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Virtual Reconstruction of Architectural Heritage made of wood, stone, and their combination in the Ancient Mataram Era.

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ABSTRACT: In this era of the Covid-19 pandemic, access to tourist objects based on ancient cultural heritage is quite limited. Therefore, this research has enabled its continued access through digital media with a more complete form than its real, concrete one by way of virtual architectural reconstruction. When the pandemic has blown over, this result will not be in vain because it can be a complement to the object in the future and become a promotional medium for the general public so that its members can be interested in physically attending the object to experience it directly. The urgency of this research lies in supporting the potential for the development of tourism based on local cultural heritage architecture such as the relics of the Ancient Mataram era and at the same time build a novelty of architectural theory based on the identity of the archipelago referring to its uniqueness. The approach adopted in this research has been carried out in explorative ways on buildings of the Ancient Mataram era. Historical, typological and morphological studies have been employed to make an architectural study in relation to the shape, plan, placement, and tectonics of these buildings. The object chosen is to consider the existing situation and conditions and determine a certain uniqueness in their architecture. Through exploratory studies, the results are realized by making a virtual reconstruction. By conducting this study, it can be discerned that the ancestors of the Indonesian people in the past had actually mastered and developed adequate architectural technology in 'building' both related to wood, stone and combination technology, enabled by local genius. This can be observed in the form of woodworking technology and stone tectonic processing such as a dome-shaped cone corbel.

KEYWORD : Stone, Wooden, Virtual, Reconstruction, Ancient Mataram

I. INTRODUCTION

Indonesia has a great potential for tourist objects as indicated by its architectural heritage, such as the relics of the Ancient Mataram and Majapahit eras. During the pandemic, these objects have been facing difficulties to achieve their goals either by visits from within or outside the country, both for tourism-related and educational purposes at the same time. These objects are basically important sources of knowledge that describe the architectural identity of the archipelago in the context of today's cross-cultural globalization [1]. In responding to globalization which can eliminate locality, it is necessary to develop research based on the reconstruction of past relics, in the hope that this may strengthen identity considering that architecture comprises knowledge that allows the development of transformative ideas in the form of three dimensions at present and in the future.

In this era of the Covid-19 pandemic, access to ancient tourist objects is limited, so through this research study it may be possible to continue to be accessed through digital media in a more complete form through virtual architectural reconstruction. When the pandemic has finally beaten its retreat, this result will not be in vain because it can be a complementary tool for the object, as a presentation medium that can stimulate the general public to be physically present at the object. In essence, humans will be happier to experience a tourist attraction directly, especially if it is equipped with a display of how it was reconstructed in the past.The selected objects are buildings that were built in the early, middle, and late Ancient Mataram eras but are not objects that are widely known in the world such as Prambanan and Borobudur, so that they can revive the existence of these objects as main tourist objects that are interesting to visit [2]. In addition, considering that their physical form is not complete, it requires a hypothetical reconstruction effort. The results of this research are manifested in the form of reconstructed images along with the background studies, in three-dimensional format and presented virtually[3]. In this format, it will be easier to achieve the results of the research, especially in supporting the development of tourism based on architectural cultural heritage[4].

II. METHOD

This research was conducted on the buildings of the Ancient Mataram era based on the study of architectural typology and morphology both through the real form in the field and the images contained in the architectural

reliefs of the temples in relation to the shape of the figure, the floor plan, and the lay-out of the environment [5]. This research has been conducted in an exploratory, argumentative, and historical manner; in the exploratory context it is used to explain the design holistically and argumentatively to explain what potential can be developed based on this study related to the context of tourism development and education, especially in buildings or complexes of the heritage of the cultural heritage. The approach taken is more exploratory by finding out what is there in the field. All data are reachable, captured, recorded, and measured [4]. After returning from the field, the data are compiled and subsequently sorted, for later use. Thus, this research also proves Krathwohl's approach [6] to historical research, by taking the past as a guide for its analysis. This can be accomplished because the object of research is already an artifact in the form of real objects and happens to be in place .

The research is based on the following main steps[7][8][9]:

1. Exploration and Description: Tracing and collecting data, then describing these, and thereby being able to raise important and critical elements so that they are more visible and attract attention. Exploration is carried out through current field documentation, looking for textual and image data, as well as old data such as photo literature or previous images, both during the Dutch Colonial and Post-Colonial eras.
2. Explanation, by helping us understand the specific situation, allows a context for the vision to predict what will happen, and thus allows organizing conclusions and research results. This explanation is achieved by making classifications, drawing comparisons, making juxtapositions, and through making an analysis based on these data.
3. Testing (Validation). The results issued by the previous process (Explanation) are tested, so as to reveal inaccuracies, exceptions and limitations that will affect the final result. This test is the final part of the analysis which is based on comparative studies with comparative objects, and architectural logic such as relating to the function of space, the activities in it, the surrounding climate such as aspects of temperature and rain, aspects of scale and proportion, anthropometry and ergonomics, sources of material resources, tectonics including materials, structures and construction as well as craftsmanship and equipment, aspects of religiosity, socio-cultural-economic aspects, and miscellaneous other elements. This basis is used for materials in carrying out architectural reconstructions with various possibilities.
4. Virtual Architectural Drawing or Reconstruction [10]. The research ends with a reconstruction in a digital-virtual three-dimensional format as described by Landes [3]. Thus, the research results will be more easily understood by the general public. Familiarizing this public with these results (socialization) will be easier to achieve, especially in supporting tourism because it is supported by three-dimensional visual media.

III. THEORETICAL BACKGROUND

Architecture of Wood, Stone and Their Combinations : Buildings in the Ancient Mataram Period based on their material can be identified through the use of wood, stone, brick and their combination. However, at present what remains is dominated by stone and brick buildings, while the wooden ones have been completely destroyed [11]. The stone building is identical to the temple while the wood is used for the non-enshrinement. However, based on the findings, it is also unavoidable that the use of wood and combined with stone in the temple can be seen in the remains of the *umpak*, the wooden pillars supporting its foundation. Experts believe that the temple was originally also made of wood and later developed into stone or brick. To see a picture of a wooden building at that time, the source of information that can be used and considered authentic is in the reliefs carved on the walls of the temple that describe what the architecture must have looked like.Relating the relief image with the past is one way of making sense of the architectural form. The relief maker in making his paintings of course took references based on his knowledge and what was developing at that time. On the other hand, relief makers could also have fantasized when describing them according to their wishes and insights. The form of the painting depicted may be the result of their fantasy, not based on the existing reality, so that the forms of the buildings depicted may behave differently from the reality. This can refute the theories that explain how the building looked at that time. On the other hand, what strengthens the assumption that the relief maker took references from the building that was developing at that time was the relationship between the real form and the form of the depiction or painting[11]. Indeed, residential buildings have in fact been destroyed, but sacred buildings such as temple buildings thought to have been made of stone can still be found and are indeed in accordance with the description in the reliefs, so this can also be used as an analogy to see how the shape of the wooden buildings can relate to their residence.In the development of architecture of wood, stone, and their combination, the emergence of new forms can be the result of creativity in modifying buildings in the past or building styles from other cultures that have entered and are considered new. However, apart from using the

symbols of the past, changes in the environment-nature-climate, spirituality, ideology, especially those that affect lifestyles also encourage creativity in creating architecture. The architectural transformation is evident in the processing of the plan (linear-concentrated), the space and mass of the building (separated into several masses – united in one mass), the composition of the building mass (single-cluster), the roof (saddle-shield), and the foot (base) of the building [12].

IV. DISCUSSION AND RESULT

Virtual Reconstruction of Architectural Wood, Stone and Their Combinations

Virtual Reconstruction is a hypothetical attempt based on premises based on the architectural logic of the building and historical background. This reconstruction is divided into three parts, namely building reconstruction type 1 which is dominated by the use of wood, and type 2 which is a combination of stone and wood, while type 3 features the use of stone in all building elements.

Wooden Buildings : For type 1, Virtual Reconstruction has been carried out at the *Dharmasala* building in Dieng. The *Dharmasala* complex consists of several zones and uses a so-called chessboard pattern. The term *Dharmasala* is used to name a heritage complex in Dieng that employs a considerable amount of wood material, like a residential building[13]. *Dharmasala* refers to the function of the building that is used to support activities at the temples in Dieng, both as a residence hall, a place for teaching and learning, a place for human interaction in preparing ceremonies, and so on. *Dharmasala* is associated with the abode of humans who care for these temples. This *Dharmasala* is reminiscent of the Nalanda Dormitory and the Priest's Dormitory in Nepal [14]. Reconstruction was carried out only on three building complexes that were visible on the surface, while the others were already buried in the ground.

Reconstruction was carried out starting with re-reading the spatial pattern and the mass following the construction of the building in it. The rest of the pedestal foundation was subsequently analyzed and through the logic of space and form, the patterns were mapped again so that patterns have been found that make up the rows of columns and the pedestal foundation. Based on the pattern of the pillar supporting the column, the possible forms of the building above it were determined, along with the orientation of the building. Most of the main buildings have a linear orientation with their façades directed towards the West which can be seen from the presence of stairs to the *batur* (shelf or board). This facing direction is similar to the temples in the Arjuna Complex which also face west. The buildings are also located on the center axis of the plot extending to the north and south except for the buildings in plot 1 which tend to be located in the right-side area of the plot. In plot 1, 2 buildings that serve a public function are situated in front, facing the entrance gate. In plot 2, there are no stairs to ascend to the rock of the building, but based on the presence of a door to the west, the direction towards the building is estimated to be west, like other buildings. However, there is an alternative direction facing east because of the existence of the supporting building pedestals that are generally located in front of the building. In plot 3, the buildings also face west there is an alternative direction facing east because of the presence of supporting building pedestals that are generally located in front of the building.

To determine the size, the *Manasara* approach can be used by way of comparison. In the discussion of the types of *sala* in the *Mānasāra* text, the *Dandaka* type is the most appropriate for the buildings in the *Dharmasala* Complex. This is because the buildings tend to be simple and consist of one single layer. In the *Dandaka* sala, there are several ratios of the width to the height of the building. The most likely comparison is *Santika*, which is width: height = 1: 1 [15][16]. However, judging from the proportions and logical construction of wooden buildings in a tropical climate, this comparison is not suitable as a reference because it will form spaces that are too high. The possibility of this proportion rule is more intended for the manufacture of temple buildings. However, it can also be compared with the size of traditional Javanese architecture known today as *petungan*[17][18]. In order to determine the proportions based on the size of the pillars, an estimate of the function of the building is needed. In the context of the *Dharmasala* Complex, the possible functions are found in the granary/mosque and the *omah* (home)*/pendapa* (gazebo-like building). This gives an estimated average pile height of around 2.52 meters, 2.88 meters, and 3 meters to 3.5 meters converted from anthropometric measurements.

To understand the physical form of the building based on the *umpak* pattern and the estimated proportions of the building, it can be compared with a picture of the enshrinement relief depicting a wooden building. In the ancient Austronesian building tradition [19][20], the building is divided into 3 main parts, namely the head, body and legs. The head includes the architectural form of the roof, the body includes column, floor, and wall elements, and the foot or base includes pedestal and *batur* foundations. On the reliefs of Borobudur and

Prambanan temples there are pictures of buildings that are considered to represent the architectural form of the people at that time, however, they can also be related to the type of traditional Javanese architecture (except for the *Joglo*, as this particular type only emerged after the Hindu-Buddhist era) which could be used as a reference in the reconstruction process because there were significant similarities in the elements of the building and the same origin.Reconstruction of the roofs of wooden buildings has been based on the reliefs of Borobudur and Prambanan temples as well as the contextuality of the tropical climate and development of technology available at that time[11][21]. The roof may be in the form of a gable and shield or a combination of these with variations in size and composition. This roof is thought to have employed wood and bamboo construction with a cover of palm fiber or *alang-alang*/coconut leaves. The roof construction is thought to have formed patterns of support poles and horizontal rods as depicted in the reliefs or *Ander* and *Blandar* in traditional Javanese architecture. The roof covering is estimated to have had a thickness or solidity to withstand the very cold Dieng air in the morning and evening. There are many roof-like structures with 2 variations of the roof slope, namely in the hallway and in the middle of the building. There is also a second level floor without walls or openings between one and two roof layers as a form of ventilation in the context of a tropical climate. Based on Chinese sources of reference, it may be added that in Ho Ling or Kalingga, the King lived in a large multi-storey building, roofed with palm leaves[22]

Reconstruction of the building body cannot be separated from the structural system used is a simple column-beam truss system. The reliefs of Borobudur and Prambanan temples depict the shape of a square column and a circle[8]. In this reconstruction, it can be concluded that all the columns of the wooden buildings are square. This is evidenced by the rectangular shape of the pedestals and the presence of dents on some of the pedestals which indicate the structural elements are square and not circular. There is no evidence that can confirm the size of the column, but with a pedestal measuring about 30cm x 30cm, it is safe to assume that the column measured 15cm x 15cm in size to support the load on it. The size of the beam is assumed to have been 8cm x 15cm. The wooden construction is estimated to use a *purus* pattern to provide strength but still allow flexibility during an earthquake. In addition, a screw system is also used in the ring beam to stiffen the joints, both in the body and legs of the building.The floor is a wooden plank arranged on a floor beam structure as shown in the reliefs. The size of the wooden planks cannot be ascertained. The use of plank flooring instead of split bamboo flooring is supported by the discovery of wood plank charcoal at the *Liyangan* Site[23]. This means that the technology to process tree trunks into neat wooden planks already existed in that era. Supporting evidence is also found in the discovery of an ancient Rembang boat dating from the 6-7th century, using wooden planks for the floor and walls of the ship. The use of walls can be seen in the temple reliefs which indicate activities in it that are more private in nature, such as bedrooms or resting rooms. The walls also prevent direct sunlight, rainwater, wind, insects, and other animals. Given that the temperature in the Dieng Plateau is quite low, it is possible that the main buildings were walled buildings made of thick material, namely wooden planks instead of bamboo booths. Parts that are more public, such as the lobby and *pendapa*, generally do not have walls. Meanwhile, the window used is a tipping window which is suitable for the tropical climate and there are references to its depiction on the reliefs of the temple.

The foot of the building clearly shows a stilt pattern given the humid and sometimes watery conditions in Dieng. The stone foundation is placed directly on the ground without further settlement. Columns are also placed directly above the pedestal except at some points. The foundation is in the form of a beam with a size of 30cmx30cm and slightly smaller at the top. The *Batur* is the base for the main buildings with the aim of keeping the wood away from soil moisture so that it is not easily weathered and exposed to insects. The shape of each building varies with a height of approximately 20 cm to 50 cm, which indicates the different functions of the building. The moldings on the *batur* also vary from those that are just plain stone arrangements to those that have carvings like temples. The connection of stone to wood is found in wooden columns with stone pedestal elements. Looking at the existing condition of the *umpak*, it shows that the dominance of the absence of wood holes indicates that the wooden columns are placed directly above the *umpak* with roller mounts. The load of the building is to hold the position of the logs so that it becomes a rigid system but still allows movement during an earthquake. The beams at the foot of the building are estimated using *purus* and *sekur* connections as depicted in the enshrinement reliefs. The *Dharmasala* complex uses a fence that is thought to have been made of stone. This can be discerned from the stone remains around the wooden buildings. This stone fence is also estimated as a water barrier if at any time there is a puddle from the outside. In the past this area was famous for the term *Bale Kamban*g (Floating Pavilion) which refers to water. Most of the stones are stacked directly on top of each layer without any connection reinforcement as in temple buildings. This fence has a fill in the form of soil in the middle.

Based on the observation of conditions in the field, it was found that the connection of the pen is continuous and the notches are continuous in some parts of the stone, especially in the gate area.Based on the activities in *Dharmasala*, the activities carried out in the buildings in the *Dharmasala* Complex are estimated to be gathering, studying, socializing/familiarization, listening to teachings, sleeping, eating, or preparing for ceremonies and worship as illustrated below. In addition, this building is estimated to have featured a fireplace that functioning as a space heater and serving a function for cooking. This can be observed in the buildings of the archipelago that were influenced by the Ancient Austronesian tradition and the buildings in Tengger. As regards social and cultural conditions, the ancient Dieng complex shows signs of an advanced civilization considering its location in a fairly isolated highland. The construction of temples and the *Dharmasala* Complex, which was occupied by many people, means that the surrounding nature could support an affluent life, for example from the presence of fertile rice fields and plantations. This is also corroborated by the discovery of 22 inscriptions, confirming that the Dieng Site had been used from the 7th to the 12th century.

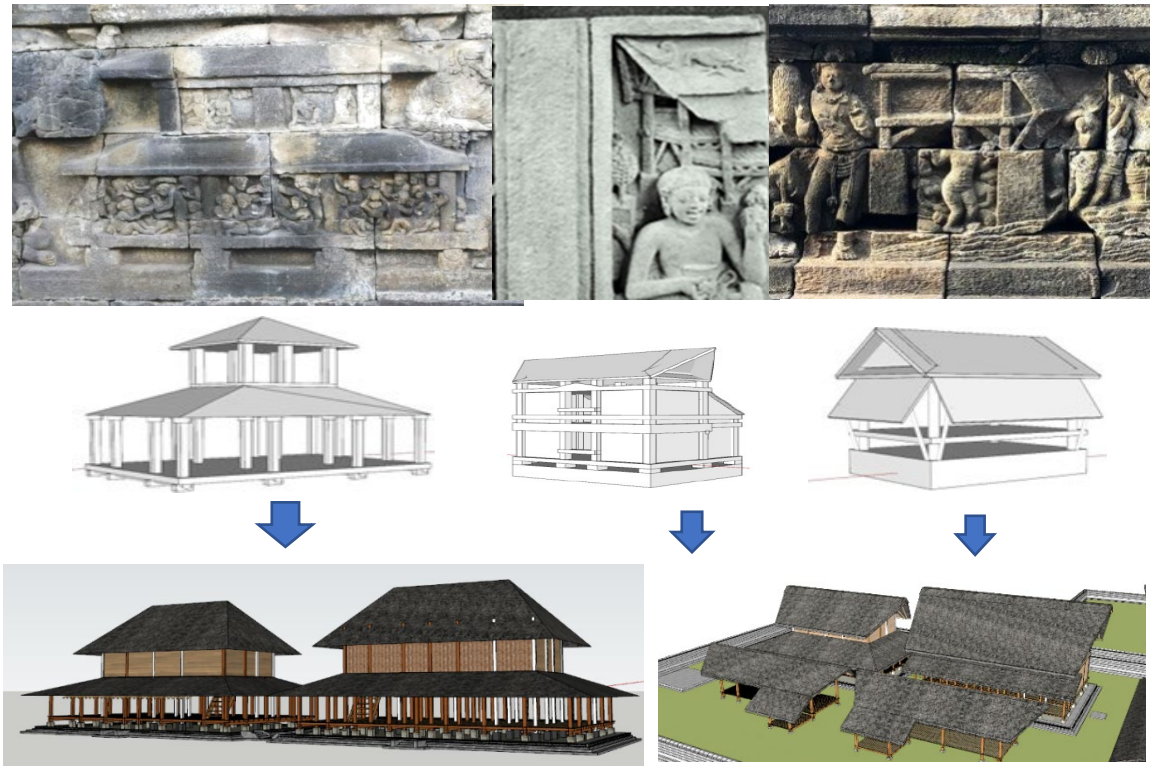


Fig 1. Relationship of relief image with several alternative, Alternative 1 (Left) and Alternative 2 (Right) [24]

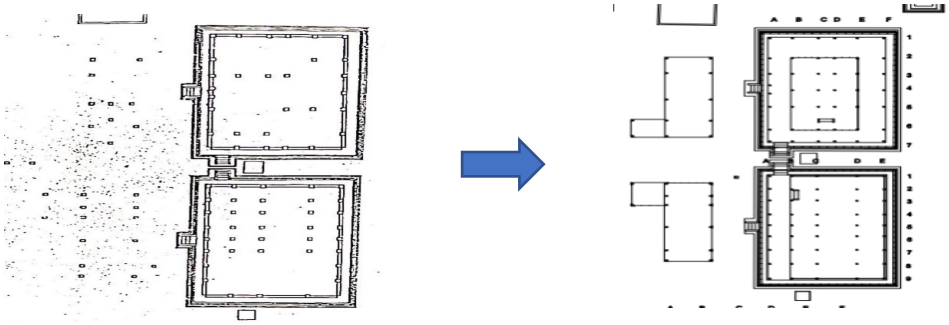


Fig 2. Reconstruction of column position [24]

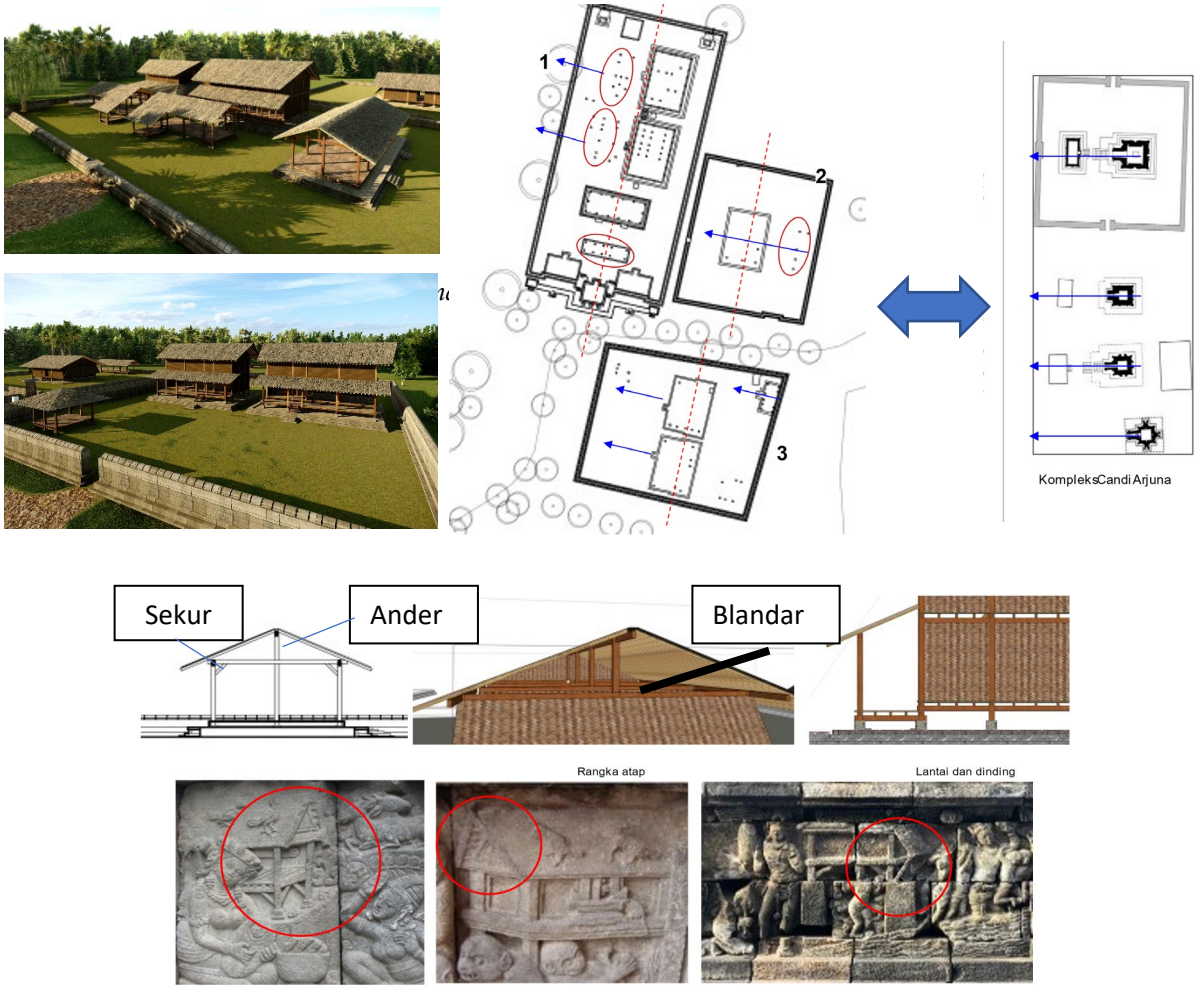


Fig 4. The Tectonic of Roof Construction, *Blandar*, *Ander, Sekur*[24]

Fig 5. Wooden board, Furnace Analogies (for cold weather), Below : *Umpak* and Square column remain, Wooden Join – *purus*, Boat Wooden Construction[24]

Temples Made of a Combination between Stone and Wood : The only ones that remain of these building types happen to be buildings made of stone. Traces of wood elements can be spotted in the rest of the pedestal foundation on the floor of the building. The foundation stands are of the roller type, while others are in the form of protrusions up and inward holes (joints and clamps). The system in the form of protrusions is used so that the two elements can bind to each other; considering that the temple could have had a larger dimension, the roof surface must have followed suit in terms of size. The larger the roof surface, the stronger the lateral forces must have been when there was a load/force from the wind. The shape of the foundation base is in the form of a circle or a square. The existence of differences in the shape of the pedestal suggests the possibility that there were differences in the shape of the columns.

Based on the structure of these buildings, no *jaladwara* for the drainage of rainwater was found, thus basically the corridors of these temples should be shaded by roofs, unlike the temples of Prambanan and Borobudur. This *Jaladwara* has a function to channel water from inside the temple to outside the temple so that the absence of *jaladwara* in the temple certainly ensures that this temple has a roof to protect the building from rainwater. This type of temple is very interesting because it looks like it has two rooms in the main temple, namely the core room in the form of a *garbagrha* which is shaded by a stone roof and the surrounding hallway is then given an even bigger shade in the form of a wooden building.The body of the building made of wood consists of wooden columns arranged in a row and is open, without walls. Columns are reinforced with horizontal beams as fasteners such as the wooden construction discussed in *Dharmasala* above. If the foundation holder consists of rollers, it will be expected to be reinforced with horizontal beams at the legs other than at the top of the column. These columns are depicted using carvings on the bottom, middle, and top of the stem. This can be seen from the description of the columns on the reliefs of Borobudur and Prambanan temples and it is possible that there were *sekur-sekur* or triangular roof supports[11]. This building is like a pavilion in today's era which allows air to flow in it.

These wooden columns are also used in the ancillary temples. The height of these columns (if related to the rain factor) should not be too high because it is related to the width of the *teritis* that it supports to prevent rainwater from flowing out. The dimensions of the column are estimated for the Sambisari temple, Klero is estimated to be quite large considering the size of the pedestal that is large as well. This large size can be related to the width of the roof it supports and the height of the roof; the wider and taller it is, the stronger the column must be that is required. The body of the building is all lined by a balustrade which also functions to keep out rain. The roof of this building is estimated to be in the form of a meru or wooden tiered roof [25][26]. This can be assessed based on a comparative study with the proportion of tower-type temples made of stone. Based on data derived from research conducted into the proportion of tower-type temples [27], it can be assumed that the number of roof structures of the Meru Temple amounts to at least 3 layers, given that the Meru roof has a number of roof structures ranging from 3 to 11. With the assumption that the roof has a roof slope of 35 degrees, it follows that the number of roof structures closest to the study of the proportions and rules of the Meru roof is 3 layers. The angle of inclination of 35 degrees is determined based on the estimated roof covering material using fibers/reeds/straw. But on the other hand, if you don't pay attention to the proportions of the Menara temple, it is possible that there is only one layer of roof with a wide *teritis* like the current pavilion. This assumption may not be based on the shape of the roof of a sacred building which is usually multi-storied like Meru. The shape of the roof of these temples which is made of wooden buildings resembles a *tajug* roof, which is centered and can be stratified. This type of roof construction system can also be linked to the roof construction of Meru in Bali, or to the roof of the barn which is influenced by ancient Austronesian traditions such as those encountered in Karo [19]. This combination type temple is indeed expected to accommodate different activities such as the Prambanan types. The difference lies in the presence of the shaded terrace space. The terrace space in a temple is already

widely recognized as in Prambanan Temple. However, what distinguishes the terrace space in this combination type temple is the one covered/shaded by a roof, in contrast to Prambanan Temple whose terraces are open/not shaded by a roof. This difference may indicate that there are longer activities or rituals, so the terrace is intended to protect the users of the space from hot/rainy weather. The existence of a longer ritual can indicate an ancient Austronesian influence such as the ceremony at the *punden* terrace which is performed by sitting around the center. This could indicate a possible revival of the old pre-Hindu-Buddhist beliefs. This concept can also be related to the presence of more attention being paid to the space in the interior of the temple, as found in the carvings on the interior of the *garbagrha* of Prambanan Temple, because in general the interior of the *garbagrha* is not carved. In addition, it is also possible that this type of temple was a special temple intended for

certain people and was considered private in nature, to be used for rituals to stay there for a long time. Certain people in question could have been leaders (kings, persons of high distinction, *wanua*) or royal family/relatives.

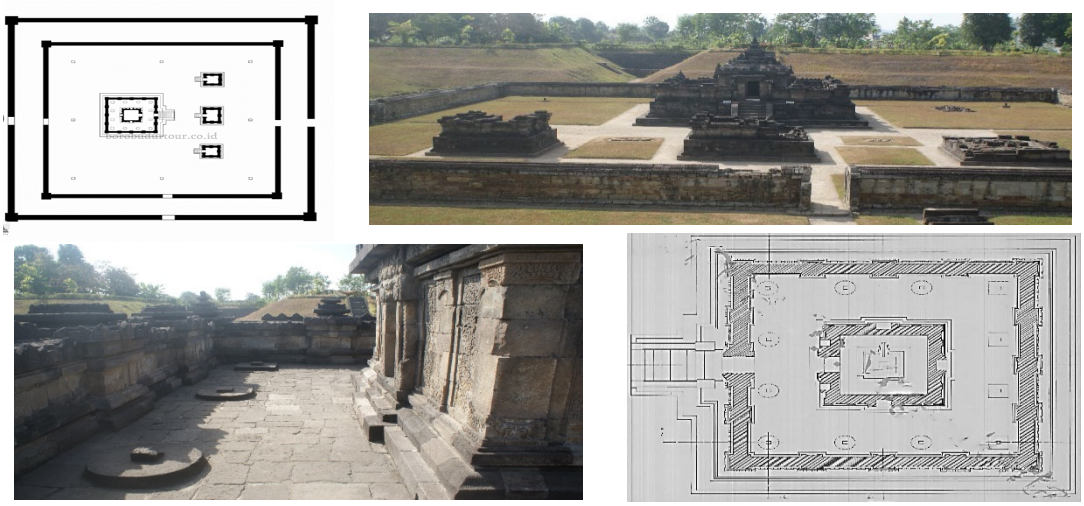


Fig 6. Sambisari Existing [24]

Fig 7. Relationship of relief image with several alternative, Alternative 1 (Left) and Alternative 2 (Right) tiered roof and *Sekur* Construction [24]

Fig 8. The Virtual Wooden Construction at Sambisari Temple [24]

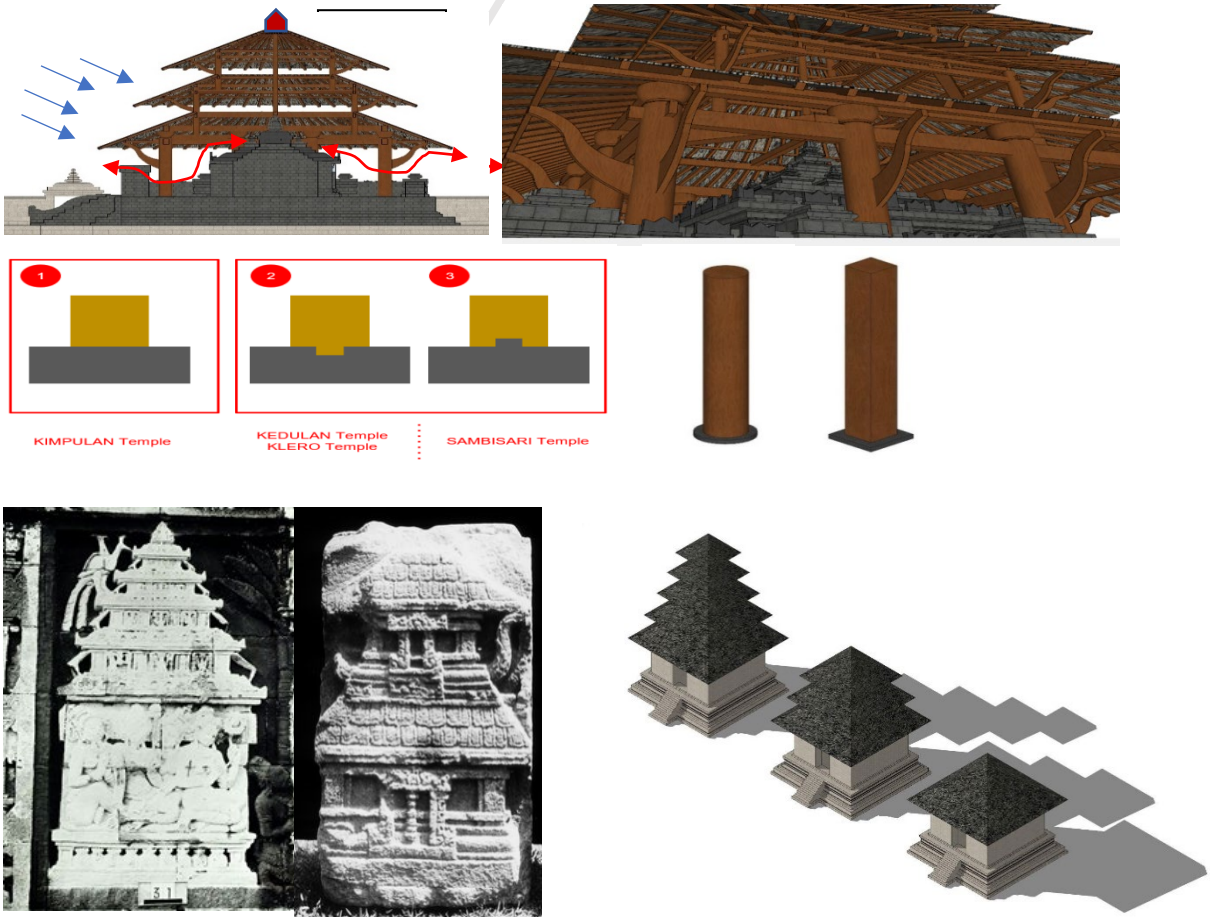


Fig 9. Upper : Ward off Rain Water, Cross Ventilation, Detail Wooden Construction; Below Column and Foundation (*umpak*) [24]

Temples made of stone – Case : Kalasan Temple : For this type of temple, it is a temple that is widely known, namely the use of stone materials. However, in this study selected temples that have specificity in relation to special architectonics in terms of construction. One of these unique temples is Kalasan. This Kalasan Temple [28][29] is thought to have been renovated or expanded during the ancient Mataram era. This can be proven from the evidence of excavation of the feet/base, that inside the foot of the temple which is now there is a temple foot in the shape of a square which proves that there has been a change in the renovation stage in the temple building. The change of the foot of the temple was originally a square turned into a cruciform due to the influence of the Mahayana flow that entered Mataram at that time. Kalasan Temple, which is known today, was probably built at the same time as Prambanan Temple, Plaosan Temple, and Sari Temple. Meanwhile, the shape of the Kalasan Temple, which was built in 778 AD according to the inscription, cannot be known with certainty. The outstanding feature of this Kalasan Temple is that it has a wall that is attached by a mixture of sand, commonly called *vajralepa* [30], as is the case in making walls today as wall smoothing. The presence of a white layer of *vajralepa* is also found in the Sari temple. as in the manufacture of walls today as wall smoothing. In the Kalasan inscription in 778 AD it is stated that the Gurus of the king of the Syailendra dynasty had succeeded in persuading the Maharaja of Tejapurnama Panangkaran, Putra Sanjaya, to build a sacred building dedicated to Dewi Tara and a monastery for priests in the Syailendra dynasty's kingdom, to whom later Panangkaran awarded the village of Kalasa as the Sangha. The sacred building is none other than the Kalasan Temple and its monastery (situated not far from the Kalasan Temple) is the Sari Temple [31][28] . It is quite possible that this Candi Sari served as a *Dharmasala* (dormitory) for priests.

Kalasan temple is a temple that is classified as still intact, as the main room did not collapse when it was rediscovered. This integrity is thought to be related to the architectural aspect in terms of construction, especially the octagonal-shaped roof. There is reinforcement in the corners. This construction is arranged in layers so that it looks like a dome. The interrelated pattern in the form of an octagon on the roof is thought to have played a role in strengthening the structural system, especially when the *vajralepa* was added. The use of substances such as cement is reminiscent of today's modern buildings. Vajralepa in addition to playing a role in construction also makes the building white so that it reflects the moonlight at night, like the Buddhist temple concept, namely the glittering diamond pagoda.

The Kalasan Temple can be said to have employed the roof architecture that forms a dome pattern which is not found in other temples except for small stupas in the *arupadatu* section of Borobudur which contain Buddha statues. The interesting phenomenon is that the roof of the Kalasan temple is in the form of a stupa but grows to form a dome inside, like the small *arupadatu* stupas at Borobudur. If in Borobudur the construction of the dome is only to shelter a Buddha statue with small spaces, in Kalasan it is a further development with a wide-span construction to accommodate more people. The idea of the Stupa Dome containing space or room inside is characteristic of the architecture of the Kalasan temple in the archipelago. Stupas are usually massive constructions that do not contain any space or room inside, and if there is a cavity or aperture it will not be too broad. In Europe, this Dome was only known in Roman times, and it was not known at all in pre-Islamic India. The dome was brought later by Islamic traditions to Southeast Asia and South Asia, however, through this Kalasan the cone-dome can be recognized in the archipelago before the arrival of Islam, although architecturally the cone-dome corbel in Kalasan differs from the domes found in ancient Rome and Islamic architecture.

To find out the proportions of the temples, the approach taken by Atmadi and Herwindo [16] [27] is to measure all parts of the temple, then compare each one in the hope that a relatively stable constant can be found or at least one containing only slight differences. A similar calculation technique was used in this study to obtain patterns of the same size. The results of these calculations are subsequently juxtaposed with each other to obtain a constant comparison. The results of these constants are then used to find the sizes and dimensions of the parts of the temple that have been found damaged/lost. In addition, the Manasara-Silpasastra theoretical approach has been used which includes a comparison of the size of the plan, the comparison of the size of the front view, and the comparison of the size of the plan and the front view [32]. Based on these studies, it is found that the proportion for the head (Arupadhatu) at Kalasan Temple is estimated (if reconstructed using the proportion calculation) to be 17.79 meters, so that the total height amounts to approximately 34 meters. A significant comparison measurement can be seen from the ratio between the legs: body: head, namely 1: 4: 4. This measurement can refer to its own function, namely as a place of worship. The results of these calculations show that there are similarities between the Kalasan temple and the comparison temples [33] [34]so that we can find sizes that have not been encountered previously in the use of proportion measures in the Manasara-Silpasastra theory. Employing the same method, this step has also been carried out in the virtual reconstruction for the Dieng temple and the Ijo Temple Complex[24].

Fig 9. Kalasan Existing [24]

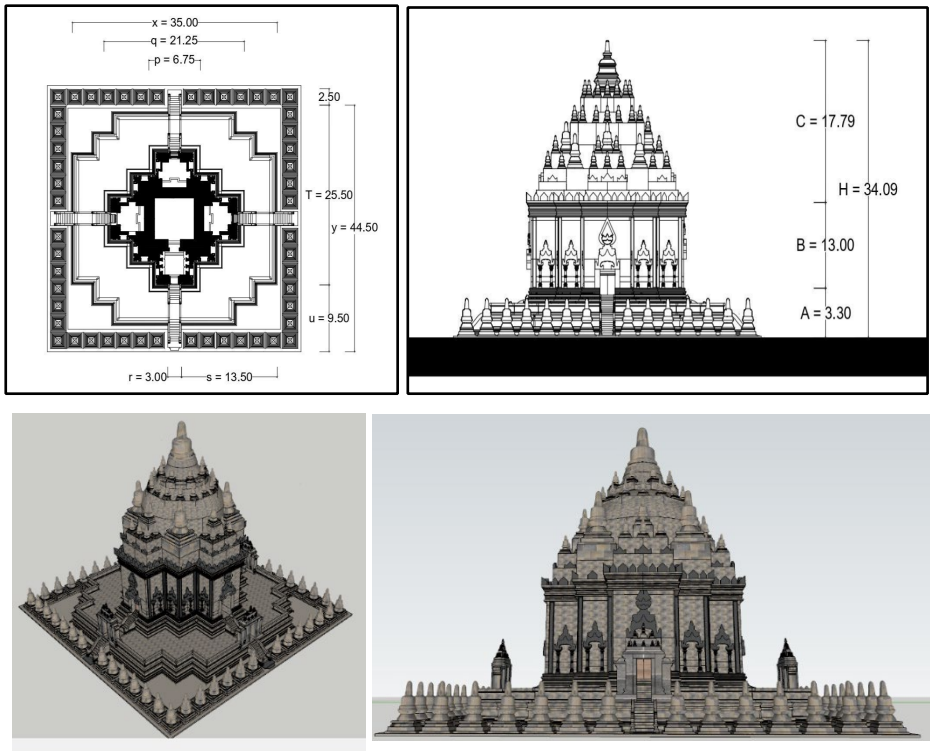
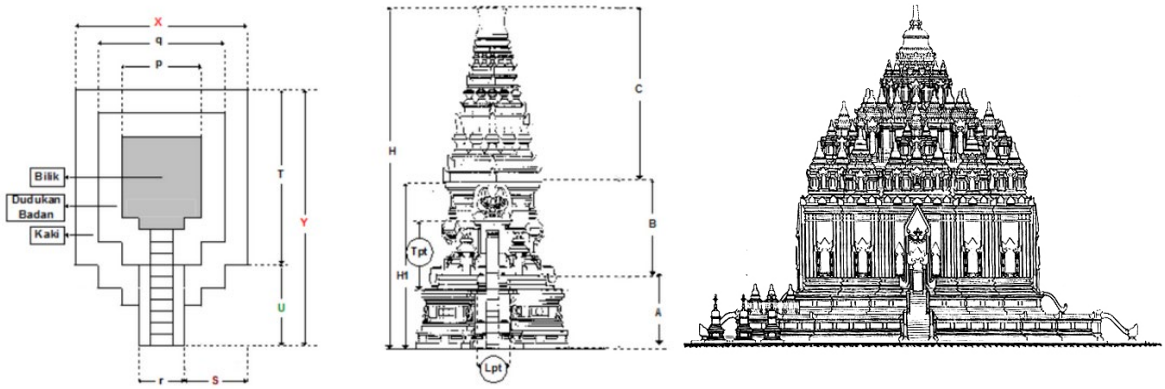


Fig 10. Kalasan Virtual Reconstruction [24]

The approach to calculating the proportion of Kalasan with comparisons to several temples can be seen in the table below:

Table 1



No.	Temple	X	q	p	T	u	Y (T + u)	r	s	A	B	C	H	H1 (A +B)	Tpt	Lpt
1	Kalasan Temple	35	21.25	6.75	35	9.5	44.5	3	9.25	3.3	13	0	0	16.3	2.81	0.93
2	Bubrah Temple	15.4	11.53	3.2	15.4	12	27.4	4	3.84	3.22	7.43	10.75	21.4	10.65	1.9	1.23
3	Sojiwan	19.46	14.76	6	19.4	11.4	30.82	1.26	6.03	2.36	11.88	13.66	27.9	14.24	3.67	1.42

	Temple					2										
4	Siwa Temple	33.5	25	14.03	21.85	4	25.85	2.28	10.26	5.2	13.8	28	47	19	2.28	1.05

In the table above, the measurement results from working drawings obtained from the Yogyakarta Special Region Cultural Heritage Preservation Office are presented as well as several working drawings obtained from books and theses which have previously been searched for data. These measurements are assumed to be accurate because the images listed use a certain scale. The formula for calculating this proportion uses the Manasara-Silpasastra theory which aims to find a comparison of architectural proportions between the main object and the comparison object. The data that has not been obtained is the size of the head height of the Kalasan Temple and the total height of the Kalasan Temple. In the table presented will use the meter (m).

Comparison of Proportions on Plans

Table 1

No.	Temple	X/Y	u/T	s/r	r/X	p/X	q/X	r/U
1	Kalasan Temple	0.7865168539	0.2714285714	3.083333333	0.0857142857 1	0.1928571429	0.6071428571	0.3157894737
2	Bubrah Temple	0.5620437956	0.7792207792	0.96	0.2597402597	0.2077922078	0.7487012987	0.3333333333
3	Sojiwan Temple	0.6314081765	0.5886597938	4.785714286	0.0647482014 4	0.3083247688	0.7584789311	0.1103327496
4	Siwa Temple	1.295938104	0.1830663616	4.5	0.0680597014 9	0.4188059701	0.7462686567	0.57
Smallest Number		0.5620437956	0.1830663616	0.96	0.0647482014 4	0.1928571429	0.6071428571	0.1103327496
Biggest Number		1.295938104	0.7792207792	4.785714286	0.2597402597	0.4188059701	0.7584789311	0.57
Difference		0.7338943088	0.5961544177	3.825714286	0.1949920583	0.2259488273	0.151336074	0.4596672504
Average		0.8189767326	0.4555938765	3.332261905	0.1195656121	0.2819450224	0.7151479359	0.3323638891

Comparison on the plan is done by comparing the long side with the wide side. This calculation is more specific to measure the proportion of the temple body to be studied.

Comparison of Proportions on Front View

Table 3

No.	Temple	H1/H	A/H	B/H	C/H	Lpt/Tpt	A/B	A/C	B/C
1	Kalasan Temple	0	0	0	0	0.3309608541	0.2538461538	0	0
2	Bubrah Temple	0.4976635514	0.1504672897	0.3471962617	0.5023364486	0.6473684211	0.4333781965	0.2995348837	0.6911627907
3	Sojiwan Temple	0.5103942652	0.08458781362	0.4258064516	0.4896057348	0.3869209809	0.1986531987	0.1727672035	0.8696925329
4	Siwa Temple	0.4042553191	0.1106382979	0.2936170213	0.5957446809	0.4605263158	0.3768115942	0.1857142857	0.4928571429
Smallest Number		0.4042553191	0.08458781362	0.2936170213	0.4896057348	0.3309608541	0.1986531987	0.1727672035	0.4928571429

Biggest Number	0.5103942652	0.1504672897	0.4258064516	0.5957446809	0.6473684211	0.4333781965	0.2995348837	0.8696925329
Difference	0.1061389461	0.0658794761	0.1321894303	0.1061389461	0.316407567	0.2347249978	0.1267676802	0.3768353901
Average	0.4707710453	0.1152311337	0.3555399115	0.5292289547	0.456444143	0.3156722858	0.219338791	0.6845708222

Table 4

No.	Temple	A/X	A/T	A/Y	q/B	p/C
1	Kalasan Temple	0.09428571429	0.09428571429	0.07415730337	1.634615385	0
2	Bubrah Temple	0.2090909091	0.2090909091	0.1175182482	1.551816958	0.2976744186
3	Sojiwan Temple	0.121274409	0.1216494845	0.07657365347	1.242424242	0.439238653
4	Siwa Temple	0.1552238806	0.23798627	0.2011605416	1.811594203	0.5010714286
Smallest Number		0.09428571429	0.09428571429	0.07415730337	1.242424242	0.2976744186
Biggest Number		0.2090909091	0.23798627	0.2011605416	1.811594203	0.5010714286
Difference		0.1148051948	0.1437005557	0.1270032382	0.5691699605	0.20339701
Average		0.1449687283	0.1657530945	0.1173524367	1.560112697	0.4126615001

Comparison on the floor plan and the view is done by comparing the variables that are considered important in the relationship between the plan and the front view.

Constant Value of C (Height of Head) and Value of H (Total Height)

Table 5

Value of C		Value of H	
Formula	Constant	Formula	Constant
A/C	0.21	H1/H	0.47
B/C	0.68	A/H	0.11
P/C	0.41	B/H	0.35
		C/H	0.52

In this table, the head height and total height measurements have not been obtained. So, from the measurements in the comparison temples, the average number of the comparison calculations can be obtained which then the results are used as a constant value to be used as a formula to find the height of the temple head and the total height of the temple from Kalasan Temple.

How to Get Value of C (Height of Head) and Value of H (Total Height)

Table 6

Value of C					Value of H				
Temple	Formula	Value	Constant (C)	Results	Temple	Formula	Value	onstant (C)	Results
Kalasan	B/C	13	0.68	19.11764706		H1/H	16.3	0.47	34.68085106

Temple	P/C	6.75	0.41	16.46341463	Kalasan	A/H	3.3	0.11	30
C				17.79053085		B/H	13	0.35	37.14285714
						C/H	17.79	0.52	34.21153846
					H				34.00881167

Then the value of the constant is entered into the formula. So, the results of the calculation are that the head height of the Kalasan Temple is 17.79 meters and the total height of the Kalasan Temple is 34 meters. With the same method, it can also be used for other temple buildings such as in Dieng below

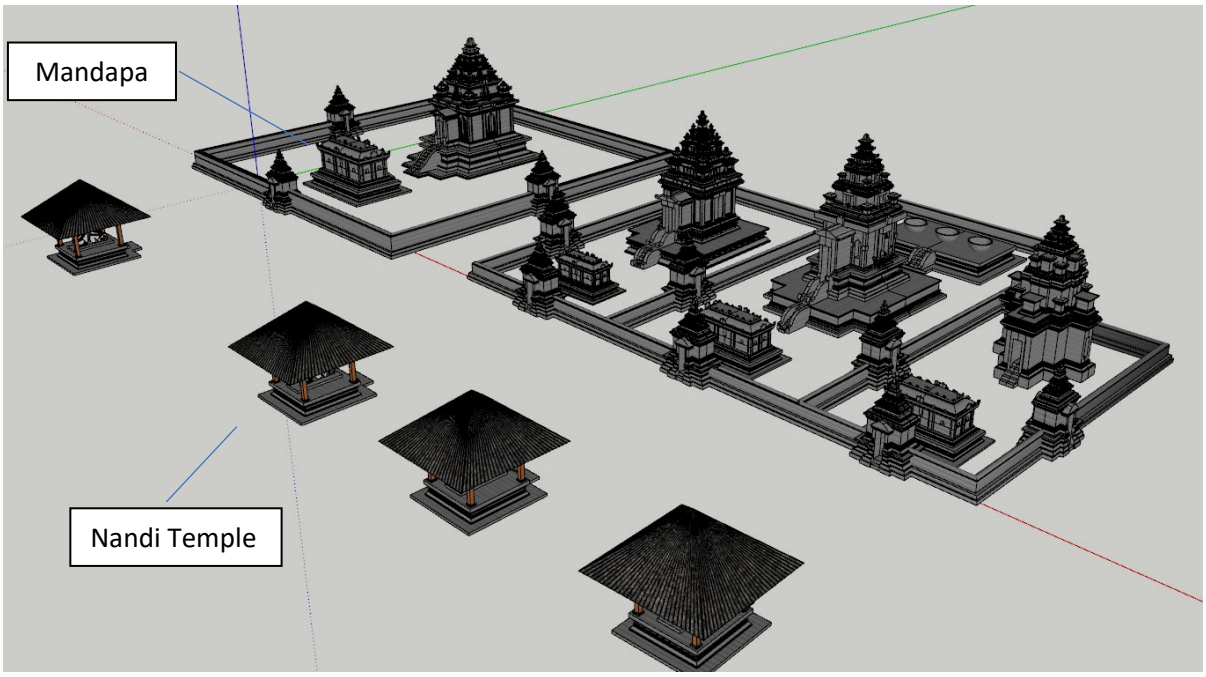


Fig 10. Dieng Virtual Reconstruction (Arjuna Cluster) with the same method [24]

V. CONCLUSION

In the reconstruction that has been carried out, there are important conclusions that can be drawn, namely: the use of wooden construction in the buildings of the Ancient Mataram or Pre-Ancient Mataram-Kalingga era does not reflect primitive but advanced technology, because it can be recognized through its traces, such as the use of square columns, not just circular ones. The processing of wood into square columns or thin boards is of course supported by adequate craftsmanship technology, such as building a boat. This woodworking technique also developed to produce large and multi-storey buildings, such as multi-storey roofs or *Meru*. This can be seen in the description of the temple reliefs, the remains of artifacts and in Chinese sources of reference. It is also undeniable that this developing technology must have had contact with foreign countries such as China and India. For example, *Meru* is a type of roof that is identified with sacred buildings of Hindu worship in Indonesia. If examined further, *Meru* is a form that may have arises from the influence of Buddha through China, as its manifestation can be found in pagodas and *chattra* elements in stupas in China. The discoveries of ceramic jars from the Tang Dynasty, such as the Liyangan Site, can indicate that the ancient Mataram Kingdomat that time already had a relationship with China. Therefore, it is highly likely that the shape of the *Meru* that existed in the ancient Mataram era until now (Bali), is the influence of Buddhist architecture that entered through China (pagodas and *chattras*), but its embodiment was still processed with a "local genius" approach. The feature that stands out in the stone construction is the tectonics of the use of the corbel space in the roof of the temple which is increasingly rising from the Dieng era to Prambanan. This requires adequate technology to create elevated and layered constructions like Prambanan. Corbel steps and rises in the form of a triangle form a peculiarity in the

architecture of temples in the archipelago because at the same time this system was not yet known in India, especially South India which still employed the post-lintel system. On the other hand, the development of this cone-corbel resulted in a dome-shaped architecture like the roof of the Kalasan stupa. This domed stupa containing space or room inside has only been known on the island of Java while in India no traces of it other than the post lintel can be found originating from the same era.The phenomenon of Postmodernism nowadays provides an opportunity for freedom to explore sources of design inspiration that present an identity/character, such as the spirit of localism and regionalism. Through this Virtual Reconstruction, the development of distinctive properties can be explored through the architectural aspect that refers to the locale. This locality cannot be separated from the historical and socio-cultural factors that underlie it. The virtual reconstruction carried out can support tourism based on the development of cultural heritage objects so that traces of their past forms can be recognized even though they are virtual.

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REFERENCES

[1] Herwindo R.P, Representasi Candi dalam Dinamika Arsitektur di Indonesia, Disertasi Doktor UNPAR, Bandung; 2011.

[2] Herwindo, RP, Eksistensi Candi sebagai Karya Agung Arsitektur Indonesia di Asia Tenggara, Yogyakarta, PT Kanisius, 2018.

[3] Landes, T; Heissler, M.; Koehl, M.; Benazzi, T.; Nivola, T, Uncertainty Visualization Approaches for 3D Models of Castles Restituted from Archaeological Knowledge. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W9;2019.

[4] Herwindo, RP, Virtual Reconstruction Dalem Agung Pakungwati Keraton Kasepuhan, Cirebon: Laporan Penelitian Balai Arkeologi Jawa Barat; 2019.

[5] Herwindo, R.P , Kajian Tipo-Morfologi Arsitektur Candi di Jawa, Thesis, Arsitektur Institut Teknologi Bandung, Bandung; 1999.

[6] Krathwohl, David R.;Methods of Educational & Social Science Research, An Integrated Approach. 2nd Ed.; Longman, New York;1998.

[7] Münster, Sander; Pfarr-Harfst, Mieke; Kuroczyński, Piotr; Ioannides, Marinos (eds), 3D Research Challenges in Cultural Heritage II: How to Manage Data and Knowledge Related to Interpretative Digital 3D Reconstructions of Cultural Heritage. Springer Verlag, 2016.

[8] De Vos, P.J.; De Rijk, M. J., Virtual Reconstruction of the Birthplace of Rembrandt van Rijn: From Historical Research Over 3D Modelling Towards Virtual Presentation. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XLII-2/W15; 2019.

[9] Vico, L.; Vassallo V, Methodologies and Techniques for the Reconstruction of Ancient Architectures in Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, CAA2010 F. Contreras, M. Farjas and F.J. Melero (eds.); 2010 .

[10] Eva Pietroni, D. F. Virtual Restoration and Virtual Reconstruction in Cultural Heritage: Terminology, Methodologies, Visual Representation Techniques and Cognitive Models. Information, 2021.

[11] Nawa, A, Kajian Tranformasi Arsitektur Kayu dari Era Mataram Kuno Sampai Majapahit. Bandung: Universitas Katolik Parahyangan, 2021

[12] Herwindo, R. P., & Richard, A. Kajian Arsitektural Percandian 'Kayu' pada Masa Klasik Tengah dan Muda di Jawa (Identifikasi). LPPM UNPAR. 2013.

[13] Harriyadi. Pertimbangan Pemilihan Lokasi Kompleks Candi Dieng. Jurnal Penelitian dan Pengembangan Arkeologi Vol. 37 No. 2., 2019

[14] Sanday, J. Building Conservation in Nepal : A Handbook of Principles and Techniques. Paris: UNESCO, 1978

[15] Acharya, Prasanna Kumar, Manasara Series Vol I-V, Oxford University Press, 1934

[16] Atmadi, Parmono, Some Architectural Design Principles of Temples in Java, Doctoral Dissertation, Gadjah Mada University, Yogyakarta; 1979.

[17] Prijotomo, Josef, Petungan: Sistem Ukuran dalam Arsitektur Jawa: UGM Press, Yogyakarta; 1995.

[18] Prijotomo, Josef, Prijotomo membenahi Arsitektur Nusantara: Wastu Lanas Grafika, Surabaya; 2018.

[19] Tjahjono, Gunawan, editor, Indonesian Heritage - Architecture, Editions Didier Millet, Singapore; 1998.
[20] Tjahjono, Gunawan, editor, Sejarah Kebudayaan Indonesia, Arsitektur, Raja Grafindo Perkasa, Jakarta, 2009.
[21] Setyawan, H, Penggambaran Arsitektur Berkonstruksi Kayu Abad ke 9-10 Masehi Pada Relief Karmawhibangga Candi Borobudur. Balai Konservasi Candi Borobudur, 2011
[22] Groeneveldt, W.P, Nusantara dalam Catatan Tionghoa, Jakarta, Komunitas Bambu, 2009
[23] Sugeng Riyanto, dkk Liangan : Mozaik Peradaban Mataram Kuno di Lereng Sindoro. Yogyakarta: Balai Arkeologi DIY, 2014
[24] Herwindo R.P, Josef Prijotomo, Nugrahani, Joe Nadia, Gavin Mika, Catharina G, Michael Steven, Marvel, Fabrian Gulla. Hasil Survey dan Analisis Riset Keilmuan Ristekdikti 2022.
[25] Herwindo, R. P., Astrina, I., & Saliya, Y. The Typology of The Balinese Meru Shape and The Roots of Its Development. Journal of Applied Environmental and Biological Sciences, 2016
[26] Gelebet, I. N., & dkk. Arsitektur Tradisional Daerah Bali. Denpasar: Departemen Pendidikan dan Kebudayaan Proyek Inventarisasi dan Dokumentasi Kebudayaan Daerah. 1985
[27] Ramos, Dinamika Penerapan Proporsi Pada Arsitektur Candi Tipe Menara Era Klasik Tua-Tengah-Muda Di Pulau Jawa. Bandung: Universitas Katolik Parahyangan, 2016.
[28] Degroot, Candi Space and Landscape: A Study on the Distribution, Orientation and Spatial Organization of Central Javanese Temple Remains, Doctoral Thesis, Leiden University; 2009.
[29] Santiko, Hariani, Dua Dinasti di Kerajaan Matarām Kuna: Tinjauan Prasasti Kalasan, 2013 Jurnal Sejarah dan Budaya, Vol 7, No 2, DOI: http://dx.doi.org/10.17977/sb.v7i2.4741
[30] https://bpcbdiy.kemdikbud.go.id/galeri-candi-kalasan (accessed March 2022)
[31] Soekmono. Pengantar Sejarah Kebudayaan Indonesia Jilid 2 . Yogyakarta: Kanisius. 1988
[32] Perdana, Aditya, Bayu, Kajian Relasi Arsitektural Candi Hindu Era Mataram Kuno dalam Kaitannya dengan Vāstuśāstra, 2020 Jurnal Riset Arsitektur (RISA) 4 (3): 234-251 ; https://doi.org/10.26593/risa.v4i03.3930.234-251 (accessed March 2022)
[33] Tuyu, M. A. dan Rahadhian P. Herwindo, Relation of Typomorphology of Hindu and Buddhist Temples in the Ancient Metiram. Bandung: 2021, Jurnal RISA (Riset Arsitektur)
[34] Clarissa, Kajian Relasi Arsitektur Kuil Buddha Mataram Sailendra dengan Konsep Mahayana, Vajrayana, dan Kitab Manasara Ditinjau dari Sosok, Ornamentasi, Tata Massa dan Ruang, 2021, Jurnal Riset Arsitektur (RISA) 5 (1) : 1-17; https://doi.org/10.26593/risa.v5i01.4414.1-17 (accessed March 2022)