LivaS: International Journal on Livable Space
Vol. 02, No. 1, February 2017 : 15-24 ISSN : 2548-7515 (online)
Doi: http://dx.doi.org/10.25105/livas.v2i1.3834

LOCAL WISDOM OF STRUCTURE AND BUILDING SYSTEM TRADITIONAL ARCHITECTURE IN RESPONDING TO NATURE

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ABSTRACT

Traditional architecture was built on a tradition inherited from one generation to the next. As a country which has hundreds of tribes, Indonesia has hundreds of traditional architecture designed by the ancestors to fulfill the function as well as responding to natural context. The aim of this research is to find out how the structural and building system traditional architecture in this country respond its natural conditions as the context. The method used is qualitative descriptive with the analysis of some traditional architecture which have been visited and conducted a theory review. The results showed that the traditional architecture in Indonesia had been designed to respond to nature as context. From the discussion, it can be concluded that traditional architecture in each region has an approach in aligning themselves with nature as context.

Keywords: *Local wisdom, traditional architecture, earthquake, climate, context.*

INTRODUCTION

Indonesia is an archipelago which has a very diverse geography. Geographic conditions in Indonesia produces natural conditions which are different from one another, including culture, and ethnicity. According to Ronald (2002:5) there are more than three hundred tribes in Indonesia which can be further divided into several customs, which each of them has its own house and bring Indonesia as a country which has hundreds of diverse customary houses. On the other hand, Mangunwijaya (1992) said that the concept of architecture of the archipelago is the adjustment and the tunings with nature.

The diversity of geographic condition, culture and social backgrounds produces diversity of architecture in Indonesia. Natural and cultural richness brought architectural diversity of this country. The land that stretches from west to east has a variety of traditional architecture, with its diversity in shape and structure system. Differences in geographical conditions produce different designs in response to site conditions. As the site conditions, climatic and environmental conditions play a role in providing a diversity of architecture in the archipelago because of traditional architecture has a role in responding the nature and the environment.

This study aims to find out how the traditional architecture in Indonesia

responds its natural conditions as the context through building structure structures and building systems design. In order to achieve these objectives, qualitative research methods had been used. Meanwhile, to enrich the data and the analysis, some previous field observations, brief interviews, and literature review were also employed. In the field observations, visual condition data were collected using a camera to record the traditional architecture conditions including its structure and building systems. The analysis is done by comparing the data obtained in the field with a literature study to get a conclusion.

LITERATURE REVIEW

Traditional houses in Indonesia were built by the ancestors of Indonesia, also noticed the natural environment as a context. And behold how each of the building work is an attempt to bring the Universe (Mangunwijaya, 1992). Traditional architecture designed by the ancestors of Indonesia to respond to its context and resolved by utilizing local potential. This explains how humans try to establish a relationship with nature and create harmony in presenting the building or architectural work. According to Lechner (2015), the reasons of differences in the architectural design of each region are a response to the climate. Design buildings in hot and dry areas will be different when compared to the hot and humid regions. This affects the design of the roof and openings in order to response natural light and thermal comfort. Rudofsky (1965:1) describes vernacular architecture as "architecture without architects". In other words Rudofsky want to show that vernacular architecture is not influenced by trends or particular style but oriented to the needs and potential of nature as the context. It can be concluded that the local wisdom of our ancestors is wisdom in dealing with nature as context resulting architectural design that can address the needs of the building and in harmony with nature.

DISCUSSION

There are four basic elements of a building; building structure, building systems, building services, and building management (So and Chan, 1999). Building services and building Management are two elements of buildings that are more common in modern buildings. Meanwhile, traditional building has been considering the structure and building systems in its architectural design. Based on these considerations, the discussion in this paper will be limited to study of the structural and building systems that are used by some of the traditional architecture in Indonesia. The selection of cases is done by considering the

geographical conditions where the traditional architecture is located. Some traditional architecture located in islands which are prone to earthquakes such as Nias Island, Java Island and Sulawesi Islands (as shown by Figure 1.) have been chosen. Meanwhile, to analyze the system of the building, some of traditional architecture that consider natural ventilation and natural lighting systems in its design have been selected as a case study.

1.1. Responding to Earthquake

Indonesia is a country which is prone to natural disasters because it is located around of the ring of fire (Wijayanto, 2016).This condition makes Indonesia is prone to earthquakes, especially for islands located in the ring of fire. Figure 1 shows the earthquake zone map indicating areas in Indonesia, which is prone to earthquakes. Sumatra (especially Nias Island), Java Island and Sulawesi Island are vulnerable to earthquakes. Therefore, traditional architecture that is located in these areas has been chosen as a case study.

Although they were situated in locations that are vulnerable to earthquakes, the traditional architecture of those areas has capability to respond the earthquake impact through their design approach. Our ancestors have responded to these conditions by the design approach of their traditional architecture, especially traditional houses that are geographically situated on the ring of fire. For instance, how is a traditional house solving the problems caused by earthquakes? Field observations showed that Nias traditional house is located on the south side of the island of Sumatra; it is also called as Omo Hada. This house has some diagonal column known (called as V-Shape) and play a role as a structure system to resist lateral forces caused by the earthquake. V-Shape structure system is able to withstand lateral forces during an earthquake occurs so that the building can remain stable. The connection between the columns and beams are not using nails, causing buildings can be moved dynamically to the rhythm of the earthquake. Meanwhile, according to Pudjisuryadi, et. al. (2007), Nias traditional houses (Omo Hada) were able to resist an earthquake measuring 8.7 on the Richter scale without any damage, while modern buildings are located in the same area have collapsed. Results of research conducted by Pudjisuryadi, et. al. (2007) showed that Omo hada has a very stable structure system. The foundation system as a base isolation has ability to reduce the internal forces as well.

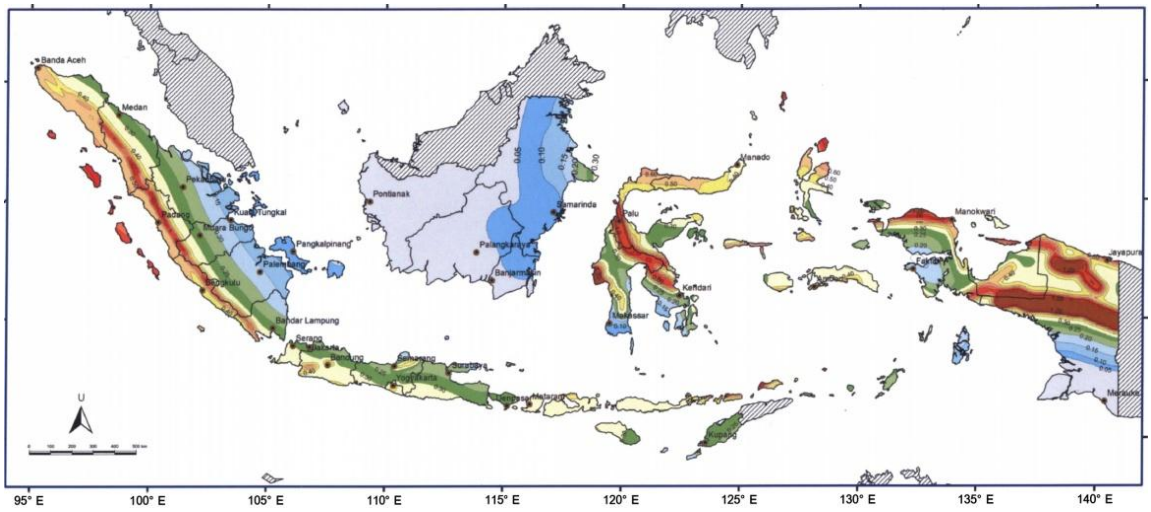

Figure 1. Indonesian Earthquake Zoning Map.
(Source: http://www.pu.go.id)

Besides the Nias Island, Java Island also has the risk of earthquake. Therefore, the traditional architecture in Java Island is one of the works of architecture that responds earthquake through its structural design. Prihatmaji (2007) in his research found that the structure of the Java traditional house (called Joglo) is capable to withstand earthquake forces zone 3. The structural factors of this traditional house has capability to withstand vibration earthquake forces through a ductility of soko guru (main vertical structure system) wood, construction quality of the connection, and the proportion of the length-width-height rong-rongan. Prihatmaji also recommends that the use of traditional Javanese house at present considered to be safe, if the system pedestal made flops, because 3-dimensional skeletal structure and the loading system is able to cope with earthquake force vibration in the seismic zone 3. His research also shows that local knowledge of our ancestors is a problem solving in responding to earthquakes. The design approach they have done has resulted in the design of buildings that can respond to lateral forces are generated.

On Sulawesi Island, one of the most famous and very unique traditional architecture on this island is Tongkonan. This traditional house of Toraja people has an interesting shape with its soaring roof. The main building material is wood, while the roof cover material used either bamboo or stone. Toraja is located in an earthquake prone area so that the shape, material and structural system of the Tongkonan is designed to respond to these conditions. The system structure has similarities with other traditional houses in Indonesia, especially traditional Batak house.

Meanwhile, in responding to the force caused by the earthquake, Tongkonan,

responds with different local materials. According to Sir (2015), the structural elements Tongkonan house standing freely, so that the building will remain stable when withstand lateral forces that occur despite the load of the building is very large. The shear stress on the ground will work flexibly, thus creating equilibrium as a result of a reaction equal to the action. Figure 3 shows how load of Tongkonan is distributed to the ground.

Most Tongkonan houses use bamboo as its roof material. However, one type of Tongkonan house use stones as its roof material (Figure 4). This local material tied up using bamboo skin on a roof structure so as not to fall during earthquakes. When an earthquake is happening roof covering material will move following the earthquake forces and re-stabilized after the shaking stops (Manurung, 2011). This type of Tongkonan is also known as Stone Tongkonan because the house uses stones as its roof covering materials. The stone material used as the roof cover has a dimension of 60x40 cm with a thickness of 2 cm. The results of interviews with the residents of the Stone Tongkonan house indicated that the house may have more than a hundred years old. Although superbly over a hundred years old, material and structure of the building is still in very good condition. Figure 3 shows the connection system of stone material with the roof frame. Connective connection used causing the roofs of buildings to survive during an earthquake.

Figure 2. V-Shape structure system is a structural respond to lateral load caused by earthquake.
(Source: Manurung, 2012)

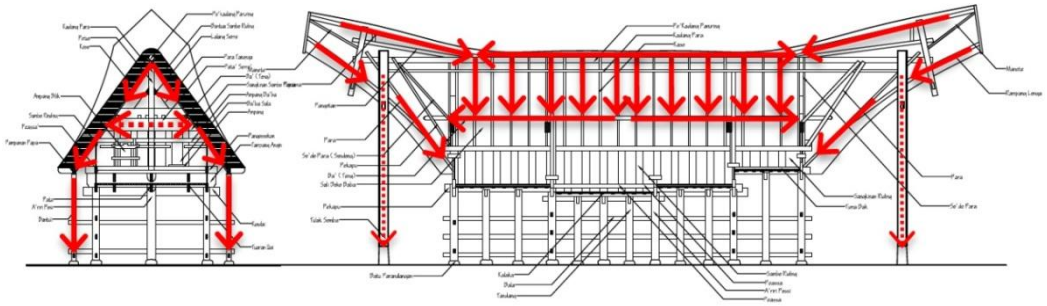

Figure 3. Load distribution on Tongkonan house .
(Source: Sir. 2015)

Figure 4.Stone as roof material on Tongkonan House
(Source: Manurung, 2011)

1.2. Responding to Climate

Indonesia is a country that has a humid tropical climate. In tropical countries, temperature and humidity becomes a problem in the architectural design process, as mentioned by So and Chan (1999), external temperature can be around 35 degrees Celsius with humidity ranging from 90% to 100%. Furthermore, they said that too hot or too cold temperature can be dangerous to human life; it shows that human thermal comfort becomes an important things that must be considered in any design process.

In the beginning of the design process, the local climate should be considered to produce the design which is energy conscious and efficient in energy use (Iyendo, et.al. 2016). A research conducted by Iyendo, et.al. indicated that on both the vernacular and contemporary building showed that the

design of vernacular buildings more sustainable than modern buildings. As a country that is located below the equator, Indonesia has a hot humid climate. Every region in Indonesia has related differences in climate and humidity levels. Climatic conditions responded in different ways by our ancestors in producing traditional architectural design in Indonesia. As Lechner (2015) said, in hot and dry climates, window size is smaller so that the hot air does not get into the building, while in the heat and humid climates size of the window is larger. In hot and dry areas flat roofs shape is relevant due for low levels of rainfall in this area, the opposite occurs in hot and humid area (Figure 5)

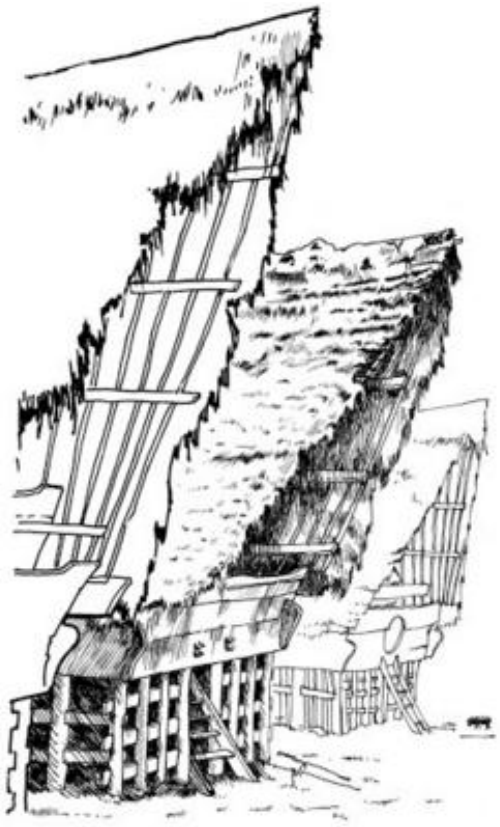

Figure 5. Traditional house in North Sumatera
(Source: Lechner, 2015)

Research on the influence of traditional roof shape in Central Java (Purwanto, et.al., 2006) found that the roof shape the which has no air circulation in the roof, contributing the heat in the room below, which affect the thermal comfort. The main Limasan roof modifications are widely used in modern buildings. However, without an effort to provide good air circulation, will reduce the performance of the building itself. The result of this study indicates that the local wisdom of our ancestors in designing their house is done by considering the environmental context. Roofs and openings design take into account the

surrounding conditions so as to answer the needs of thermal comfort of the building. Whereas the modifications made by modern buildings do not consider the environmental conditions as the context.

According to Lippsmeier (1984) building orientation towards sun and wind, and the shape and construction as well as the selection of appropriate materials, can create a good room temperature. In general, traditional architecture in Indonesia was designed with an orientation towards the sun, wind, and oriented to the mountains and the sea. These design considerations influence the thermal comfort in the building because of the direction of sunlight and air movement into the building. Tongkonan house in Toraja oriented north-facing so get the sun's light and heat stable the whole day. Alahudin (2012) mentioned that Tongkonan using bamboo roof (traditional) has room temperature lower than Tongkonan using metal roof (modern). This indicates that the local material has better performance in reducing heat caused by solar radiation.

High humidity levels responded wisely by ancestors to lift the building. Stilt houses as a typical traditional houses in the archipelago is an excellent solution, it separates building floor from the ground. The space created between the buildings and the ground allows the creation of air movement and provide comfort in buildings (Figure 6). In some traditional houses, the space created beneath the building functioned for various purposes and activities, either as pets or as a place for some activities. Magunwijaya (1992) mentioned that the stilt house or under house is really a high-quality problem-solving. It means. It means the completion of the ancestors to the climate issue and the humidity is an outstanding local wisdom in responding to natural as building context.

In order to providing thermal comfort and expel warm air, Nias home leave openings on the roof. This approach allows hot air to quickly leave the building and replaced by fresh air coming into a building through openings are provided along the front side of the building (Figure 2). This approach shows that our ancestors have excellent understanding about air flow, and know how to drain the lighter hot air through the top of the building as well as fresh air to enter through the walls of the building shell. On the other hand, in terms of the orientation of the building, some traditional houses in Indonesia are oriented towards the north so as to get a very good daylight quality. As Livingston (2014) said north side of the building will receive the most consistent light, easily controls light distribution, and reduces the risk of direct light.

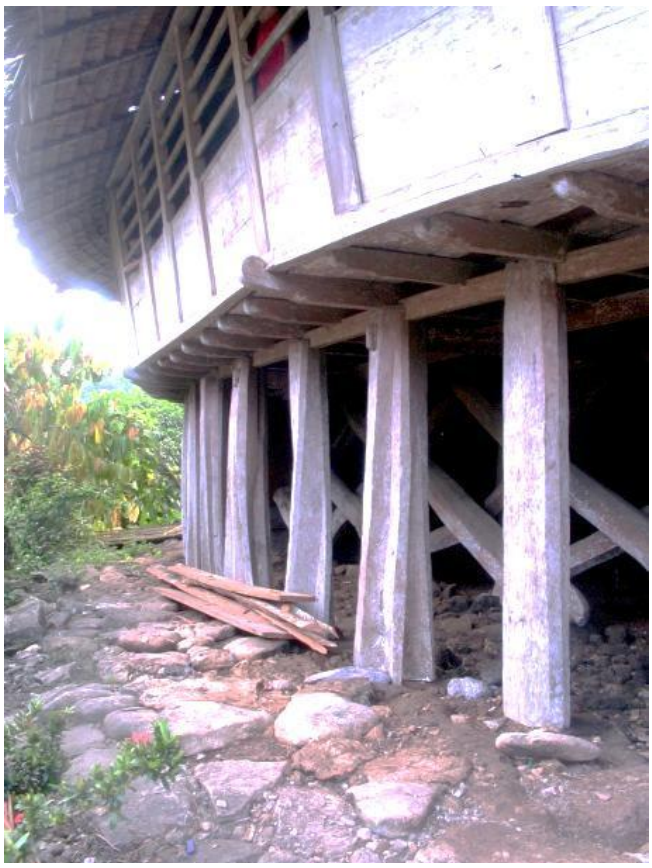

Figure 6. Stilt house is a problem solving for humidity.
(Source: Author)

CONCLUSION

Indonesian ancestor had designed their traditional houses considering building elements such as structural systems and building systems. Structural systems of the houses were designed as a response to the load that occurs, both the building loads and loads caused by earthquakes. Traditional building situated in the area of "ring of fire" has been designed with earthquake-resistant design approach; it is applied through the system structure, material selection, as well as the type of foundation used. Pedestals foundation system has been able to respond to lateral force caused by earthquakes.

In addition, our ancestors also have designed a traditional architecture with consideration of thermal comfort. This is done to respond to different climate in each area, a traditional house located in a hot area has dimensions larger openings than traditional home in the cooler areas. Opening at the top is designed to circulate the hot air out of the building, while the fresh air flow through the openings in the building shell. This shows that our ancestors had to have an understanding of the principles of thermal comfort and how to apply them in the design of their homes.

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