala.*

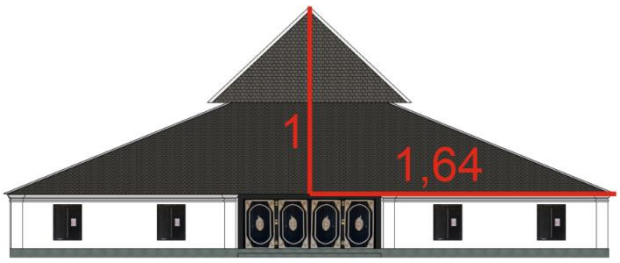


Figure 16. Ratio of Roof Height and Width
Source: Researcher (2022)

The ratio of the height and half the width of the roof of Dalem Ageng Prabayeksa has a ratio of H: ½ W = 1: 1.64. The reason for using the ratio H: ½ W refers to the design procedures in Manusyalayacandrika. The ratio is then converted into a ratio with a larger number but still has the same value.

Table 1. Conversion of Roof Height and Width Ratio

Height	½ Width
1	1.64
2	3.28
3	4.92
4	6.56

Source: Researcher (2022)

The ratio in Table 1. above can reveal that this ratio has similarities with the ratio described in Manusyalayacandrika, namely Vasundhara, which is in the category with the use of houses, and antariksa, which is in the category with the use of places of worship (temples) with a ratio of H: ½ W = 2 : 3.

The Dalem Ageng Prabayeksa building itself has a sacred function in the Dalem Mangkubumen complex, where its uses include a place of worship and also the residence of the Prince's family. It means that the building has a dualistic function in its sacredness. Its function as the residence of the Prince's family is seen as a material sacred function, while the sacred function related to its use as a place of worship is seen as something immaterial. These characteristics in their sacredness, are the combination of the functions of a house and a place of worship in accordance with what was explained in Manusyalayacandrika that there are two uses for two different buildings, but in the Dalem Ageng Prabayeksa building, the two uses become an inseparable sacred unit. Vasundhara and Antariksa have their own meaning in Hinduism. Vasundhara means Mother Earth which has very fertile land and unlimited wealth. So that the meaning of Vasundhara itself has similarities with the belief in 'sang tani' or *dewi sri/dewi padi* in Javanese culture, who is considered the goddess of fertility, the guarantor of successful harvests, as well as prosperity, and protector of the family who has a place in the Javanese house *(senthong tengah)* and specifically in the Prabayeksa building in the context of a building that functions as a house. Meanwhile, antariksa literally means a space 'which contains stars' or is called the sky. The area that covers the space between earth *(bhuloka)* and heaven *(*svarloka*)* is called Antarikṣa or also known as bhuvarloka. Antariksa is a Sanskrit word that means space, space, sky, and atmosphere. The meaning of antariksa, or in the beliefs seen in Hindu temples, is commonly called bhuvarloka (middle world). Where in that

world, it symbolizes humans in a place that is purified and leads to inner perfection, so there is a relationship between antariksa as a representative of a place of worship (temples) and the immaterial sacred function which also occurs in Dalem Ageng Prabayeksa in the context of being a building with a worship function (temples) so that it is a sacred building. The two uses or functions in the form of a house, and a place of worship become one unit or side by side and are in harmony with the Dalem Ageng Prabayeksa predicate as the most sacred building in the Dalem Mangkubumen complex.

5. Conclusion

The Dalem Ageng Prabayeksa building is the most important and sacred building in the Dalem Mangkubumen complex, which, intentionally or unintentionally, by the owner or builder has an optical illusion in the shape of the roof which can affect the visual perception of those who see it and also how the roof is formed which leads to the meaning of the building. There are 6 (six) findings from this study, namely; **(1)** The length of the horizontal line A: B: C : D has the same proportions, namely 1: 1: 1: 1. **(2)** The horizontal line A looks wider than the horizontal line C due to the diagonal lines B and D that form a horizontal line imaginary perspective that intersects the horizontal line A, so the horizontal line A looks wider than it actually is. **(3)** The horizontal BCD line is indeed longer than the horizontal line A, but due to the perspective effect, it makes it appear as if the BCD line is very long so that the roof of the building feels wider than it should be. **(4)** This perspective effect also creates a distant impression resulting in the visual perception that the building is taller than it should be. **(5)** The ratio of the height and half the width (H: ½ W) of the building is measured according to the guidelines in Manusyalayacandrika and according to the ratio contained therein, H: ½ W = 2 : 3, the ratio is included in the Vasundhara category with the function of the house and antariksa with the function of places of worship (temples). **(6)** Buildings that have this sacred nature have dualism in them. Generally, only buildings with religious or worship functions have sacredness, but in this building, one of its functions as the residence of the Prince's family can be seen as a material sacred function, while other sacred functions are related to its use as a place of worship or worship of transcendent entities seen as something immaterial sacred function.

It is in line with the intent and purpose of this building being built, as a building that has the function of being a gedhong pusoko (a place to store heirlooms), the residence of the Prince's family as well as a place of worship for transcendental authorities who are in the Dalem Mangkubumen complex, so it makes sense that the building is made to have the impression that it is physically wide, large and tall with a limited area of location and techniques, which can also be understood as a building that has an impression of gallantry, strength, and grandeur that can make anyone who sees this building think that the building Dalem Ageng Prabayeksa, not an ordinary building. In addition, the function of the building, based on the comparison and ratio of the roof, states that this building has dualism in which there is a sacredness in the form of material things and sacredness in the form of immaterial things and also its relation to the function of the building as houses and places of worship (temples) which become one unit.

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