Material and Cultural Values in Joglo Architecture in Indonesia

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Abstract

Joglo is a residential architecture heritage intended for the Javanese nobility. Since the Yogyakarta earthquake in 2006, the eminence of joglo has been questioned because many of them collapsed in this disaster. Through tectonic studies, this paper aims to reveal whether joglo structures were created with more consideration for technical matters (material and strength of construction), for non-technical considerations (creation of the spatial atmosphere following the cultural values), or the harmony between them.

The study employs a historical interpretative method through three stages. First, it examines the technical aspects of joglo construction to produce a narrative about the logic of joglo construction. Second, it examines the cultural aspects related to joglo to develop a narrative about how the Javanese nobility interprets joglo spaces. Finally, the two stages are discussed to look for the relationships between them.

This research has revealed that the process of creating joglo is based on two concurrent knowledge, traditional wood and stone construction technology and the knowledge of Javanese religiosity originating from the Hindu cultural values. Both of this knowledge are combined harmoniously so that there is a harmony between the material, construction and form elements, and the philosophical meanings that give rise to a sacred atmosphere in the joglo architectural space.

Keywords: *joglo*, tectonics, construction, culture, architectural space.

Background

Southeast Asia is a tropical region with humid air and hot temperatures. Such climatic conditions have become a general consideration in the construction of buildings in this region from the traditional era to the current modern era. However, in the island of Java, Indonesia, an exception exists. In this island, there is a traditional building model called *joglo*, which is a residential building of the nobility (Tjahjono, 1998). Besides having the general characteristics of a tropical building that maximizes natural air circulation, *joglo* is also constructed as a ductile building using wood as the main material. Moreover, the arrangement of the constructions has created space and construction details that are not only beautiful but also rich in symbolic meanings.

The general characteristic of construction in the *joglo* building is the *rong-rongan*, a core structure composed of four main pillars called *saka guru*. This *rong-rongan* supports the beams stacked upwards called *tumpangsari* (Dakung, 1981).

The *rong-rongan* is a form generator of the *joglo* building. It becomes the main structure of the building, which the roof and the other pillars depend on.

Fig. 1: *Rong-rongan*, the core structure of the *joglo building*.
Source: Author

Mangunwijaya says that the correct form will bring out the beauty (Mangunwijaya, 2009), while Vitruvius states that the architecture of a building must contain elements of robustness, function, and beauty (Winter, 2007). The form of *joglo* construction can indeed be said to be beautiful because of its uniqueness. However, is it sturdy enough? When a 6.4 magnitude earthquake occurred in Yogyakarta on May 27, 2006, it was found that many traditional Javanese buildings, including *joglo*, were damaged and even collapsed. Data from the Jogja Heritage Society states that Kotagede, an area in the southern city of Yogyakarta where there are many traditional Javanese buildings before the earthquake existed was recorded to have had 550 traditional houses. After the earthquake, there were only 450 houses left (Jogja Heritage Society, 2007).

Indeed, the strength of the *joglo* construction is influenced by many factors such as the precision of the connection, roof load, weathering of wood, and maintenance. However, Prihatmaji (2007) through a study that uses mechanical calculations provides technical proof that *joglo* is not truly earthquake-resistant. He made a *joglo* simulation which was tested using a horizontal slip table, which is a tool to create lateral movements that represent earthquakes.

According to Prihatmaji (2007), there are two types of earthquake movements that most often occur in the island of Java, namely high-frequency earthquakes, and low-frequency earthquakes. The results of tests using these two types of earthquake movements show that the *joglo* construction joints are resistant

more to the high-frequency earthquakes, but weak to the low-frequency ones. This implies that the traditional construction system of *joglo* is not really safe against the earthquakes in Java.

Can Prihatmaji's discovery be used as evidence that *joglo* is a traditional architectural work that does not deserve to be preserved because scientifically, the structural system is not yet perfect? If architecture can stop until technical matters are resolved, maybe this statement can be accepted. However, because construction in architecture is to create a spatial structure, and space must follow the values of human culture that comes into being in it, then assessing architecture only in terms of construction is not enough. A comprehensive study is needed to assess the structure in architecture, and in accordance with this, the study of architectural tectonics comes into being.

Gottfried Semper, in *Die vier Elemente der Baukunst* (Four Elements of Architecture) distinguishes the basic understanding of tectonics into two terms, namely: the tectonics itself and stereotomics (Porter, 2004). Tectonics is a study of the expression of 'light' material construction, which means that in the law of statics, it has a equal compressive and tensile strengths. Materials that meet these characteristics, for example, are wood. The principle of structure in tectonics is the balance between the tensile strength and the compressive strength so that a structure can stand free above the earth against gravity. On the other hand, stereotomics is described as the study of the expression of 'heavy' material construction, which means that in the laws of statics, the compressive strength is more dominant than the tensile strength. For example, the materials that meet these characteristics are rock. The principle of structure in stereotomics is to press down by utilizing gravity so that a structure can stand firmly on the surface of the earth.

In Javanese architecture, Semper's tectonic principles are often found in the traditional Javanese architecture which uses wood with fixed and roller constructions, rooted in Austronesian architectural traditions. These traditional Javanese buildings are usually residential houses. The principles of stereotomics are found in the classical Javanese architecture that uses stone with pile and compressed constructions. These classical Javanese buildings are usually Hindu and Buddhist temples.

Furthermore, Frampton (1995) has developed the theory of tectonics integrally by stating that construction includes cultural and poetic meanings. This can be achieved by paying attention to the material properties, structural logic, and the craft of making. Thus, looking at architecture from the perspective of tectonics is not limited to observing existing artifacts but also exploring the process of creating these artifacts. Furthermore, Reiser (2010) extends the scope of tectonics not only to the form of the artifact and its creation process but also the atmosphere that it evokes. Tectonic studies are concerned with not only the materials but also the atmosphere, from the case of structure to the effects it causes.

Through tectonic studies--covering technical aspects that produce structures to cultural aspects that produce spatial atmospheres--this paper aims to reveal whether *joglo* structures have been created with consideration predominantly for the technical matters (material and strength of construction), for non-technical considerations (creation spatial atmosphere following cultural values), or the harmony in between.

Review of Literature

Many scientific publications as well as books on *joglo* architecture have been published. Dakung (1981) has documented all the types of traditional Javanese buildings, including the *joglo*, from the arrangement of the buildings, and their shapes to the details of ornamentation. Frick (1997) describes various concepts of cosmological approaches associated with various structural patterns and building

techniques that have been developed in Indonesia. In fact, Frick takes many cases from Javanese architecture, especially the *joglo*. Ismunandar (1997) describes the *joglo* house starting from the preparation for building it, the equipment used, the installation of the parts of the house, to the ceremonial celebrations that should be carried out.

Tjahjono (1989) suggests that the Javanese in southern Central Java maintain a strong architectural tradition based on the idea of 'center and duality'. Through the interaction of these ideas, the Javanese activate their system of symbolic classification, institutionalize their cosmos, and define their world view. Tjahjono (1998) explains the basic principles of *joglo* architecture while Cairns (1997) broadens the scope of architectural discipline boundaries through his study of wayang performance spaces in the traditional Javanese houses. The flat, as well as the ornamental and unsubstantial nature of wayang can open up space for radical changes in architecture.

Triyanto (2001) explains the function of culture in relation to the attitudes and behavior of its citizens in an effort to meet the architectural needs of the houses. Santosa (2000) examines the Javanese house in terms of its role as a dwelling: a place for ritual events and a stage, to understand the range of meanings it carries. Furthermore, Santosa (2007) presents an overview of how the daily life of the people who live in Kotagede gives meaning to the physical environment which is rich in Javanese architectural artifacts. Ju, Do and Santosa (2018) explain the changes in the Kotagede community in understanding the concept of Javanese cosmological dualism in the architecture of their homes.

Prijotomo (1988) reveals the values of the Javanese way of life which are reflected in joglo architecture. Meanwhile, Prijotomo (1995) explains how the Javanese interpret the importance of a house, which is not just a place to live. The unity between the house and the owner's soul is expressed by calculating the size of the house using a comparison of the owner's body size. Furthermore, Prijotomo (2006) provides an interpretation of Javanese architecture according to the Kawruh Kalang and Kawruh Griya scripts which are placed as records of the knowledge of the oral traditions of the Javanese people.

These show that the researchers have studied many aspects about Javanese architecture, especially the *joglo*, as an effort to express the values contained in them with a high appreciation. However, there is one aspect that has been rarely studied: the aspect of *joglo* architectural construction. In fact, the essence of *joglo* architecture lies in its construction, especially the *rong-rongan*, which is the main construction that supports the stacked beams called *tumpangsari*.

Related to this, there are two who have studied specifically the problem of *joglo* construction, in more depth. They are Prihatmaji (2007) and Maer (2015). Prihatmaji examines the behavior of *joglo* structures against earthquakes, while Maer provides solutions to the structural weaknesses found in Prihatmaji's research. The results of their research are important so that they are worthy of being used as a basis and are followed up in this study. The gap in Prihatmaji and Maer's research is that they are still focused on technical issues only, while the *joglo* building can only be understood as an architectural work when it is linked to its human culture. Through tectonic studies, this research will reveal the relationship between material aspects and the cultural values in *joglo* architecture.

Research Methods

This research employs the historical-interpretative research method. It is a method to investigate physical and social phenomena in a complex context by explaining those phenomena in a narration holistically (Groat, 2002). According to Groat, the key to this method is interpretation. Furthermore, this research uses a post-structuralist approach. In this approach, the reality is part of the discourse,

because the post-structuralist point of view sees cultural material products as part of a larger subject matter. Any historical assessment of architecture is also an assessment of the socio-cultural discourse (Groat, 2013).

This study uses a historical narrative strategy, where past facts are seen as a collection of unstructured events. The researcher makes the facts structured to form a logical and accountable storyline. The type of historical facts in this study is contextual, in which cultural factors that coincide in time and place with the object of study are the contextual evidence of the object of study.

This historical-interpretative method is used to study *joglo* architecture through three stages. First, it examines the technical aspects of *joglo* construction and the underlying considerations. Some research about the construction of *joglo* is used as a source to analyze and compare in order to build a narrative about the logic of *joglo* architectural construction. To prove that the *joglo* construction system was primarily designed to deal with the earthquakes, data related to the history of earthquakes in Java are gathered. Second, the cultural aspects related to *joglo* architecture are examined.

Some references on Javanese traditional culture and architecture, especially the values of Hindu teachings that influenced the spiritual life of the nobility have been expressed in the architecture of their residences, and are used as a source to connect and to develop a narrative about how the Javanese nobility interprets *joglo* spaces. Finally, the two stages of this study are discussed to look for the relationships between the logic of *joglo* constructions and the thinking of the Javanese nobility about the atmosphere of space. It thus critically interprets whether *joglo* architectural structures were created-out with the emphasis on technical issues such as the materials and the strength of construction, or were based more on non-technical considerations such as the creation of spatial atmosphere following cultural values, or the balance between them.

Findings

The Technical Aspects of Joglo Construction

Since the big earthquake occurred in Yogyakarta and parts of Central Java in 2006, many studies on *joglo* architectural construction have been carried out. This earthquake has damaged and destroyed many *joglo* buildings, whereas *joglo* is an architectural heritage that had been believed by many scholars to have good resistance to earthquakes because of the ductility of its wooden frame structures. In the case of the 2006 earthquake, it was found that much of the damage to the *joglo* building has been caused by the old and weathered wood, in such a way their ductility has been lost. When this happens, there is a greater chance of structural failure when facing an earthquake, as can be seen in the following:

Fig. 2: A heavy damage *joglo* due to the 2006 earthquake: it but did not collapse completely; the core structure (*rong-rongan*) remains.
Source: Author

The building above is more than one hundred years old. It is a *joglo* in the Bantul Regency, Yogyakarta which was severely damaged during the 2006 earthquake. From the conditions found, all elements of the building has collapsed although the core structure (*rong-rongan*) has remained intact. However, one of the four main pillars (*saka guru*) has fractured at the point where it meets the beams. This proves that the fracture-prone point is indeed in this position. In addition, the persistence of the other three main pillars proves that the ductility of the core structure (*rong-rongan*) of this *joglo* is still quite good. This could indicate the possibility that the three main pillars are still in a well-maintained condition. This is very different from the example in the following *joglo*.

Fig. 3: *Joglo* which completely collapsed due to the 2006 earthquake; the four main pillars (*saka guru*) in the core structure (*rong-rongan*) were broken.
Source: Hidayatun, 2006

The *joglo* in the Figure above is also over a hundred years old, located in the Yogyakarta Municipality area. This *joglo* also completely collapsed in the 2006 earthquake. It fell to the side. All the main pillars (*saka guru*) in the core structure (*rong-rongan*) have been broken at the connection point with the beams (the red circle in the Fig. 3). The difference with the first case is that this *joglo* can indicate

the possibility of a poor core structure ductility. One possibility could be because wood of the four main pillars are rotten. Maintenance of wood in this *joglo* is questionable.

Traditionally, how to treat wood in a *joglo* architecture has been known. As explained in the *Homeowner's Conservation Manual, Kotagede Heritage District*, the traditional way to protect the natural wood color and preserve the wood is to use a mixture of cloves, tobacco, and banana stems. This mixture is soaked in water for one to three days, and after that, it can be rubbed on the wooden surface. If the natural color of the wood has faded, it is better to rub it with coconut oil on the wood surface until the natural color reappears. The sap from a mixture of cloves, tobacco, and banana stems is intended to protect the wood from the pests such as termites (*Isoptera*), sawdust beetles (*Lyctus Brunneus*), wood bees (*Hymenoptera*) and wood beetles who damage wood. Coconut oil can protect wood from weathering due to water absorption or air humidity, while keeping the wood fibers tough so that the ductility of the wood can be maintained (Jogja Heritage Society, 2007).

The problem of maintaining the old *joglos* is closely related to the changes in the lifestyle of the Javanese people who do not live in the traditional way. Modern life has made old *joglo* buildings lose their functions. Thus, many are neglected. In this regard, Gunawan (2019) has provided solutions through six strategies including: adjustable (non-fixed objects can be placed according to its function), versatile (the skin and the service can be updated, changed, demounted, etc.), refitable (some roofing materials and structural parts sometimes are replaceable), convertible (building can be used for different functions), scalable (the building size can be changed) and moveable (building frames made of wood can be moved to other places). This can be done because *joglo* has an open plan nature, detactable system of skin, service and structure, and knockdown ability.

Prihatmaji (2007) has conducted one of the important studies related to the construction of *joglo* after the 2006 earthquake. As mentioned in the introduction, Prihatmaji has made a *joglo* simulation which has been tested using a horizontal slip table: a tool to create lateral movements that represents earthquakes. There are two types of earthquake movements that most often occur in the island of Java, namely high-frequency earthquakes, and low-frequency earthquakes. The results of tests using these two types of earthquake motions indicate that the *joglo* joints are more resistant to the high-frequency earthquakes but weak to the low-frequency ones. This is due to the fulcrum of the joints of the four main pillars (*saka guru*) with their pedestal and the connection of the joints to the *saka guru* with the ability to maintain their ductility. The earthquake shock can be stabilized quickly by the *tumpangsari* (stacked beams) which function as the weight of the reinforcement structure.

Conversely, when a low-frequency earthquake occurs, this *tumpangsari* instead becomes a pendulum that accelerates the lateral force of the earthquake so that it increases the chances of the four main pillars (*saka guru*) to break or push the structure of the cavity to collapse. With this finding, Prihatmaji has concluded that *joglo* building was safe for the earthquake area (southern Java region) if the support system was fixed. Because the *joglo* construction support system is a roller joint, the results of this study indicate that the *joglo* construction is not really safe from the earthquakes in Java. To overcome this weakness, Prihatmaji has recommended the use of a fixed joint construction system on the pedestal of *saka guru*, to replace the roller joint support system as it has the existed in the *joglo*.

Prihatmaji's recommendation above will make the *joglo* building safer against the earthquakes. However, it also has the potential to have the opposite effect. *Joglo* will be safer against the low-frequency earthquakes, but it will be weaker against the high-frequency ones, considering that the stickiness of the fixed joint construction system will reduce the ductility of the *saka guru*. Besides, changes in the pedestal construction system can change the principles of construction design

and appearance of the *rong-rongan* of *joglo*. Therefore, as a middle solution, Maer (2015) has followed up Prihatmaji's findings by developing a *joglo* construction system more resistant to the earthquakes while maintaining the roller joint support system but increasing the rigidity of the core structure (*rong-rongan*) of *joglo* by modifying the shape of *Santen*. That is a booster component which is located between the upper and the lower beams as a buffer for the lateral forces.

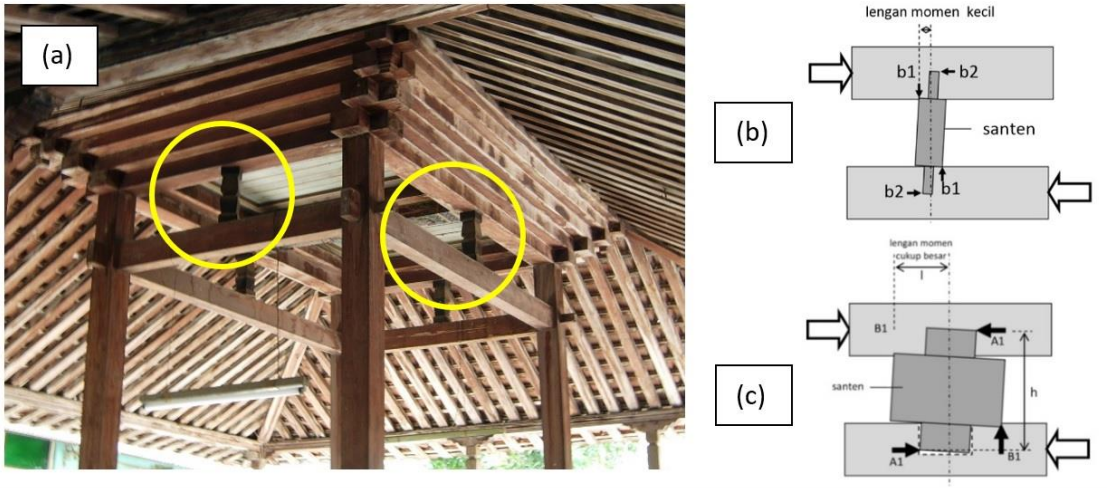

Fig. 4: (a) The position of *santen* on the core structure (*rong-rongan*) of the *joglo* building, (b) original *santen*, (c) *santen* with extended torque arm to withstand the lateral shear forces. Source: Maer, 2015

Through theoretical analysis and simulation using ETABS software, a computer program to analyze structures, Maer (2015) explains that improving the endurance of *rong-rongan* structures against earthquakes with long vibrational times (low-frequency earthquakes) can be done by strengthening the structure so that the vibrational time of the structure does not "tune" (in rhythm) with the natural ground shaking time. Meanwhile, the stiffness of the connection between the four main pillars (*saka guru*) and the beams can be increased by: 1) increasing the dimensions of the *santen*'s depth at the column's meeting with the beam, 2) changing the beam into a truss, or 3) changing the beam until it becomes a Vierendeel truss. Thus, *santen* can function as a Vierendeel truss by widening the horizontal plane. The wider horizontal plane will then extend the torque arm so that it can better withstand the lateral shear forces caused by the earthquake. From Maer's research, it can be interpreted that by widening the *santen*, the *rong-rongan* will be more resistant to the low-frequency earthquakes, because it does not change the joint and the pedestal support system of the *saka guru*. In fact, the joints will also be able to withstand high-frequency earthquakes as produced in Prihatmaji's research.

The *joglo* construction analysis raises the question why earthquake resistance is important for the *joglo* buildings. As mentioned earlier, *joglo* is a building for the nobility in Java. These buildings are found mostly in the cities of Yogyakarta and Surakarta, which were the former centers of power of the Javanese Kingdom of Mataram before the establishment of the modern state of Indonesia in 1945. Both cities are in the southern part of Central Java. Meanwhile, geographically, the island of Java is in the southern part of the Eurasian plate which is directly opposite to the India-Australia plate. The meeting of these two plates is in the sea South of the island of Java. This is what causes the large earthquakes in Java to have their epicenters here. These large earthquakes were first recorded in 1867 with a magnitude of 7.5 on the Richter scale and occurred again in subsequent periods until recently.

Yogyakarta and Surakarta used to be the center of the Javanese Kingdom of Mataram which had many *joglo* buildings. Because these two cities are in the southern part of the Java Island, it is very likely that both are affected often by the earthquakes. Thus, there is a strong reason that the construction of the *joglo* building must have been developed by considering the earthquake factor.

Cultural Aspects Related to Joglo Architecture

In 'Home, Territory, and Identity', Wise (2006) defines the difference between house and home. The house refers only to the physical aspects of the building, while home has a deeper meaning. Home relates to identity, based on one's physical and personal location. These areas are an environmental condition influenced by the objects in the vicinity. This influence of environmental conditions regulates the area known and experienced as 'home'. Ownership of a house building signifies identity, but their presence (owner/user) in the context of history and memory creates an articulation effect. A house is built as an effort to create a permanent territory. However, the accumulation of owner/user lifestyle habits makes the meaning of space changeable. The theoretical explanation of Wise (2006) indicates that understanding the meaning of a residential architecture cannot be separated from the context of how residents live and inhabit the house in a certain period, where cultural factors are attached and influence.

Geertz (1976) has examined the cultural patterns of the Javanese society in the early 1950s. It is a source of data for analyzing *joglo* architecture, because in it, there is a documentation about the Javanese cultural behavior patterns in the early era of Indonesian independence comprised of traditional life patterns. This study is relevant in understanding the atmosphere of space in the Javanese community living at that time. Thus, this will have relevance to theory of the notion of home as proposed by Wise (2006) as an identity based on the location of one's body and person, where human presence in the context of history and memory will create an articulation effect in the form of the meaning of space.

Geertz (1976) describes the Javanese people as religious communities and divides them into three groups: *santri*, *abangan*, and *priyayi*. *Santri* is a group of Muslims who are devout in practicing Islam. They generally work as farmers or traders. *Abangan* is a group of Muslims who do not obey the teachings of Islam and are influenced more by animism and syncretism. They generally work as farmers or laborers. *Priyayi* is comprised of aristocrats who have an orientation to Hindu culture as a pre-Islamic culture. Geertz says that these *priyayi* groups focused their attention on the world of mysticism and etiquette. Refined courtesy, high art, and intuitive mysticism, all become the main characteristics of the Javanese elite.

Lombard (1996) corroborates Geertz's (1976) opinion about nobility in Java as a legacy of the Hindu era by explaining that Islam has more influence on the people of the northern coast of Java, while the interior of southern Java retains the Hindu culture. According to Lombard (1996), these rulers were heirs to the nobility of Majapahit, the largest Hindu kingdom in Java before the Islamic era. In this way, it can be understood how the Javanese nobles who, despite being Muslim, still practice Hindu traditions in their daily lives. Mulder (2005) shows the lack of Islamic influence among the nobility in the interior of Java. He explains that the royal courts of Surakarta and Yogyakarta were centers of what he called Javanism, a cultural value originating from the Hindu-Buddhist period in the Javanese history and combine in a philosophy–in the sense of a particular system of principles to conduct life.

The descriptions given by Geertz (1976), Lombard (1996) and Mulder (2005) above are relevant to relate to traditional Javanese residential architecture. As Tjahjono (1998) says, the traditional residence intended for the nobility is *joglo*. It is composed of several building units which are distinguished according to different

functions. The buildings with a *joglo* structure are applied only to the two main building units: the front pavilion called the *pendopo*, and the main house called the *dalem*. *Pendopo* building is an open space used for the cultural activities, especially dance, gamelan performances, *wayang* puppet shows, and ceremonies for the life cycle of humans (*rites de passage*). Meanwhile, the *dalem*, although as a private building, has the main function although it is not a place for the daily family activities. For daily life such as sleeping, cooking, eating, gathering with family members, receiving guests and other daily activities, other complementary building units are available such as *gandok*, *pawon*, *pekiwan*, *gadri*, and *pringgitan* which are located around the *dalem* building (Widayati, 2018).

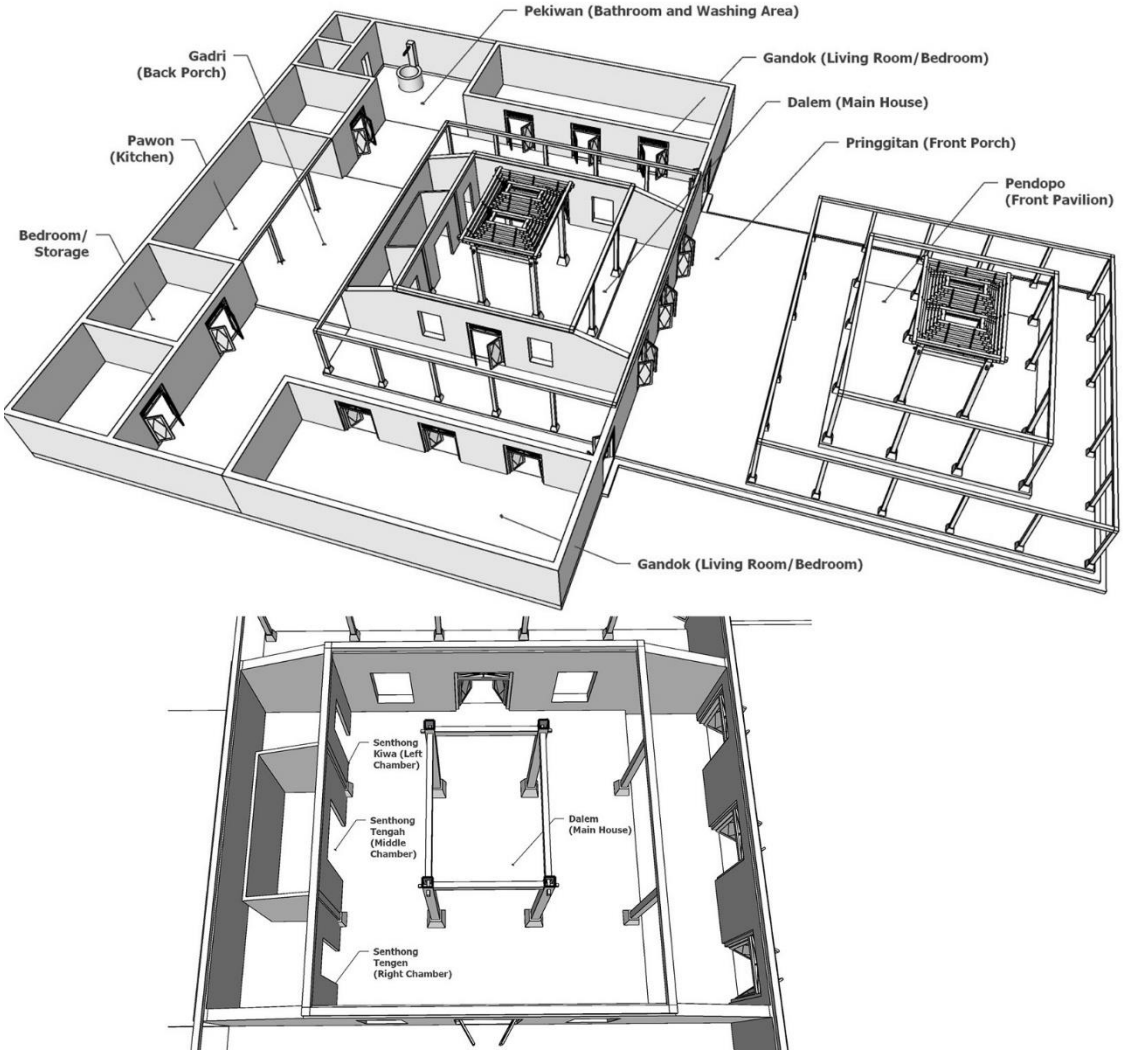

Fig. 5: Building units in the *joglo* house and the chambers in the *dalem* building.
Source: Author

The main function of *dalem* is a sacred activity, which is a place of respect for Dewi Sri or the Hindu Goddess of Fertility, which is marked by the presence of a chamber inside the *dalem* building called *senthong tengah* (the middle chamber). It is always emptied of human activity and acts as a place-to-place offerings. On the left and right, there are two other chambers called *senthong kiwa* (the left chamber) and *senthong tengen* (the right chamber). Besides functioning as bed chambers, these two chambers can function as a place to meditate by staying silent for several days while doing *mutih* fasting (only eating rice or cassava and drinking water) or

ngebleng fasting (not eating or drinking at all for several days). Each husband and wife live in two different chambers. The two chambers are connected by a hallway behind the middle chamber so that the husband and wife can go to each other's chambers. This means that marital relations can happen in the left or right chambers. Thus, the marital relationship is sacred to the nobility. This is in line with the values of the Javanese Hindu teachings about the concept of *lingga-yoni*, symbolizing the relationship between men and women who have a meaning of fertility.

Discussion

From the technical analysis conducted by Prihatmaji (2007), it can be interpreted that the core structure of *joglo* (*rong-rongan*) is in accordance with the Samper tectonic principle, in which the wooden buildings can stand because of a bond through the construction of a pinch in the connection between the beams and the four main pillars (*saka guru*). On the other hand, the *tumpangsari* structure above the *rong-rongan* of *joglo* is actually in accordance with Samper's stereotomics principle, in which wood is stacked to form a ballast for joint construction at the connection between *saka guru*, beams and pedestals. Thus, there are indications of a mixture of traditional Javanese architectural tectonics (wooden structure principles) with classical Javanese architectural stereotomics (stone structure principles) in the *joglo* structure.

If this assumption is true, an anomaly is found, that in the *joglo* wood construction, there is a tectonic as well as a stereotomics principle, in which stereotomics principle is commonly applied to the stone buildings. The combination of these structures does give rise to a unique visual aesthetic, in addition to its uniqueness in mechanical principles. Here, when a lateral force occurs, the arrangement of inter-cropping beams functions as a ballast that will confine the joint connection between the four main pillars (*saka guru*), beams and pedestals, and stabilize the building. However, according to Prihatmaji's research findings, this turns out to be effective only in responding to the lateral forces due to the earthquakes in high frequency (rapid vibrations) situations, but not effective in responding to the lateral forces in low frequency (long vibrations) situations.

The next question is whether, in the historical context, Javanese traditional society has never known the technical weaknesses of the *joglo* construction system. If the island of Java is in an earthquake-prone area so that the history of the earthquake always repeats itself, it can be interpreted that traditional Javanese people must have known from their empirical experience that the *joglo* construction still has weaknesses in responding to the earthquakes. Meanwhile, in terms of the engineering of Javanese ancestors, since the Mataram Hindu era in the ninth century, they were familiar with the principle to carry out construction more effectively with the truss construction system as can be found in a survey on one of the Prambanan Temple reliefs (Fig. 6). If it refers to Prihatmaji's conclusion, that the *joglo* construction is safe against earthquakes if the pedestal support is fixed, it means that the truss construction system can be applied to strengthen the core structure (*rong-rongan*) of *joglo*. *Joglo* does not apply to this construction system.

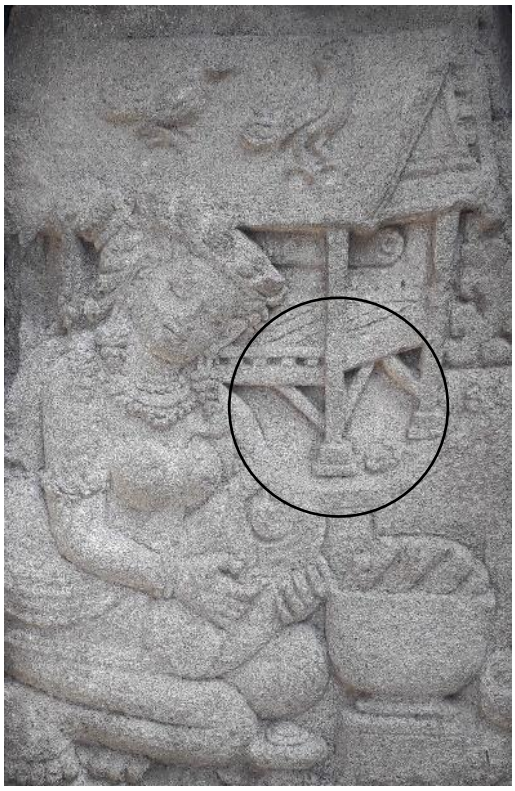

Fig. 6: Truss construction system in a relief of the ninth century Prambanan Temple, an ancestral knowledge of the rigid wood construction system which is no longer applied to the *joglo*.
Source: Author

The next question is why the *joglo* construction system was never developed again even though there are still weaknesses, and there has been truss technology since at least the ninth century as found in the Prambanan Temple reliefs. In architecture, construction is not only based on technical considerations, but also with other considerations such as a function to symbolic meanings. To reveal this, the Semper theory is no longer sufficient because Semper's theory rests on the artifact as the object of study, while answering this question must be examined from the viewpoint of its users.

As explained above, and in the royal house complex, the *joglo* buildings are located at the front, called *pendopo*, and at the rear, called *dalem*. *Pendopo* is a pavilion used for the cultural activities including gamelan performances, dance performances, shadow puppet shows, and places for conducting *rite de passage*. Meanwhile, *dalem* is used for religious activities in honor of Dewi Sri, the Goddess of Fertility. Thus, *joglo* is a building that reflects the values of sacred culture.

Rong-rongan (core structure with four main pillars) is a *joglo* form generator. More than just a major construction, it presents centrality. The arrangement of the *tumpangsari* (stacked beams) on *rong-rongan* that cone upward presents a spatial effect which gives the impression of the center as the middle. This is the same as the spatial effect arising from inside the stone temple building which refers to the concept of mandala.

Mandala comes from Sanskrit whose literal meaning is the circle. Mandala is a diagram of a universe that has a center in the middle. In Hindu belief, the mandala is interpreted as the highest achievement of human spiritual life. Mandala is the center, where the ultimate goal of life is addressed. The reflection of the mandala in Hindu architecture can be found in the form of temple architecture, where the

temple building is always centered to the middle, where the value of purity is placed. Because the center is in the middle, the shape of the temple building is always symmetrical. Because *tumpangsari* on the *rong-rongan* of *joglo* has the same space character with the conical temple roof in the middle, it can be interpreted that the *tumpangsari* on the *rong-rongan* of *joglo* is sacred because it also refers to the mandala principle.

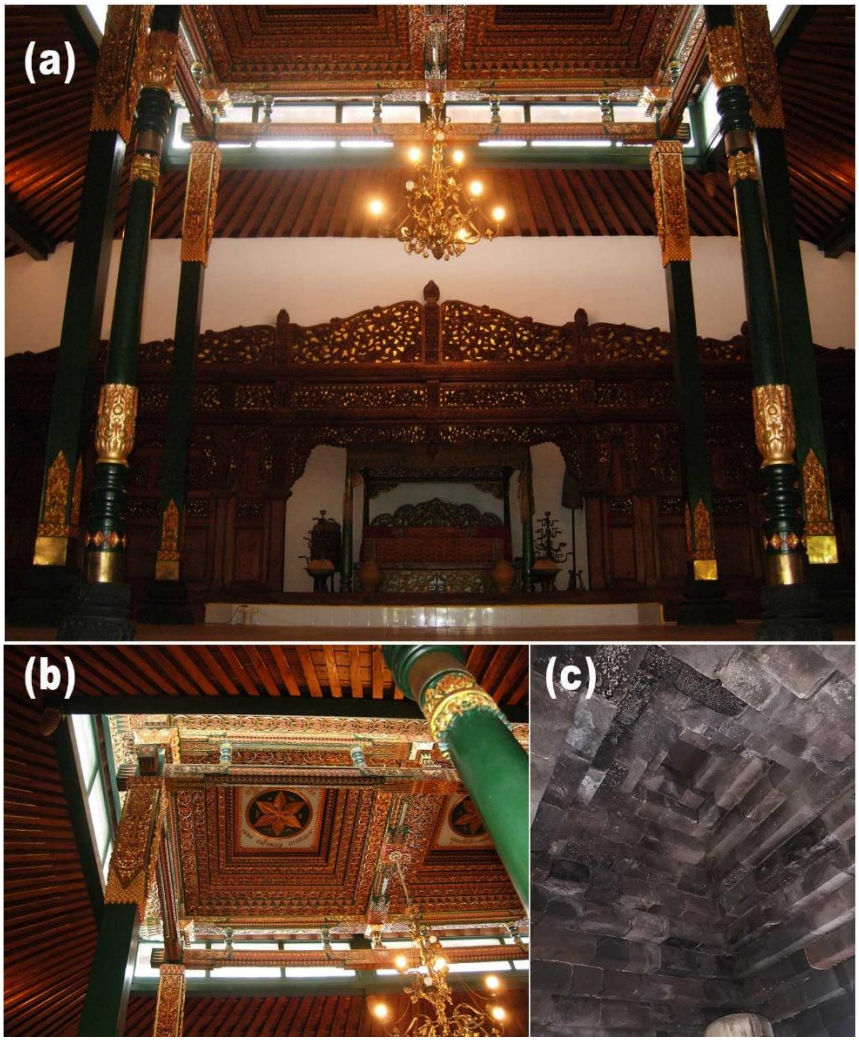

Fig. 7: (a) The sacred atmosphere in the *dalem*, (b) *tumpangsari* on the *rong-rongan* of *joglo*, (c) mandala form in the ceiling of a stone temple.
Source: Author

From this cultural analysis, it can be interpreted that there are logical reasons why the Javanese nobility continues to conceptualize *joglo* by using the *rong-rongan* and *tumpangsari* structures even though it has been proven in Prihatmaji's research that this construction has a weakness in the face of earthquakes.

The possibilities are:

Joglo construction is applied only to the *pendopo* which functions as a cultural space and *dalem* which functions as a sacred space. For daily activities, they use complementary buildings around *dalem*. Thus the intensity of the use of *joglo* buildings is low. In addition, the maintenance factor of the building also greatly determines the ductility of the *joglo* building structure. This can be seen in the case of damage to the *joglo* building due to the earthquake in Fig. 2 which shows that

even though it was hit by a large earthquake, if the building is well maintained, the structural ductility will greatly help keep the building standing, even though it is badly damaged.

These cultural and sacred activities in the *joglo* buildings represent the orientation of the Javanese aristocracy towards Hindu culture. They demonstrate that *joglo* construction can represent a blend of traditional Javanese architectural cultural values represented by a tectonic *rong-rongan* construction with Hindu cultural values represented by stereotomics *tumpangsari* construction.

In conclusion, this research has revealed that the process of creating *joglo* architecture is based on two concurrent knowledge systems: they are traditional wood and stone construction technology, and knowledge of Javanese religiosity originating from the Hindu cultural values. Both of these knowledge systems are combined harmoniously so that there is a harmony between the material, construction and form elements, and the philosophical meanings that give rise to a sacred atmosphere in the *joglo* architectural space.

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