

# The Development of Construction Technology in Joglo Architecture

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**Abstract**— In the field of architecture, buildings created before the modern era are usually categorized as classic buildings when referring to Greco-Roman architectural principles and are categorized as traditional buildings if they are local and built in the same way over a long period of time and without any significant changes. In Java, Indonesia, there is one type of building that is categorized as a traditional building, called "joglo". This research traces the development of joglo architecture with the aim of proving that traditional buildings are not always built in the same way and without significant changes.

This research uses historical-interpretative method. This method investigates social-physical phenomena in complex contexts, by looking at explanations of these phenomena in narrative and holistic form. By tracing the development of joglo architectural construction through umpak artifacts (stone pedestals), stone temple reliefs, and historical joglo buildings that still exist from the era of the Ancient Mataram Kingdom, the Majapahit Kingdom, the Demak Kingdom, to the Islamic Mataram Kingdom, this research has found that joglo architecture is not stagnant but develops dynamically through developments in construction technology.

**Index Terms**— Development, Construction Technology, Joglo, Traditional Architecture

## I. INTRODUCTION

Joglo is one of the traditional architectures in Java, Indonesia. Joglo has been extensively researched and written about in various books and scientific journals (Santosa, Rachmawati and Noerwasito 2023). However, there are no researchers who have scientifically investigated when joglo began to exist, and how it developed. Traditional architecture is also associated with the pre-modern development period, where traditional architecture is a local building and is distinguished from classical architecture which refers to Greco-Roman architectural principles. Because the joglo is categorized as a traditional architecture, it can be perceived as an architecture that has never changed significantly. This refers to the definition of traditional architecture as "the design and development that has been carried out the same since several generations without significant changes, to meet the space requirements for carrying out certain activities" (Achmad 2019).

Therefore, research on the development of joglo architecture is important. Aside from being a source of new knowledge, this research is also useful for proving whether traditional architecture is always fixed or can change and develop dynamically from time to time. This research focuses on the development of construction technology that composes the joglo architecture.

## II. RESEARCH METHOD

This study uses the historical-interpretative method, a research method by investigating socio-physical phenomena in complex contexts, by looking at explanations of these phenomena in a narrative and comprehensive form.

Throughout the process, interpretation is key (Groat 2002). Interpretation can be done by explaining, clarifying, and decoding (Lorand 2010). Through this method, reference sources related to the development of joglo architecture are discussed to produce an initial understanding. Furthermore, an analysis is carried out by conducting field studies to explore artifacts that can provide clues about the development of joglo architectural construction. The artifacts are in the form of temple reliefs, stone pedestals on historical sites, and historical joglo buildings that still exist. The temple reliefs are used to look for clues as to when the construction of joglo buildings began to appear. The arrangement of stone pedestals (called "umpak") is used to find clues as to when the floor plan pattern that formed the joglo construction began to exist.

After that, a field study was carried out to document samples of the remaining joglo artifacts, from the oldest to the youngest. All data from the documentation are then examined regarding the form of construction and compared in detail to one another to find out the similarities and differences. The result of this comparative study is an understanding that can explain the history of the development of joglo constructions, whether joglo constructions only repeat without significant differences from time to time, or whether they develop dynamically to produce novelties.

## III. DEFINITION OF JOGLO

To find out when joglo began to exist and how it developed, it is necessary to set definitive boundaries about joglo. Joglo is a residential building specifically for nobles (Tjahjono 1998). Joglo is characterized by the presence of a "rong-rongan" structure, a space created by the arrangement of four "saka guru" (main pillars) connected by "sunduk-kili" (lower

beams) and “*blandar-pangeret*” (upper beams) (Frick 1997). At the top there are “*pemidangan*” or “*tumpang*sari” (stackable beams) which function as ballast which stabilizes the *rong-rongan* structure (Prihatmaji 2007) as well as preening (Prijetomo 2006).

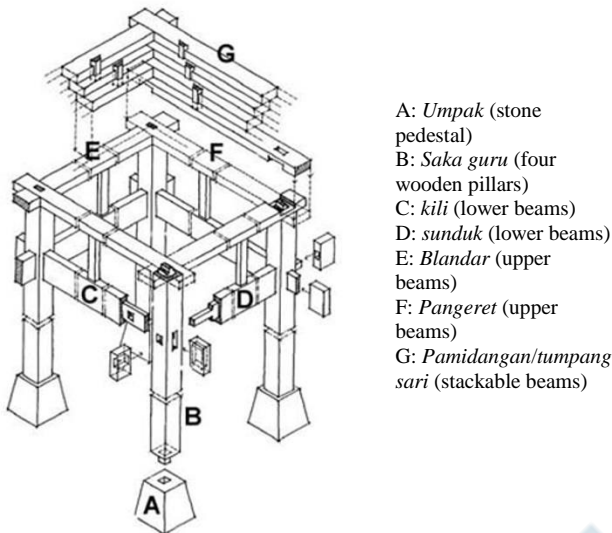


Fig.1. Rong-rongan structure (Frick 1997)

This *rong-rongan* besides being the main structure is also a form generator of the *joglo* architecture. From this *rong-rongan* then emerge the first sector which is called the “*sektor guru*”, the second sector which is called the “*sektor penanggap*”, the third sector which is called “*sektor penitih*”, and the fourth sector which is called “*sektor peningrat*” as shown in the following figure:

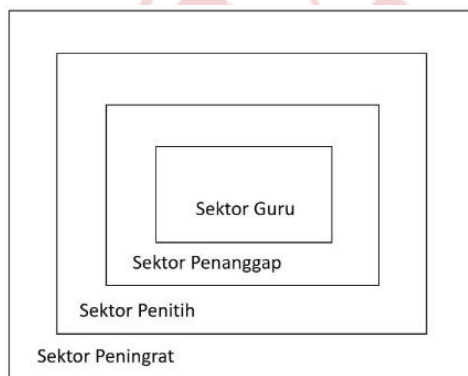


Fig.2. Sectors in the *Joglo* (author’s document, referring to Dakung 1981 and Prijetomo 2005).

The figure above shows that the spatial arrangement of *joglo* architecture is concentric and layered. This spatial arrangement then forms the arrangement of stone pedestals (*umpak*) and other pillars (*saka*) in *joglo* architecture as shown in the following figure:

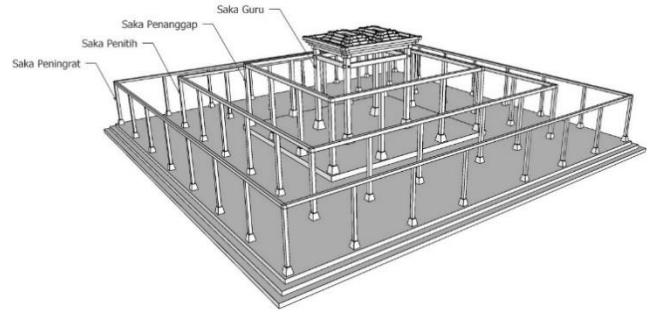


Fig. 3. Arrangement of stone pedestal (*umpak*) and pillars (*saka*) (author’s document).

A building can be called a *joglo* if it has at least the first two sectors including the *guru* sector and the *penanggap* sector. This *joglo* is the simplest, called a “*joglo lawakan*”. Furthermore, *joglo* which has three sectors is called “*joglo sinom*”, and *joglo* with four sectors is called “*joglo hageng*” or big *joglo* (Dakung 1981). The *joglo*, which spatial arrangement is concentric and layered, creates a concentric and layered roof shape, called the “*tumpang*” roof, as shown in the following figure:

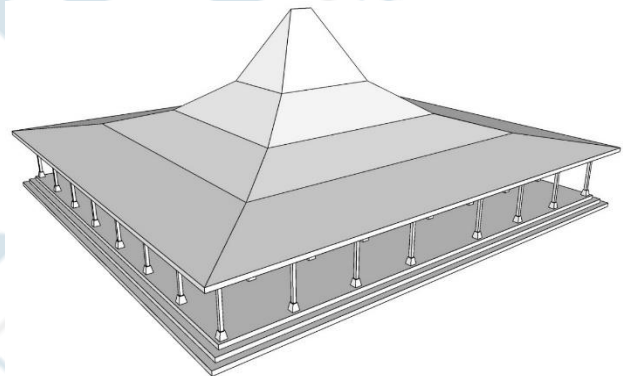


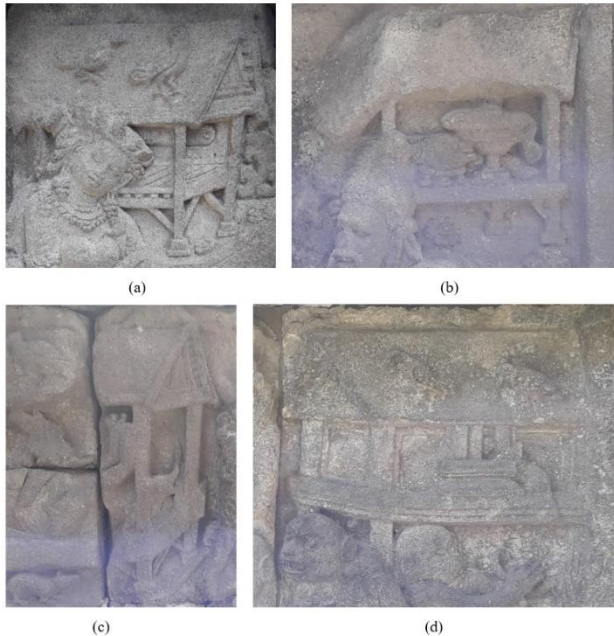
Fig. 4. The *tumpang* roof arrangement (author’s document).

#### IV. FINDINGS

##### A. Examining the Development of Joglo in the Ancient Mataram Era

The Ancient Mataram Era lasted from about the eighth century to the tenth century AD. At this time no remains of wooden buildings can be found. However, indications of the existence of these wooden buildings can still be traced through the reliefs of the temples that were built at that time. The temple that has the most reliefs depicting buildings is the Shiva Temple in the Prambanan Temple complex which was built around 850 AD. Based on the observation of the reliefs, it was found that there were two types of buildings that could be distinguished by the difference in the shape of the roof. The first type of building is a building with a gable roof, and the second type is a pyramid roof. Each of these building types still has different characters which will be explained through the following figure:





**Fig. 5.** Gable roof buildings with exposed walls in the reliefs of Shiva-Prambanan Temple (author's document).

Figure 5 above is a relief of a building with a gable roof, supported by four columns, open without walls or partitions, the floor is stilts, and the columns are supported by pedestals. From the shape of the roof, this building is clearly different from the *joglo* roof, which has a pyramidal shape. The material used in these buildings was probably wood. Because the wood is tough, it is more likely to make smaller/thinner logs as shown in figure 5 (a), (b), and (c). However, the consequence is that the building structure can become too flexible. Therefore, to make it stiffer, it makes sense if the frame of this building is then given a diagonal bar under the frame beams of the platform. Whereas in the building shown in figure 5 (d), because the columns are larger, the joints with the stilt frame beams can use pegs as is the case with the *sunduk-kili* in the *rong-rongan* of *joglo* frame. This connection is sufficiently stiff, because the columns are large and do not require diagonal bar stiffeners.



**Fig.6.** Reliefs of multi-storey buildings at the Shiva-Prambanan Temple (author's documents)

Figure 6 above also shows a building with a gable roof. The construction of the two buildings above seems to have the same principles as the buildings in the previous reliefs. The difference is the building in this picture has multilevel floors. This is not surprising because at that time multi-storey buildings were already recognized. Sari Temple can be evidence that supports this fact. The interior of Sari Temple has holes where the supporting beams of the second floor were used. Because the floor beams probably used wood, the floor is currently destroyed. Evidence of the existence of two floors in Sari Temple can be seen in the following pictures:



**Fig.7.** (a) Exterior of Sari Temple and (b) the holes for the wooden floor beams in its interior (author's document).

The building in figure 8 below shows a roof shape that is different from the building in the previous figures. This roof shape is more like the roof shape of Austronesian architecture as seen in traditional Batak buildings in Sumatra or Toraja in Sulawesi. Compared to the *joglo*, it will likely have different construction principles.

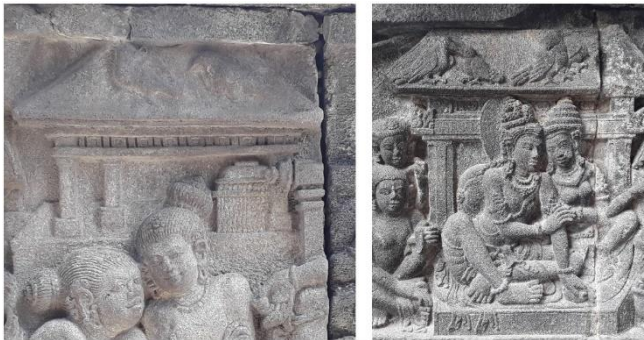


**Fig. 8.** Reliefs of buildings with Austronesian architectural roof forms at Shiva-Prambanan Temple (author's document).

Compared to the buildings in the previous figures, the buildings in figure 9 below have begun to approach the basic characteristics of *joglos*. The shape of the roof on these buildings are pyramid-shaped like on a *joglo* roof. The roofs of the buildings are supported by four columns. The upper columns are seen to be intersected by two beams, the supporting beam of the roof and one beam below it which is likely to support the column, reminiscent of the construction of *blandar-pangeret* beams and *sunduk-kili* beams in the *rong-rongan* of *joglo*. The column legs appear to be supported by pedestals. Another difference from the previous figures is the absence of platforms above the pedestals. The platforms are under the pedestals and look solid. These are to be expected as a raised floor, like the floor of stone temples. *Joglo* is also a building with a raised floor. Because all the



characteristics that have been mentioned have the same principles as the *rong-rongan* of *joglo*, it is reasonable to suspect that these buildings are the forerunner of the *joglo* building. However, because there is only one layer of roof, there is no second layer and so on (in *joglo* it is called *penanggap*, *penitih* and *peningrat*), these buildings cannot be called *joglos*.



**Fig. 9.** Reliefs of buildings with pyramid-shaped roofs and wooden columns at Shiva-Prambanan Temple (author's document).

Based on the examining of temple reliefs above, it can be interpreted that during the Ancient Mataram period there was no *joglo* architecture like that which exists today: buildings with concentric and layered patterns. However, the principle of a building with a central pattern with a pyramid-shaped roof supported by wooden columns stiffened by hanging beams at the top and stone pedestals at the bottom has existed. It is possible that these principles will become the forerunner to the creation of *joglo* architecture in the future.

### B. Examining the Development of Joglo in the Majapahit Era

Based on historical records, the Majapahit Empire lasted from around 1293 to 1527 AD. Like wooden building artifacts from the Ancient Mataram Era, wooden building artifacts from the Majapahit Era are no longer found. The remaining traces are stone pedestals which can be assumed to be the former plinths of wooden columns, and reliefs on temples built in the Majapahit Era.

Pedestals which are thought to be artifacts left by the Majapahit Kingdom can be found in several places in East Java. There are pedestals which position has been changed, some are still intact. Researchers found artifacts of pedestals which arrangement had not changed at a site in Sentonorejo Village, East Java. There are 14 pedestals in Sentonorejo, lined up two by two extending east-west. From the size of the pedestals and the distance between the pedestals, it indicates that these pedestals used to support a large wooden building structure, so that it could possibly have been a public building. Because these pedestals are resting on the ground, not on a stone floor, it can be assumed that the type of building is a stilt building. Meanwhile, the two-by-two linear arrangement of pedestals with the same size clearly indicates that this

building does not refer to the basic form of a concentric *joglo* building. The following is the arrangement of the pedestals:



**Fig. 10.** Arrangement of pedestals in Sentonorejo Site (Sidarta, 2015).

Besides pedestals, artifacts from the Majapahit Era that can be used to trace building shapes can be seen in the reliefs of temples built at this time. Researchers took two temples which depict several forms of wooden buildings in the Majapahit Era. The first is the relief on Jago Temple in East Java which can be seen in the following figure:



**Fig. 11.** A relief at Jago Temple (Pulung Gelung Drupadi, 2014).

In the relief above there are 3 buildings with columns without walls with pyramid-shaped roofs. The two buildings at the top have similarities in the form of elongated pyramid-shaped roofs with 4 columns. The type of building is stilts, while the columns stand on the stone floor. While at the bottom there is a columned building with a pyramid roof that is conical at one point. The building does not have stilts but is set on a stone floor. The first two buildings clearly do not show the characteristics of a *joglo* because they are a type of building on stilts. Whereas the second building, even though it has stepped directly on the stone floor, because the arrangement of the columns and the roof is only one layer, it cannot be said to be a *joglo*.

The next wooden building relief is found in Minakjingga Temple. This temple is thought to have been built during the reign of King Hayam Wuruk who reigned from 1351 to 1389 AD. In this temple there is a relief as follow:



Fig. 12. A relief at Minakjingga Temple (Hoetama, 2016).

This relief depicts a stilt building with 6 columns superimposed on 6 pedestals lined up two by two. The arrangement of the columns like this bears a resemblance to the arrangement of the Sentonorejo's pedestals artifact discussed earlier, which are lined up two by two lengthwise. The shape of this building is clearly different from the *joglo* building because it is not concentric but linear, and the roof is not arranged in layers.

By finding a close relationship between the examining of pedestals and temple reliefs in the Majapahit Era, in general the type of wooden buildings in the Majapahit Era were stilts with a linear pattern, using a wooden frame structure system with a pyramid roof shape. These characteristics are different from the *joglo* building which has no stilts and is patterned concentrically with 4 columns (*saka guru*) as the center, while the following columns are not lined up lengthwise but spread outward to the four sides of the building to form *penanggap*, *penitih* and *peningrat* areas.

### C. Examining the Development of Joglo in the Demak Era

Demak is the first Islamic kingdom in Java which was founded by Raden Patah at the end of the 15th century AD. This kingdom was founded when Majapahit Kingdom had declined. Unfortunately, the Kingdom of Demak only lasted for 3 short leadership periods and today the existence of the palace is no longer known. However, there is one of the patrons of Demak, which was established shortly after the establishment of Demak, the Kingdom of Cirebon. The initial building complex of the Cirebon Kingdom named Siti Hinggil, was established in 1529, and the building artifacts are still maintained today, so that it can be used as a media to trace the existence of *joglo* architecture in the Demak Kingdom era.

Within the Siti Hinggil there are 5 pavilion buildings (*mande*) including: Mande Malang Semirang, Mande Pandawa Lima, Mande Semar Tinandu, Mande Pengiring and Mande Karesmen. The five pavilions are made of wood with original frames, while the roofing materials have been replaced several times. Among these five *mande* there are three of them which have similarities with the *joglo*, they are: Mande Malang Semirang, Mande Pengiring and Mande Karesmen.

Mande Malang Semirang is the main building which used

to be the seat of the sultan and his family in military ceremonies and court proceedings. This building is a wooden frame building with a rectangular plan, supported by 6 main pillars, and the outer sides are supported by 14 pillars. The appearance of the Mande Malang Semirang building can be seen in the following figure:



Fig. 13. Exterior of Mande Malang Semirang (Masyon, 2019).

The structural principle of the Mande Malang Semirang has shown many similarities to the *joglo* building. This is because the columns stand on pedestals, there are no stilts, there are *rong-rongan*, there are stackable beams (*tumpang Sari*) on the *rong-rongan*, the roof form is concentric and layered. The inner columns are the same as *saka guru* sector in the *joglo* architecture. The difference is that in the *joglo* the *guru* sector is supported by 4 pillars, while in Mande Malang Semirang it is supported by 6 pillars. The outer pillars are the same as *saka penanggap* in the *joglo* architecture. The difference is that in the *joglo* the *penanggap* sector is supported by 12 pillars, while in Mande Malang Semirang it is supported by 14 pillars.

Mande Pengiring used to be the seat of officials accompanying the sultan, judges, and prosecutors during court hearings. This building is a wooden frame building with a square plan, supported by 4 main pillars in the middle and the outer sides are also supported by 4 pillars. The appearance of the Mande Pengiring can be seen in the following figure:



Fig. 14. Exterior of Mande Pengiring (Masyon, 2019).

The structural principles of the Mande Pengiring have also shown many similarities to *joglo* buildings such as the Mande Malang Semirang. The inner pillars are the same as the *guru* sector in the *joglo* architecture, and there are also 4 of them,



the same as the number of saka guru in the *joglo*. The outer pillars are the same as the *penanggap* sectors in the *joglo* architecture. The difference is that in the *joglo* the *penanggap* sector is supported by 12 pillars, while in Mande Pengiring it is only supported by 4 pillars.

Mande Karesmen used to place gamelan instruments which are played every Eid al-Fitr and Eid al-Adha in a celebration called Sekaten. This building is a wooden frame building with a rectangular plan, supported by 4 main pillars in the middle, and the outer sides are also supported by 4 pillars. The appearance of Mande Karesmen can be seen in the following image:



Fig. 15. Exterior of Mande Karesmen (Anak Rantau, 2019).

The structural principle of the Mande Karesmen has also shown many similarities to the *joglo* building. The inner *sakas* are also 4 pillars. The outer saka is the same as the *penanggap* sector in the *joglo* architecture. The difference is that the *penanggap* sector in *joglo* is supported by 12 pillars, while in Mande Karesmen it is only supported by 4 pillars. Therefore, the structure of the Mande Karesmen is almost the same as that of the Mande Pengiring. The difference is that Mande Karesmen has a rectangular plan, while Mande Pengiring has a square plan.

From tracing the buildings in the Siti Hinggil Keraton Cirebon complex, it can be known that *joglo* architecture emerged in the era of the Islamic kingdom of Demak. At the beginning the *joglo* was a single building with the main structure of *rong-rongan* and was equipped with second layer pillars (*saka penanggap*). Thus, the *joglo* in this early period only consisted of the *guru* sector and the *penanggap* sector. This type of *joglo* is now known as the *joglo lawakan* (the simplest *joglo*).

#### D. Examining the Development of Joglo in the Islamic Mataram Era

The Islamic Mataram Kingdom was the last Islamic kingdom in Java that existed until now, but was split into 4 kingdoms including Surakarta, Yogyakarta, Mangkunegaran and Pakualaman. The Islamic Mataram Kingdom was founded by Panembahan Senapati in 1586. The peak of the power of the Islamic Mataram Kingdom occurred during the reign of Sultan Agung with the centre of the kingdom in Kerto, Yogyakarta. The palace building in Kerto is no longer there, but there are still 2 stones left which are thought to have been

pedestals. It is estimated that initially there were 4 pedestals. The remaining pedestals measure 85x85cm with a height of 65 cm. If these pedestals used to be the foundation for a *rong-rongan* of *joglo* palace building, then it can be estimated that during the reign of Sultan Agung, *joglo* architecture had achieved rapid development, because with the large size of the *rong-rongan*, it can be estimated that the *joglo* building as a whole must be large. If the building is large, it is likely that the number of sectors has also grown, not only in 2 sectors: *guru* and *penanggap* like those at the Cirebon Palace, but there is a possibility that there has been a third sector, which is called *penitih*, even a fourth sector, which is called *peningrat*. If so, at this time *joglo hageng* (big *joglo*) may have been created.



Fig. 16. A pedestal in Kerto (merdeka.com, 2020).

The Islamic Mataram Kingdom was finally split into two in 1755, Surakarta and Yogyakarta. Surakarta was eventually split into two to become Surakarta and Mangkunegaran. Meanwhile, Yogyakarta was finally split into two: Yogyakarta and Pakualaman. These four palaces still exist today, and the *joglo* buildings have become the main buildings in these four kingdoms. The *joglo* building at the Surakarta Palace was first built in 1744, and at the Yogyakarta Palace in 1756. Both were named Bangsal Witana. The shape of the buildings are as follows:



Fig. 17. Interior of Bangsal Witana of (a) Surakarta Palace and (b) Yogyakarta Palace (merbabu.com, 2001).

Regarding the structure of the building, the difference between the two buildings lies in the level of complexity of the arrangement of the stackable beams (*tumpang-sari*), where the Witana Pavilion of Yogyakarta Palace (b) is more complicated than the Witana pavilion of Surakarta Palace (a). While the similarities are, both pavilions use the "*cathokan lambang gantung*" technique. This technique has not yet been found in the *joglo* at the Cirebon Palace. In this technique, the upper end of the skewers of the *penanggap* sector do not meet

directly with the lower end of the skewers of the *guru* sector (*pandedel* skewers) but hang below the *pandedel* skewers by a vertical rod called *saka jantur* as the connector. For more details, see the following figure:

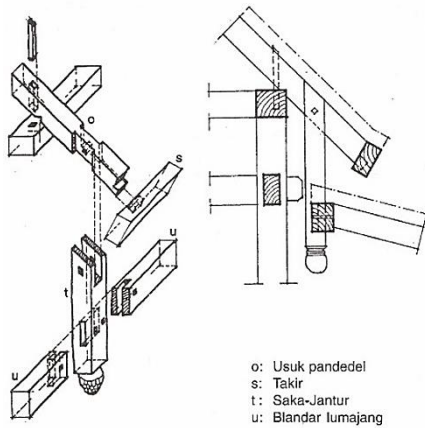


Fig. 18. Cathokan lambang gantung (Frick 1997).

This *cathokan lambang gantung* technique is a further innovation in the *joglo* building structure. With this innovation, it is possible to have a gap between the upper roof and the lower roof which can be used as air ventilation or to allow natural light to enter the center of the *joglo* building space. Moreover, it makes the roof structure under the *guru* sector more flexible when lateral forces occur, thereby reducing the risk of damage to the *joglo* wooden construction during an earthquake.

Further development of *joglo* architecture can also be seen from the wider space that can be created. One example of a *joglo* building that has the widest floor is the Pendopo Ageng Pura Mangkunegaran, which was built in 1757 AD. The *joglo* building which functions as a hall has a floor area of 3,500 m<sup>2</sup>. The shape of this hall can be seen in the following figure:



Fig. 19. Exterior of Pendopo Ageng Pura Mangkunegaran. (Wikipedia, 2023).

This *joglo* has 4 sectors: *guru*, *penanggap*, *penitih*, and *peningrat*. The *guru* sector has 4 pillars, the *penanggap* sector has 12 pillars, the *penitih* sector has 20 pillars, and the *peningrat* sector has 28 pillars. Thus, the Pendopo Ageng Pura Mangkunegaran is the type of *joglo* with the most sectors, so that it can produce a maximum floor area. The appearance of these four sectors can be seen in the following figure:



Fig. 20. Four sectors of the Pendopo Ageng Pura Mangkunegaran (Juwono 2017).

The uniqueness of the structure of this building is the existence of a truss structure system on connecting beams between columns in the *penanggap*, *penitih* dan *peningrat* sectors. In the principle of *joglo* architectural structure, this is not commonly applied. By arranging the beams diagonally on the truss structure system, it will create a rigid structure. The response of a rigid structure is to absorb any forces that occur. The advantage is that the building will be more stable, for example during an earthquake, because the lateral force from the earthquake will be damped by this truss structure.

The structural system of the *joglo* generally uses flexible clamp joints. When the *joglo* experiences a lateral force due to an earthquake, for example, the earthquake energy is not resisted but channelled into energy that shakes the building and the rest will be dissipated. This is what distinguishes it from the *joglo* of Pendopo Ageng Pura Mangkunegaran which uses a rigid truss structure, a structural model that is generally applied to European wooden buildings. So, there is a possibility that this is one proof of the influence of European architectural structural principles on the *joglo* architectural structure. This is very possible considering that the establishment of the Mangkunegaran Palace was not free from the interference of the Dutch as its colonialist.

The study of the development of *joglo* architecture in the Islamic Mataram Era has found that in this era the *joglo* has developed rapidly. Construction engineering innovations and building structures have been carried out. The novelty of the *joglo* construction details in this era has been able to increase the functional value of the building and improve the quality of the *joglo* building structure. Better lighting and room ventilation due to the *cathokan lambang gantung* is a structural innovation that can increase the value of a building's function. Meanwhile, a more flexible structure on a roof that uses *cathokan lambang gantung* can improve the quality of the building structure. The creation of the building sector up to the *peningrat* sector is an example of innovation in building structures to increase the area of space so that the capacity of space increases. In this era, the *joglo* was also influenced by European construction technology so that it could stand more rigidly.



**REFERENCES**

- [1] Achmad, Z.H. (2019) 'Typology of Bena Traditional Architecture, Flores', Local Wisdom Scientific Online Journal, 11 (2), pp. 90–106. Available at: [10.26905/lw.v11i2.2980](https://doi.org/10.26905/lw.v11i2.2980)
- [2] Anak Rantau (2019) *Dolan ning Keraton Kasepuhan Cirebon, yuk!*. Available at: <https://jurnalanakrantau3.wordpress.com/2019/01/03/dolan-ning-keraton-kasepuhan-cirebon-yuk/> (Accessed: 12 May 2020).
- [3] Dakung, Drs. Sugiarto (1981). *Arsitektur Tradisional Daerah Istimewa Yogyakarta*. Jakarta: Departemen Pendidikan dan Kebudayaan.
- [4] Frick, Heinz (1997). *Pola Struktural dan Teknik Bangunan di Indonesia: Suatu Pendekatan Arsitektur Indonesia Melalui Pattern Language Secara Konstruktif Dengan Contoh Arsitektur Jawa Tengah*. Yogyakarta: Penerbit Kanisius.
- [5] Groat, Linda and Wang, David (2002). *Architectural Research Methods*. Canada: John Wiley & Sons, Inc.
- [6] Hoetama, Soleh (2016) *Candi Minakjingga, Inspirasi Rumah Majapahit*. Available at: <https://hurahura.wordpress.com/2016/09/04/candi-minakjingga-inspirasi-rumah-majapahit/> (Accessed: 29 September 2021).
- [7] Juwono, Indri. (2017) *Joglo Mangkunegaran Anggun dalam Sahaja*. Available at: <https://tindaktandukarsitek.com/2017/10/14/joglo-mangkunegaran-anggun-dalam-sahaja/> (Accessed: 3 December 2020).
- [8] Lorand, Ruth (2000). *Aesthetic Order: A Philosophy of Order, Beauty and Art*. London: Routledge.
- [9] Masyon (2019) *Keraton Kasepuhan Cirebon: Siti Inggil*. Available at: <http://keratonkasepuhan3.blogspot.com/2019/01/komplekssiti-i-inggil-sitiinggil-atau.html#> (Accessed: 12 May 2020).
- [10] Merbabu.com (2001) *Komplek Siti Hinggil Lor*. Available at: [http://www.merbabu.com/keraton/keraton\\_surakarta\\_hadinin\\_grat4.php](http://www.merbabu.com/keraton/keraton_surakarta_hadinin_grat4.php) (Accessed: 12 May 2020).
- [11] Merdeka.com (2020) *Munjungungi Situs Kerto, Saksi Bisu Kejayaan Mataram Islam yang Hampir Tak Bersisa*. Available at: <https://www.merdeka.com/jateng/munjungungi-situs-kerto-di-bantul-saksi-bisu-kejayaan-kerajaan-mataram-islam.html> (Accessed: 12 May 2020).
- [12] Prihatmaji, Yulianto P. (2007) 'Perilaku Rumah Tradisional Jawa "Joglo" Terhadap Gempa', Dimensi Teknik Arsitektur, 35 (1), pp. 1-12. Available at: <https://dimensi.petra.ac.id/index.php/ars/article/view/16621>
- [13] Prijotomo, J. (2006). *(Re-)Konstruksi Arsitektur Jawa, Griya Jawa dalam Tradisi Tanpatulisan*. Surabaya: P.T. Wastu Lanas Grafika.
- [14] Pulung Gelung Drupadi (2014) *Otentik Drupadi di Candi Jago, Jawa Timur*. Available at: <https://pulunggelungdrupadi.wordpress.com/2014/05/30/otentik-drupadi-di-candi-jago-jawa-timur/> (Accessed: 29 September 2021).
- [15] Santosa, Adi, Murni Rachmawati and Vincentius Totok Noerwasito (2023) 'Material and Cultural Values in Joglo Architecture in Indonesia', ISVS e-journal, 10 (2), pp. 3-4. Available at: [https://isvshome.com/pdf/ISVS\\_10-2/ISVSej\\_10.2.1\\_Adi.pdf](https://isvshome.com/pdf/ISVS_10-2/ISVSej_10.2.1_Adi.pdf)
- [16] Sidarta, Mawan S.P. (2015) *Watu Umpak, Sisa Bangunan Kuno Majapahit*. Available at: <https://www.kompasiana.com/mawan.sidarta/5548576b547b61e90b25245c/watu-umpak-sisa-bangunan-kuno-majapahit> (Accessed: 29 September 2021).
- [17] Tjahjono, Gunawan (1998). *Indonesian Heritage: Architecture*. Singapore: Archipelago Press.
- [18] Wikipedia (2023) *Pura Mangkunegaran*. Available at: [https://id.wikipedia.org/wiki/Pura\\_Mangkunegaran](https://id.wikipedia.org/wiki/Pura_Mangkunegaran) (Accessed: 1 March 2023).