Microclimate and architectural tectonic: vernacular floating house resilience in Seberang Ulu 1, Palembang

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Abstract. This paper aims to describe the results of preliminary research on floating houses on the Musi River, Seberang Ulu 1, Palembang, focused on studying the influence of microclimates to the tectonics of Rumah Rakit (Floating House). The increase of water surface due to global warming will increase the need of using floating house typology in the future. The description of the inhabitants' experiences on applying technics to create vernacular floating houses is considered as significant knowledge to develop advance technology on the basis of local characteristic. Vernacular floating houses resilience consists of natural experiences of inhabitants in adapting their daily activities to the characteristic of local climate. By using qualitative approach, the Rumah Rakit inhabitants’ verbal information in this article becomes the main aspect in exploring local knowledge. At the end, the conceptual model of vernacular Rumah Rakit in Seberang Ulu 1, Palembang is formulated, in terms of building architectural tectonic that is closely related to the local climate characteristic. The knowledge can be utilized in the context of rehabilitation or preservation of such architectural objects that are their existences tend to be extinct at this time.

Keywords: floating house-Rumah Rakit, microclimates, building tectonic, vernacular architecture

1. Introduction
Theoretically, the house is a human response to the characteristics of climate, geography, topography and culture by using technology that is enriched by normative ritual and art. Today, humans face global climate change. The change is caused by the fluctuating increase of earth's surface heat that impact on the uncertainty of weather condition, the increasing of sea level and the occurrence of various natural disasters. It is predicted that the expansion of water area will occur in the next 100 years. The inward expansion will be going around 1-1.5 km towards the mainland. Therefore, the demand for floating settlements is possible increased in the future.

Architecturally, the above conditions are pose challenges to prepare various capabilities, especially in the development of structural technology and building construction. What to do right now is to learn from the occupants’ experiences of floating houses. The occupants inhabit the vernacular houses and survive for a long time by trial and errors. The occupants build their house based on the experiences of tackling local climate change without the use of high technology. By applying simple techniques, they can survive and solve the problem of the influence of microclimate fluctuations to form a reliable building system.

Some studies on the same location have been conducted by other researchers. They concern on the phenomenological study of floating house transformation in relation to the history of the existence of...
Chinese in Palembang [1]. The study of floating house forms on its structure and construction concerned more on the study of the relation of Chinese architectural proportion principles to traditional floating house in Palembang by using deductive analysis [3], [6]. While researcher [2] try to explore the potential of Rumah Rakit as tourism object. The research conducted by [7] contributes to enrich the insight of vernacular waterfront house related to microclimate characteristic.

Related to the topic of writing, the important key words that should be comprehended are vernacular architecture and its endurance, local climate, architectural tectonic and floating house of Rumah Rakit. Vernacular architecture (Latin: vernaculus = native = indigenous) is a pragmatically constructed architecture, based on local or traditional knowledge by using local materials [8], [9]. Tectonics (Greek, tectonics = tekton = carpenter/builder) is the art of construction or the art of linking material by applying certain techniques. The subjects of architectural tectonic are focused on: the correlation between interconnected materials, construction technology, technical mechanisms and procedures, climate behaviour, geographical conditions, topographic and environmental settings [5]. The resilience of vernacular architecture relies on its ecological-based technology, its resistance to the climate change fluctuations, the use of local materials and the techniques with simple equipment [9].

The microclimate is a specific weather condition that is different from its zonal climate [4]. The microclimate affects the design of building in terms of: its orientation, form, volume, facade, opening location, building construction and site plan [8], [11]. Floating buildings require a floating structure system that capable to buttress free vertical movement to follow the changes of water level and its movement in all directions. The movements influenced by wind speed, speed of water flow and weight of load [10]. Rumah Rakit is a house that is set up on a bamboo or wooden circuit and float on the water [3]. This paper is for enriching the above findings by emphasizing on the influence of local climate to the tectonics of Rumah Rakit based on the empirical experiences of the occupants and local expert.

2. Research Method

This paper is descriptive-qualitative, aimed to describe the results of field observations and interviews. The interviewees are conducted among local experts who have the expertise to build a floating house. The technique for determining the interviewees conducted in a purposive manner by following the instruction of local informants who has been living for more than 20 years in the target location. Local experts’ verbal information was recorded by tape recorder. Observation units determined purposively. Data and information analysed inductively to produce an integrated conceptual model. This conceptual model is temporary considering that the perfection of the model depiction depends on the comprehensiveness of data and information.

3. Results and Discussion

The location of research is the area of Rumah Rakit on Musi River, Seberang Ulu 1, Central Palembang Old City. At that location there are a number of jetties for boats transporting goods and passengers that cross between riverbanks or inter-districts traffics. Based on the interviews of local experts and occupants, the findings are described as follows.

3.1. The determination of Rumah Rakit location in relation to the characteristic of topography, geography and water surface behavior

The location, where Rumah Rakit will be located, depends on the slope level of river base ground. The angle of ground slope is the angle of riverbank surface slope that leads to the river base. The facade of Rumah Rakit is facing to river body while the rear side is accessible from the mainland. A sloping ground surface considered unfavourable to the position of building during the low tide season. The rear side of foundation will hit the ground slope as well as cause the front side of building's floor to be submerged.

The local expert said that the position of Rumah Rakit to the mainland is determined by the results of observations on the rise and low tides of river water surface. If the river base surface is relatively slanting, the distance of Rumah Rakit pile should be approximately erected 2 meters from the base river surface in a maximum low tide. The tight distance will cause the foundation of the Rumah Rakit hit the river base surface because of the waves force caused by the movement of passing boats. This force influences to the back-forth movement of buildings. However, this distance will vary by geographic
location. Rumah Rakit on steep topographic locations may be located less than 2 meters from the river base surface in maximum low tide. The piles that control the position of Rumah Rakit are possible shifted in case of collision.

The Rumah Rakit location is also determined by the length of pile. Commonly, the length of pile is 12 m and it planted into the river base ground at a depth of 3-4m. The piles appear above the water level at an altitude of 3 m or more, corresponding to the height of building. A certain location considered not selected when the pile does not appear above the water surface.

3.2. The movement of Rumah Rakit

3.2.1 The movements due to the changes cycle of day-night and rain-tide seasons

The changing tides of Musi River occur according to the cycle of day and night. The surface of river water recedes in the morning until noon and it risings in afternoon towards the morning. The river water surface tides behaviour is influenced by the downstream sea level. Day-night changes determine the direction of wind flow. The wind flows from the sea to land during the day while it flows from land to the sea at night. Therefore the change of day-night cycle causes the up-down movement of Rumah Rakit due to tidal behaviour, and the left-right movement due to the cycle of wind flow from the sea to land and vice versa.

Based on the experience of local expert, the rainy season occurs on the 11th (November) to fourth (April) months and the rising tide season occurs on the fifth (May) to 10th (October) months. The highest rising tide season occurs in May-June. During rainy season, the water flows from the upstream mountain and this causes flooding in the downstream area. While in the highest rising tide season, the water flows from downstream to upstream. This condition affects to the change of water currents direction and the left-right building movement or vice versa.

A countermeasure the movements of building related to flexibility connection between foundation and piles. The foundation tied by a rope and the rope looped around piles. The rope will rise and fall following the ups-downs movements of building. The distance between foundation and pile is about 1 m. In order to make foundation saves from the hard crash, then two or more rubber tires mounted on both left and right sides of foundation.

3.2.2 The movements related to the passing rate and anchoring activity of boats and ships

The movements of traffic (boats or ships) passing around Rumah Rakit affect to the occurrence of waves. The waves pushed the Rumah Rakit in all directions: back-forth, left right, and up-down. The power of thrust generated by the waves depends on the speed and load of boats/ships. The local expert stated that they tackle the movements by: 1) keeping the position of building at least 2m from the river ground in maximum low tide; 2) looping the rope in triangle position to piles and binding it to foundation of building. A straight bond rope causes the building unstable and rolling down to the front side. It is possible to set the piles in four sides of building; however the occupants argue that it is not profitable in cost and the force of rear reflective waves is relatively insignificant.

3.3. Building components and construction

3.3.1 Foundation

The foundation of Rumah Rakit is constructed by a series of bamboos arranged in several layers. The bamboo series called as Rakit (rafts). The bamboo commonly has a diameter of 15 cm and a length of 12 m. The width of foundation is the same as the width of building plus a minimum extension of 20 cm on each side. Terraces on all four sides are usually on the size of 10 bamboos. The width of terrace should be 1.5 m when the used bamboo has diameter of 15 cm, while the length of terrace corresponds to the length of Rumah Rakit (about 8-10 m). The front terrace (which faces to the river) is used as an access of boat. One of the left and right side terraces is used for bathing and washing. While the rear terrace (which faces to the mainland) is for a wooden stair leading to the mainland.

The foundation is tied to wooden piles planted into the bottom of river ground as deep as 3m on the left and right side foundation. To keep the foundation from drifting, the tied ropes wrapped around the
piles forming a triangle. The rope can move in accordance with the ups-downs of water surface and the left-right as well as front-rear movements of building. The number of piles depends on the affordability of the owner to pay for the cost; at least two piles on each left and right side of building.

The pile placement is arranged on the division of axes on the length size of foundation. For example, if using 2 piles, one pile placed at a distance of \( \frac{1}{4} \) x the side length from one corner of the foundation, and the second pile is \( \frac{1}{4} \) x the side length from the other foundation corner. The rope tied at the bottom corner of foundation then it wrapped around the pile and tied again in the middle of the side length of foundation in order to form a triangle. The total length of rope is about 1.5x2 m, so if the length of foundation is 12 m then the length of required space on the river for one Rumah Rakit is 15 m.

The length of pile is 12m, and it plugged into the ground as deep as 3 m. If the depth of water is 6 m then the rest 3 m of pile appears on the water surface. The piles joined and clamped by two woods at the top. Before the piles fixed, the location marked first by using woods. When the actual piles fixed then the marker removed. The piles first placed in the direction of the flow of water in order to prevent the foundation from drifting. The winding rope will be tighter to the piles in the direction of the flow of water.

3.3.2 Walls and openings
Columns are set on the transverse woods by using bolts, pegs or clamped by that transverse woods. The next is to install the wooden frame for walls, openings and roof. The wooden frame arranged according to the size of doors and openings. A large door is set at the middle of front door and small door is at the rear, while the wooden or glass windows installed at the left and right side of the doors. According to the local expert, the doors position placed not directly opposite to the windows. It is because the reason to keep a good fortune. Anyhow, it is a right consideration because a cross ventilation is on that position.

Another philosophical consideration is to keep the bedroom in the upstream direction in order to avoid the drifting position.

3.3.3 Roof
Zinc is used for roof cover material, in addition to shingles. The shingle roof cover is to be rare today and it is relatively not last longer than zinc. The shingle roof cover needs to change every 6 months, so the actual cost of treatment is higher than zinc. However, the room temperature is relatively cooler by using the shingle roof cover. Both material zinc and shingle considered suitable for Rumah Rakit because they are relatively lighter. Zinc is a better conducting material than shingles. Therefore, the room temperature will be relatively higher with zinc roof cover. In order to flow out the heat, the sloping wooden planks ventilations created on the roof wall. In this position, the rainwater does not flow into the room.

The roof slope angle is in the ratio 2 m of skoor length for 4m of beam length. The slope angle could rationalized be 30°. But the owner was often shortening the length of skoor (hanging pole on the roof horse frame) into 1.5 m for saving the cost, so the slope of the roof is relatively more sloping. A sharper roof slope angle will reduce the room temperature. The heat level of room temperatures is determined by the feelings of occupants.

Based on the above research results, it can be formulated a conceptual model as follows: the architectural tectonics of Rumah Rakit is related to three important aspects, namely the determination of buildings location; buildings movement; building components and construction system. The location of building determined by water surface behaviour; as well as geography and topography conditions. The movement of buildings occurs due to day-night cycles; the cycles of rainy and tides seasons; the speed movement of passing and anchoring boats/ships; and reaction to the weight of the load. Building component and construction system of Rumah Rakit is required to be flexible against movement in all directions; responsive to the nature of local climate; it built on trial and error and empirical experiences (Figure 1).
Figure 1. The conceptual model of vernacular architectural tectonic of Rumah Rakit, Seberang Ulu-1, Palembang.

4. Conclusion
The result of the research is a conceptual model, which can be used as reference for the architects and observers on the settlement environment so they may be able to develop the design model of floating building. The characteristics of local climate determine the form and system of building tectonics. Different geographical conditions influence to the differences of water tide behaviour and the stability of building position against topographic conditions. The characteristic of local climate causes the various movements of buildings in all directions. The movements caused due to the cycle of day-night and the cycle of rainy-tide seasons. Other factors are the movements originated by the surrounding in the form of the passing rate and anchoring movement of boats/ships; in addition to the heavy load reaction heard by foundation. These types of movements require a flexible construction system that has high capabilities to control the various forces from all directions and responsive to local climatic characteristics. Such tectonic system of Rumah Rakit based on the vernacular experimentation and sensory experiences.

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References
[1] Adiyanto, Johannes. 2008. Transformation of Architectural Shape of Resident of Descendants China in Palembang (Architectural Reading with Hermeneutics Method Phenomenology, Proc. on Ke-Bhinekaan Bentuk Arsitektur Nusantara, 12-13 September 2008. Surabaya: Jurusan Arsitektur FTSP, ITS.
[2] Aniza, Fiaatria. 2015. Designing Rumah Rakit as Culinary Tourism Object. Palembang: Politeknik Negeri Sriwijaya
[3] Iskandar, Yulindiani and Lahji, Khotijah. 2010. Local Wisdom in the Settlement of Structure and Construction of Raft House on the Musi River, Palembang. Lel.Wsd. II2. p.37 – 45.
[4] Latifah, Latifah, Nur Laela. Building Physics 1: Natural Penghawaan & Natural Illumination, Thermal Control (Silar Chart & SPSM). Jakarta: Griya Kreasi. 2015.
[5] Mangunwijaya. Wastu Citra. Jakarta: Gramedia Pustaka Utama. 2013.
[6] Perkasa Jaya, Anjuma. 2012. Proportion in The Architecture of Palembang Traditional Rafts House, Thesis. Yogyakarta: Universitas Gadjah Mada.
[7] Priya, R. Shanti, Sundarraja, Radhakrishna, Vijayalakshmi. Solar Passive Techniques in the Vernacular Buildings of Coastal Regions in Nagapattinam, Tamilnadu, India: A Qualitative and Quantitative Analisys. Engy Bld. 49 p. 50-61. 2012.
[8] Susetyarto, M. Bambang. Vernacular Architecture: Cultural Sustainability at Bena Flore Villages. Sukoharjo: Padepokan Seni Djayabhinangun. 2013.
[9] Tipnis, Aiswarya. Vernacular Traditions: Contemporary Architecture. New Delhi: The Energy and Resources Institut (TERI). 2012.
[10] Wang CM, Wang BT. Large Floating Structure. New York: Springer. 2015.
[11] Wiryomartono, Bagus. Perspectives on Traditional Settlements and Communities: Home, Form and Culture. Singapore: Springer. 2014.