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Publication date

2018

Document Version

Final published version

Published in

TU Delft DeltaLinks

Citation (APA)

Ham, P. (2018). Vernacular architecture inspires flood-proof housing. *TU Delft DeltaLinks*.
<http://flowsplatform.nl/#/vernacular-architecture-inspires-flood-proof-housing-in-the-philippines-1519054933087>

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Vernacular architecture inspires flood-proof housing

Urbanisation in Southeast Asia has to cope with land subsidence, rain floods, clogged rivers, storm surges and typhoons. On particular locations, like in the deserted fish ponds in the Manila Bay Area in the Philippines, floating housing can be an attractive building style. PhD researcher **Pieter Ham** and **Finch Floating Homes** are inspired by centuries-old building technologies to design 21st century housing.

February 2018

Flooding in Bulacan, Pampanga and Southeast Asia

The situation in coastal areas of the provinces Bulacan and Pampanga in the Philippines (figure 1) resembles many urbanized areas of Southeast Asia. Analysing the housing situation, and generating implementable designs of housing types can thus be translated to other regions that are dealing with similar problems.

The housing situation in Pampanga and Bulacan is highly affected by floods which are mainly the result of incoming seawater by tidal movement and by overflow rivers after heavy rainfall. A worsening trend in floods is detected. One cause of this trend is channel filling by sediments from floods and lahars (slurry volcanic debris flows) due to the Pinatubo volcano eruption in 1991. However, before this eruption, and in areas that were not affected by the eruption, worsening trends in regional floods were also already detected (Rodolfo & Siringan, 2006). Causes of these increased flood events are upland deforestation, rapid urbanisation, channel encroachment by squatters and fishponds, and garbage dumping in river delta's (Nippon Koei Co., 2001, Rodolfo & Siringan, 2006).

Around 1999 the Philippine public and the Philippine government became aware that sea levels of the oceans rise by 1 to 3 mm per year due to global warming (Intergovernmental Panel on Climate Change, 2001). On top of that, groundwater overuse causes land around northern Manila Bay to subside more than 10 times faster than the sea level is expected to rise (Rodolfo & Siringan, 2006). Land subsides relatively fast since extraction rates are higher than recharge rates. Hereby, rapid urbanisation has a big impact since it causes an increasing demand for groundwater. Land subsidence occurs all over large urbanized parts in Southeast Asia (figure2) (Deltares - Taskforce Subsidence, 2015).

Another cause of increasing flood risk is the vulnerability of these areas to storm surges. Storm surge is the increase in water height near the shore as a storm passes by due to pressure changes and wind patterns. During Yolanda (also known as Haiyan), storm surge heights reached up to more than five meters (Deltares, 2013). Changes in ground level can aggravate the risk of these storm surges due to increasing flood levels.

During floods brackish water can flow freely into the coastal regions of Pampanga and Bulacan. Where growing rice on rice fields once was one of the biggest sources of income, it is now no longer possible to grow rice on these flooded areas because of salinization. For this reason, over the last decades many rice fields have been transformed into fish ponds. Due to the increase in flood events, fish ponds overflow regularly. As a consequence, many of the fish ponds have been abandoned, and thereby large flooded areas nowadays don't have any spatial function.

Housing situation in the northern Manila Bay Area

Another phenomenon that affects the housing situation in Bulacan and Pampanga is rapid urbanization. Rapid urbanization is occurring around the world. In the following 30 years, more

than 60% of the world's population is expected to be found in cities and urban areas. This fast and often unplanned development results in serious problems due to scarcity of land, congestion and poverty. The current deficits in housing are in the low cost sectors and the housing backlog has been estimated to have reached over 10 million units in 2030. (Villegas, 2017) This enormous housing backlog and land scarcity not only occurs in Metro Manila, also smaller urban settlements situated further away from the city, like the coastal areas in previously described provinces, face this backlog. Figure 4 shows the municipality of Hagonoy (Bulacan). It shows that human settlements are developed along the riverside. Originally, the river was of high importance for the daily life of people, since the river was used for transportation, fishing industry and sewage disposal. People settled mainly in family owned compounds along those rivers. Over multiple generations this family-owned land has been divided several times over the family members in order to build their houses on their properties. By the rapid growth of population these areas are now divided several times and are hereby crammed with buildings. Expansions to areas located further away from the river are also not possible, as they are constantly exposed to flooding (figure 4). A negative side effect is that squatters settle themselves in self-built unsafe structures above the river. These informal settlements obstruct the waterways, resulting in an increase of flood risk (figure 5). Furthermore these provisionally built structures are highly vulnerable for typhoons. Due to an increase in intensity of typhoons in the near future these structures will become even more insecure to inhabit and add further risks (Mei & Xie, 2016). So the combination of land scarcity, large housing backlog, increased number of flood events and increased intensity of typhoons creates a major demand for safe, sustainable and affordable housing.

Analysis of vernacular Philippine architecture and culture

An answer to developing new resilient buildings can be found by analysing vernacular building types. Vernacular buildings are ancient buildings which are not designed or built by formally-schooled architects and engineers. They rely on designs, skills, craftsmanship and traditions of local builders.

The Bahay Kubo (which literally means cube house) is a Philippine building type of which its architectural principles were created in the pre-colonial era. This ancient building type provides a practical template for designing sustainable, climate-conscious, energy-efficient houses and buildings.

As most vernacular architecture in the Southeast Asian regions, the Bahay Kubo is built from low-cost, readily available, indigenous materials - in this case, mostly bamboo and nipa leaves. It is designed for a tropical climate. This is reflected in the architecture with the tall, steeply-pitched roofs for shedding monsoon rain, and enough overhead space for dissipating heat (figure 6a). The long eaves provide shade and protect the facades from rain (figure 6b). The large windows, held open by a simple rod, provide natural ventilation and natural light (figure 6c). The Silong (space under the building figure 6d) creates utilitarian space and allows ventilation from below through the bamboo porous floors. As well it gives the building protection against floods. All of the materials of the Bahay Kubo are organic, renewable and readily available at little cost. By its squared or sometimes octagonal floorplan and pitched roof it can withstand most typhoons.

An interesting feature of the Bahay Kubo is its ability to be relocated, since it is made of indigenous light materials. This relocation was practiced for agricultural reasons or for protection from floods or landslides. A few strong townspeople were able to lift up the Bahay Kubo and carry it with bamboo poles on their shoulders. This relocation is known as 'Bayanihan' which means 'being in a bayan'. It refers to the spirit of community work and cooperate to achieve a particular goal.

Many building elements were carried over when the Bahay Kubo evolved into the Bahay na Bato during the Spanish colonial period. The Bahay na Bato was modified to suit a more urbanized lifestyle by building the ground floor with solid stone blocks or bricks. The open timber structure of the second floor still gave the building its natural ventilation and natural lighting, but the protection and ventilation provided by the space under the building (Silong) were lost.

In the 20th century, foreign Western-style architectural models were adopted, with little regard for the tropical climate. The results were predictable: the new enclosed, mainly concrete buildings with glass windows required air conditioning, or else they created an unliveable indoor climate. New building facades were soon streaked with watermarks, because their flat roofs without eaves (roof overhangs) weren't designed for the monsoons during rainy season. Despite these drawbacks, the trend toward foreign architectural styles persists. However, because of relatively high energy costs and growing environmental awareness, many of today's designers and engineers re-examine the design principles of the Bahay Kubo and its approach to the challenges of climate in a simple but efficient way.

Implementation

Simply rebuilding the Bahay Kubo will not be a solution for all situations. There are some design principles that need to be translated to the present. An aerodynamic pitched roof with an angle of around 45 degrees is a better shape to withstand typhoons than a flat roof. However, large eaves and verandas or porches will form a weak part of the structure during these strong winds. Since the intensity of typhoons is increasing, typhoon resiliency of the building becomes more important.

Building on stilts has been a solution for protection against floods. However, due to increasing land subsidence and storm surges, and thus increased and more severe flood events, stilts become less advantageous. Furthermore, available land in the coastal areas of Bulacan and Pampanga to build the demanded houses is nowadays scarce. A solution for this lack of available space may come from the previously described vacant former fish ponds and rice fields. By building floating structures or floating houses in these areas, there will be new space available. Since these vacant fish ponds and former rice fields are located close to currently built settlements, people do not have to move to places far away from family or work. Furthermore, these floating houses won't be vulnerable for the daily floods and can create a dry and safe place for people to live. By considering the design principles and elements from vernacular architecture as the Bahay Kubo, and hereby design contemporary homes for today's needs and lifestyles, these floating homes can be a good solution for the lack of proper sustainable and affordable homes.

By creating locally prefabricated modules of locally renewable materials and recyclable materials a floating foundation can be built. By prefabrication, the production can take place in controlled (dry) climate conditions, without the impact of floods. This has a positive influence on the quality of the building and can reduce building costs (Badir & Kadir, 2002). By making use of as much as possible local renewable and recyclable products, both the CO₂ emission and the costs can be kept as low as possible and new local jobs are created. Upon this floating foundation, prefabricated panels can be installed and can be connected to each other. Like the Bahay Kubo these panels can be opened to create a naturally ventilated indoor climate. On top of the wall panels, a prefabricated pitched roof can be placed. The roof has openings for natural ventilation, and natural light, but can be closed in case of typhoons. Eaves that protect the building from monsoon rains can be folded inwards in case of strong winds.

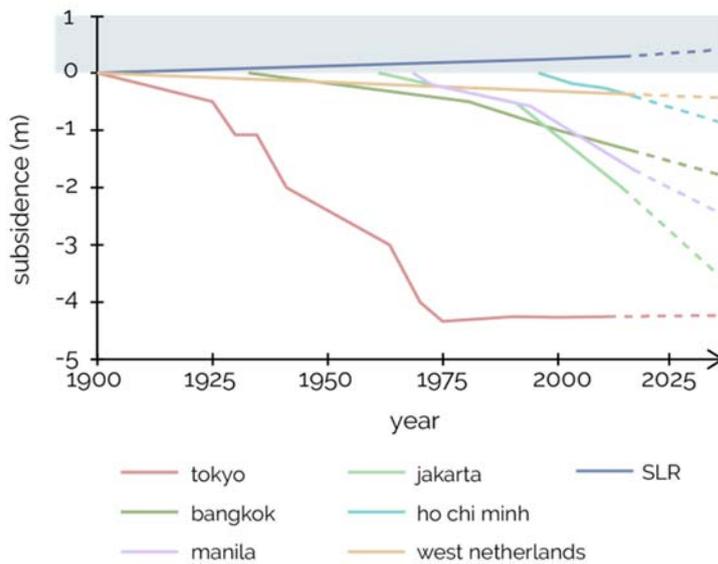
Since the building is made of locally produced prefabricated building parts, it can easily be repaired with new elements in case of damages by typhoons. Moreover, these buildings can easily be demounted and relocated, or even in its entirety be relocated over water, as learnt from the Bayanihan.

Analysing vernacular architecture offers a rich repertoire of architectural and engineering knowledge in the field of design, innovations, and low-tech techniques. By applying this knowledge to modern design, energy efficient buildings can be shaped that are perfectly adapted to their location.

Author: Ir. Pieter Ham



(1) Northern Manila Bay Area.
 Bron: (Rodolfo & Siringan, 2006)



(2) Land subsides fast in Southeast Asian urban areas. Land subsides more than ten times faster than the sea level is expected to rise.
 Bron: (Deltares - Taskforce Subsidence, 2015)



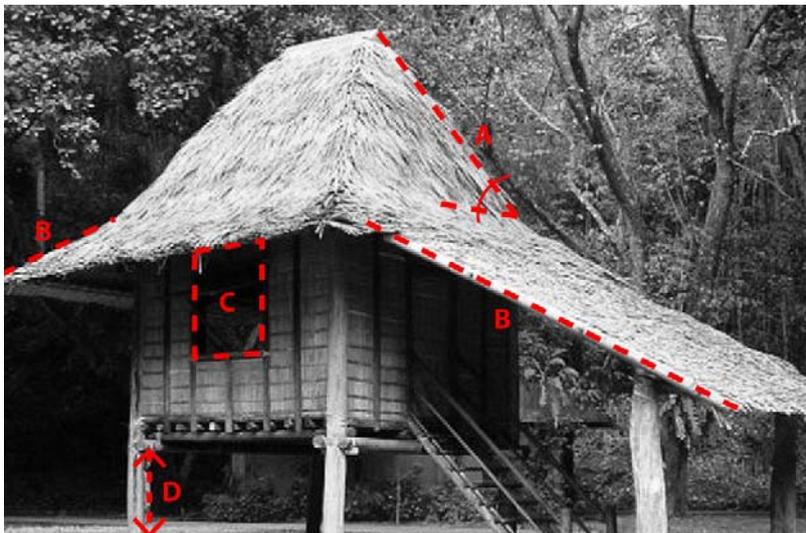
(3) Flooded Houses.



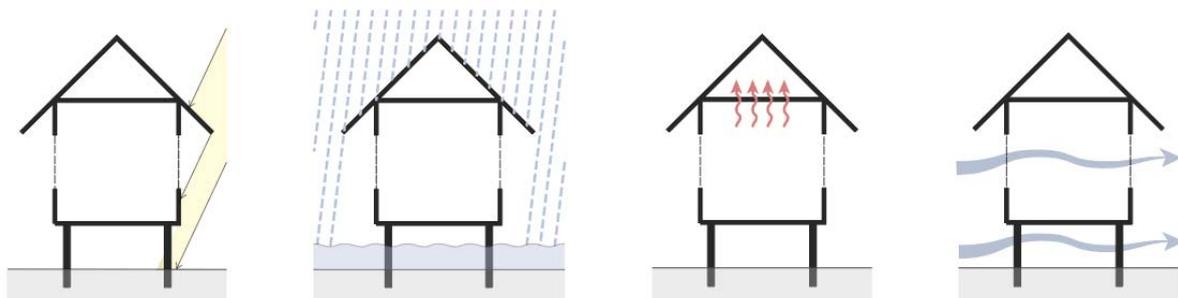
(4) Hagonoy (Bulacan): urban ribbon development within the overflowed areas.



(5) People build informal settlements along the riverside and above the river.



(6) The Bahay Kubo (cubic house) is designed based on local needs with readily available indigenous materials. Its architectural principles were created in the pre-colonial era.
Bron: (Thomas, 2017)



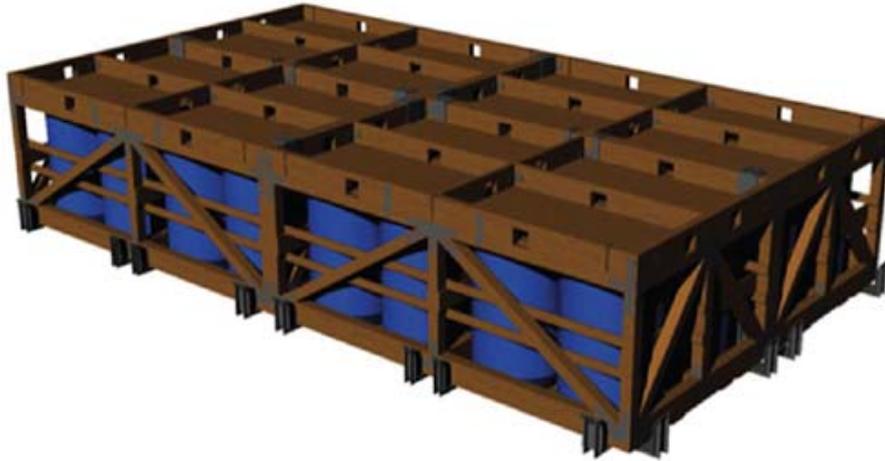
(7) The Bahay Kubo provides protection against sun, rain, floods and creates a liveable indoor climate.



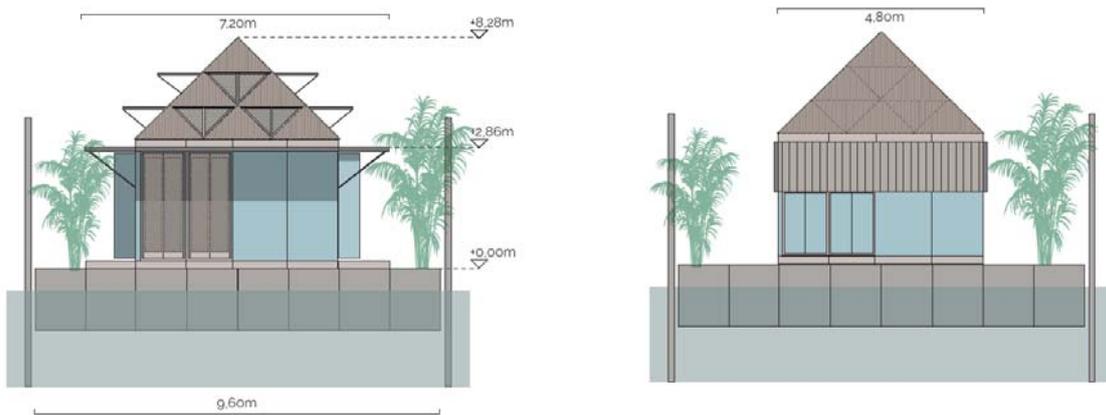
(8) *Bayanihan*: a typical Philippine tradition that refers to the spirit of community work and cooperate to achieve a particular goal.
Bron: (Bonvalite, 2012)



(9) *Floating structures* can provide building locations on functionless abandoned fish pans. People can hereby stay close to family and work.



(10) By connecting foundation modules, a rigid floating or amphibious structure can be created. The foundation modules are made of timber cages filled with plastic recycled barrels.



(11) A building can be placed on top of the floating foundation. This building creates natural ventilation by openings in the facade and roof elements. By closing these openings, the building is resilient to typhoon winds.



(12) The design of the floating flood-proof homes by Finch Floating Homes and TU Delft.