UMA SUMBA: CONSTRUCTIONAL ADAPTATION TO EARTHQUAKE AND MORPHOLOGICAL RELATION WITH PAPUA AND TIMOR LESTE

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ABSTRACT

This paper presents the process of erecting a Sumba uma, a Sumba architecture, taking place at the time of reconstruction of the traditional building. The process of reconstruction was meticulously documented, every step taken was documented. On this documentation a study was done, the examination on the types of wood construction was carried out, as well as its adaptability around the location of Sumba island in the ring of fire. This study and examination utilizing a qualitative method is carried out in order to find out whether there is any prior building possessing similar shape as Sumba building in architecture in the Archipelago (Nusantara), especially architecture in eastern part of Nusantara. From this study it was found that the construction of this traditional house utilizes a sway construction which was found to be very adaptive to earthquake, a frequent natural phenomenon on the islands located in the ring of fire. It was also found that the shape of Sumba uma architecture has a morphological correspondence with architecture in southern part of Papua and in Timor Leste.

Keywords: *Nusantara Architecture, Sumba Architecture, earthquake resistance, sway construction, morphology*

INTRODUCTION

Knowledge on Nusantara architecture is indeed still very limited, especially compared to knowledge on traditional architecture. Knowledge on raditional architecture, which forms part of knowledge in the field of culture, is distinct from knowledge on Nusantara architecture which is located in the discipline of architecture (Prijotomo, 2019). This reality could be shown in the case of Sumba architecture. There are no small numbers of research report and writing about Sumba architecture, including reports and papers prepared by reserachers and bachelors of architecture. However, under careful examination all of them are found to be under the discipline of cultural studies, within the discipline called architectural anthropology by Roxanne Waterson (Waterson, 1990).

One of the clues of the fundamental differences between the two disciplines lies in the structural system and architectural construction. For example, in the case of Sumba architecture, in the review of traditional Sumba architecture there is almost no discussion about the contruction of the building. The technical drawings presented tend to provide non-architectural sketch images; the photographes presented are dominated by cultural studies. Structural system and construction of a building is one of the prerequisites on the firmness in architecture. Therefore, the limited attention given to this prerequisite can naturally be undertood, since this is not required in the studies of culture. If we limit our discussion only in the field of Sumba architecture, in the year 2012 and 2013 in Sumba Barat Daya (Southwestern Sumba) a rare architectural event was held, that is the construction of a traditional house of Sumba in Ratenggaro village and Wainyapu village (Fig.1).

Figure 1. *Uma Sumba in Wainyapu (author's collection)*

The construction process in each village lasted up to four months. This construction process can entirely be followed because there were students in architecture who were doing 'live-in' program for the whole four months and also four professors taking part as resource persons These professors are from diverse diciplines, thereupon each can contribute their own views, thoughts, and opinions. Although, there are plentiful photograph documentation on this process, unfortunately they are still underutilized for generating and developing of knowledge on Nusantara architecture. As a Nusantara architectural piece produced by community with verbal tradition according to Claude Levi-Strauss (undated), who does not express their views and thoughts in writing, the construction process can actually be utilized to find out and confirm whether the knowledge on structure and construction found in the discipline of architecture can also be mastered by community with verbal tradition. In other words, the process of erecting the building is in reality the aplication of knowledge on structural system and construction that they master, especially on timber construction. Fitting together of pieces of timber naturally is carried out with consideration of technical and mechanical engineering principles, notably in relation to the generating, imposition, and transfer of loads.

The structure system and building construction put emphasis on the knowledge on designing the structural system and construction. Mario Salvadori in 1960s has generated the knowledge of structure and construction in his book Structure in Architecture (Salvadori, 1975). This book which highlights the theory on structure no longer talks about buildings classified as simple building and timber structures, albeit the theory and knowledge on structure and construction also apply in simple buildings. In a more practical presentation, Edward Allen offered in the 1980s How Buildings Work. Both, Salvadori and Allen, did not say that any of the principles of structural system described are practiced since prehistoric time. The existence of the truss system itself, for example, was just mentioned after the middle age, but the system itself has been used long before that. The system has been applied and utilized in the buildings and objects which were considered to be outside of the realm of architecture, such as stated by Nikolaus Pevsner, "Lincoln Cathedral is architecture, bicycle shed is building". In this book Allen gives attention to 'simple' buildings. As the title of the book, his presentation on the structural system and construction is done by informing that the configuration of the pieces fitted in the building refers to the structural system and construction of truss, the structural system of load bearing section.

In the study of architectural theory, we can find a study on 'simple' building. The theory of Gottfried Semper, for instance, states that the existence of two structural systems, that is, the framed construction (tectonics) and load bearing wall construction (stereo-tomy) (Semper, 1989). This is because Semper takes the case of simple buildings which are very different from buildings in Nusantara environment (Semper proposes buildings without space under the floor, meanwhile Nusantara buildings are with space under the floor; Semper uses walls filling the frame construction as an obligatory building element, but in Nusantara wall is not obligatory). A very important part of Semper's theory is the point of view he employs. In his theory, Semper has a concept of wall bearing and of frame-construction; this theory is supported, according to Semper, by the existence of simple buildings. Hence, buildings are used as the proofs of the theory being constructed. The problem which arises now, whether the thinking about the truss-structure also in the mind of the community of that 'simple' building? The answer to that question is not easily obtained, considering that the said community is a community with verbal tradition, it does not use writing to express its thoughts. Here, challenges arise in connection to the process of building construction in

Sumba. If we can follow the process of fitting and erecting the frame construction, can we use the occasion to express and articulate the thinking of the verbal tradition community about the structural construction of its building? The process of constructing and erecting of Sumba architecture is made into a case to estimate the knowledge on firmness which is owneded by Sumba community.

From this stage then, it can be demonstrated that verbal community also possesses knowledge on construction structure found in written community, and not to be called as having tacit knowledge. This shows that in the building construction field among the verbal communities, we can find knowledge 'owned' by written communities.

METHODS

The documentation of the process of erecting Sumba building is made as the starting point of this study. At the beginning, a familiarization of the order of erecting and fitting of parts until all the building frame is fitted. The order of fitting is analysed from every step of the fitting; every load imposed and transfered is expresessed. It is very probable that in certain step loading behavior is found (receiving load, transferring dead load and applied load). Next, to examine the whole building frame fitted on the types of construction and structural system utilized. At the stage of examining the exertion of loads, the conformity of the theory and the practice on the structure and construction is forming the main reference. In speculating the precedents of uma Sumba, a comparison of formal characteristics of a number of architecture outside Sumba is examined in their resemblances.

3. RESULTS AND DISCUSSION

Components of the building

Uma Sumba can be divided into three components of spatial section. The first component, which I call the core, is the part of building which consists of the main poles and all building parts above it, mainly the vertical part of the roof. The second component is part of uma that can be said as the extention of the core. This part can be called as the extention component, marked by the plate of the roof which shows strong horizontal character to its facade. This roof plate on its upper part is tied to the bottom part of overhang of the vertical roof of the core, and its lower part is sits on the *patenga ripi* (secondary beam), a beam that is sitting on *pongga ripi* (secondary poles, peripheral poles) that goes around the building. The third component is the deck component, that is the part of uma Sumba which forms the floor with space underneath and surrounds the four main poles of the building. This component is completely covered by the horizontal roof and not united with all the poles of the building; hence this component is a *free standing* component. With these three components, *uma* Sumba shows that the core component and the extension component are parts of the building whose structure and construction are still related, marked by the joining of the vertical roof slabs with the horizontal roof plates that are owned by each respective component. The deck component, as said earlier, is completely free standing structures.

The construction of *uma* Sumba may be called as basic construction assemblage. All poles *(pongga bokolo*, main poles, and *pongga ripi*, secondary poles) are simply planted around 80-100 cm into the ground. The result is the poles are strictly become part of the ground; every movement, such as earthquake, will only makes the poles fully follow the earthquake. By allowing the tips of the poles are costumized in a concave form, horizontal logs may fully sit upon this concavity. A two- to four-layered beam then placed upon this lower beam. All beams are composed as heap beam with no single joints is inserted. Since no joints are there, every single force and movement (e.g. earthquake) will instantly responded by swaying of the whole beams. The weight of the beams is a very significant factor that reduces the sway. To avoid excessive movement of the heap beam, a long peg is added at each corner of the top beam and going through its underneath beam. The reduction of movement is also contributed by the weight of the vertical roof. The structure of the roof is of bamboo so it does not give any contribution in responding to the movement. Additional parts of the roof are undoubtedly contributing, due to its self-weight. Layers of *alang-alang* (thatch) are the roof covering that becomes heavy because of the height that may more than five meters. The bamboo roof skeleton is tied to the top heap beam. The bottom part of this vertical roof is forming an overhang as long as the bottom part of the heap beam. This overhang is very purposeful to the whole structure of uma Sumba (Fig.2).

Figure 2. *The core component of Uma Sumba (Antar, 2017)*

Tied into the lowest tip of roof overhang are extended roof, characterized by its horizontality. This extended roof is simply a construction of the same bamboo construction and *alang-alang* of vertical roof. If the upper part of this extended roof is tied to the vertical roof, its lower part is rest freely upon *patenga bokolo* (horizontal beam) that sits on *patenga ripi* (secondary poles). This horizontal roof (part of the extended component of *uma* Sumba) plays an important role, particularly to earthquake. Since this extended roof is tied to the vertical roof, it becomes the part who hold the vertical roof in responding the earthquake (sway and vibration).

Standing freely from the core component and secondary component is the deck component. Here, a structure of poles and beams are surrounding the *pongga bokolo* (core poles) but do not touch the *pongga ripi* (secondary poles). The poles are dug into the ground and the beams are simply sit on those poles. A structure of floor made of bamboo becomes the costumary space who is fully free from structural affairs in cor and additional components.

Analysis of Core Component, the sway construction

The core component consists of poles which are implanted to the ground. This makes all the poles to be united as one and fixedly embedded to the ground. The implanted poles make every single pole to be the continuation of the ground, especially when the ground experiences shake and sways. The embedded poles make the connection between poles and the ground as a static connection in which every movement of the ground will be followed by the movement of the poles. The poles which experience shakes and sways will not collapse because they are well locked to the ground.

Contrary to the connection between the poles and the ground, the connection between the poles, all beams and all parts above are in very loose relation. All the beams and all elements on the beams are building elements that are completely just resting on the pole which its tip was in concave shape. Most of the beams in the building are just sit on the elements under them. There are neither tie nor any connection present in the heap connection of the beams. As a consequence, the shakes and sways happen to the poles of the building are responded elastically by the composition of beams, by experiencing sway, following the rythm of shakes and sways of the poles of the building (Herwindo, 2019).

Along with this *sway* movement all parts above the poles are hindered from collapse caused by the shakes and sways. Subsequently, the dead load weight of the roof plate and of the beams have an important role, that is to exert loads to the beam to reduce the magnitude of the shakes and sways of the beams. If there is dislocation of the beam, the part of the roof and the floor will not be destroyed, but simply slide (Fig.3).

Figure 3. *The core component of Uma Sumba, the sway construction (Kosasih, 2009)*

Re-examination has not been carried out as to why the poles are tied to the ground, producing a fixed connection. Certainly, the connection of the pole and the beams which consists of beams resting freely on the poles has become an intelligent solution for situations of earthquake and volcanic eruption. As we know Sumba is located in the area of ring of fire frequented with earthquake and volcanic eruption.

Analysis of Precedent

Uma Sumba takes the form of an architecture which is characteristic of the Nusa Tenggara Timur and also of Indonesia. The form which connecting the vertical roof and the horizontal roof is its main character. The search in all architectural forms in Indonesia shows a relationship in the formal form between Sumba architecture and architecture in Papua and Timor Leste. The most distinct relation is the main poles of each building which form the most dominant poles in its height. The dominance of the main poles is not readily apparent in Uma Sumba because the main poles are hidden behind the facade of the building which has a horinzontal characteristic. In papua and timor Leste, the main poles are very apparent and not hidden.

A tree house and a tall house of Papua (Fig.4) firmly converting trees as the main poles of a dwelling. Here, the trees which are occupied by the building are living trees. At times the building is almost all covered and hidden behind the foliage of the trees. The trees grown on the ground are completely tied to the ground; every shakes of the ground will automatically have followed by the movements of the said trees. Just like in uma Sumba, the building constructed on top of the trees is made completely to sit, or rest, on the trunk of the living trees. The beamswhich are heaped also fitted with tying to the uppermost beam; then all elements of the building are fitted, such as the floor beams, sagu trunk as the floor, post for supporting the roof, roof frame which rest on the roof supporting poles, and the plate of roof covering. All connections in the building construction are fasten by tie technique using rattan.

Figure 4. *left-tree house https://id.pinterest.com/pin/777011741942607342/; right-tall house https://id.pinterest.com/pin/27689970826763710/, both in Papua*

If a tree house is using the trunks of living trees as its supporting poles, then a tall house is using dead trees as its main poles. In some places, it was found that tall houses are utilizing poles made of cut tree trunks in different sizes. The size of a tall house can be larger than the size of a tree house. If The juxtaposition of a tree house and a tall house, shows that a tall house has undergone fundamental changes. At the time it still is a tree house, the location of the trees serves as the deteminant of the presence of the house on the tree top. It is different witha tall house. Since the poles of the building are not necessarily trees, the poles can be implanted anywhere, at any spot considered suitable by the dwellers. Architecture is no longer controlled and determined by the place (of the trees). It is an important factor of the tall trees to spread to wider areas; tall houses dan be erected at any spot desired. The potentiality of proliferating of the tall house supports the speculation of is spread to Timor Leste and Uma Sumba.

Timor Leste house (Fig.5) is a shape that is not very different from a tree house, or even better, a tall house. The house has a rectangular floor plan having a strong characteristic of vertical appearance. The works on the building seems to be very *advanced* as shown by the dominant character of rectangular shape, leaving only some poles in round shape and some round beams. The building clearly appears dressed up with accessories on the upper part of the roof. The walls of the space are from timber board. Its four round main poles are implanted to the ground. The round poles and rectangle beams remind us of the configuration of beams in Uma Sumba. Using heaping technique for the beams, the role of the heaped beams in response to the vibrations and sways generated by the poles are optimized. Therefore, the building is spared from severe damage caused by the shakes and sways. Juxtaposed with a tall house, Timor Leste house is a transfromation of a tall house, which put emphasis on accuracy and neatness of architectural appearance, marked by the utilization of a more accurate geometry. From the changes of a tall house to Timor Leste house, one can see how a Timor Leste House formal transfomation taking place, transformation that happens in the scope of shapes.

A tall house seems to transform not only to beceome Timor Leste house but also undergoing transformation to become Uma Sumba. If we direct our attention to the core component of Umah Sumba, we can clearly discern some striking similarities. The form of these three buildings do not have obvious difference. They are different in the tectonical workings of the Timor Leste house and Uma Sumba. Uma Sumba places a roof with a roof space as a part that rest on the heaped beams. In tall hose and Timor Leste house, the part above the poles are used as dwelling space.

Figure 5. Timor Leste House
(left https://id.pinterest.com/pin/99219998021130963/)
and right: Bent poles of an Uma Sumba ruin (Kosasih, 2009)

Uma Sumba presents itself with its own specific characters. The building is present with combination of harmony between vertical and horizontal characteristics. By dividing Uma Sumba into three distinctive components — core, extention, and deck — we can understand the reliability of Uma Sumba in responding to earthquake in particular; we can also understand that there are formal and spatial transformation in the direction of the existence of Uma Sumba. The process of formal transformation is from a tree house to a tall house to Uma

Sumba; while the spatial transformation specifically is from Timor Leste house to Uma Sumba. Furthermore, although in the case of the response to earthquake show similar workings from all architectures in question, it is not so in spatial composition. A Timor Leste house locates the dwelling at the top of the poles, and the deck as a porch under the dwelling; but it is not so with Uma Sumba. In Uma Sumba, the upper part of the building is a sacred space, and the living quarter is on the lower space at the deck component.

Putting aside the various locations of each architecture that spans from Papua to Timor Leste to Sumba, the architecture in Nusantara region is capable to demonstrate their connectedness and relatedness among these architectures which are located in places far away from each other, and which have not been given due attention because so far we put each architecture as an isolationistic unit, namely an architecture which considers that only itself exists as architecture. By setting aside the location of each architecture that stretches from Papua to Timor Leste and Sumba, the architecture in the Archipelago is able to show the connections and connections that occur from distant architectures, which so far have been given less attention because they place each architecture as an isolationistic unity, namely architecture which presupposes that only itself exists as architecture (Nuryanto, 2019).

CONCLUSION

From the process of constructing the building frame of Uma Sumba, it be as certain that

1. The fitting of one piece of timber to another only uses the technique of [a] heap and [b] tie. The only exception is in the fitting of two pieces of ngandingingo (roof-base beam) using a peg which cuts through both pieces of that lies on top of each other. The mortise-joint connection was not found. Eventhough the building only uses heap and tie techniques, it is able to withstand the forces of strong wind blowing from the Indian ocean, as well as the shakes and sways of earthquake.

2. Using the fitting technique that only requires basic reliability to ensure the strength in the connection or fitting, then the dead load weight of the building most likely is given a significant role in producing this earthquake and wind resistant building. The ability to have its own dead load weight to withstand the forces of wind and earthquake is shown among others ini the knot of alang-alang grass (thatch) as big as two bundles. The unit of bundle is employed because the installation of alang-alang as roof cover is done by tossing bundles of alang-alang from below to the roof. The use of the roof frame is not adequate when viewed from the point of view of the dead load weight of the frame; the use of timber as building material certainly will increase the the dead load weight of the building,

but that was not done. Deflection force which refers to high flexibility, maybe the reason for the use of bamboo.

3. The use of timber is dominated by logs. Only the base of the roof frame uses rectangular beams. It is highly probable that the use of rectangular beams is a recent development. What is certain is that the logs are maintained as they are, because a saw is not employed due to the preference in keeping the logs as memory of the past. The utilization of not-straight pieces of wood, bent pole in particular, may also be the reason why rectangular poles are not a priority.

4. Acknowledgement of customary law (*adat* law) shed light to sustainability in building materials since the local tribe has the liberty to manage their local forest. Wooda and bamboos may be transported kilometers away from the site

5. The work of erecting the building does not require tools and equipments of advanced technology. The process of erecting uma building can be carried out by using a mere machete. Next, by examining the techniques in fitting, it can be said that constructing uma building does not need a highly skilled expert. Therefore, the concept of an expert in building who is a specialist in constructing a building is not known. In fact, a building can be erected by using the principle of DIY (do it yourself). The use of large size and heavy building materials necessitates numerous manpower. The construction and building of uma is the work of a community, not a private work.

6. The construction system and process of uma Sumba represents the similar process and system of Nusatenggara Timur architecture in particular, and possibly in eastern part of Indonesia in general.

7. Sustainability is preserved and resiliency is maintained. The ease in construction, the use of tools in very small numbers (so that everybody may do the work), the commitment to community work, are keys to sustainability and resiliency.

8. From morphological point of view, the presence of Uma Sumba demonstrates a morphological connection between it and the tree house and the tall house of Papua as well as the Timor Leste house.

ACKNOWLEDGEMENT

The author wishes to thank various people of Faculty of Engineering, Architecture Department, and LPPM Universitas Katolik Parahyangan (Unpar), Bandung, Indonesia, for their valuable technical support on this research project.

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