Architectural Characteristics of Floating Building

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Abstract
This study aims to investigate the architectural characteristics of floating building on water comparing with those of ordinary building on land, and to suggest the reference ideas for the new building projects around the water space. Floating architecture is basically endurable to a sudden or continuous rise in water level, re-locatable & long-term usable due to mobility. Some more architectural characteristics of floating building through the case studies can be summarized as fast and low-cost construction due to prefabrication & modular design; hydrothermal energy usage, introduction of solar photovoltaic & heat energy due to easy application of various renewable energy; use of re-usable & up-cycled building material due to environmental and economical consideration; provision of landmark, viewing points & social places due to revitalization of underdeveloped area by unique design. By the way, disadvantageous aspects of floating building from water environment are to be investigated in depth and countermeasures to overcome need to be suggested through further study.

Keywords: climate change; floating building; architectural characteristics

1. Introduction

Climate change like global warming steadily brings a rise in sea and river water level. Natural disasters like flooding and earthquake happens a lot in recent years. On the other hand, people likes to have a residence and enjoy leisure activities near or on the water according to the improved income level. New floating buildings such as house, apartment, restaurant, café, school, exhibition hall, marina club house, swimming pool, hotel, prison and so on are being built around the world. As previous researches about the floating building have been very few, this paper can have the meaning to provide the basic ideas for the practice of floating structures.

The aim of this study is to review the architectural characteristics of floating building through the built floating structures, and to suggest the reference ideas for the new building projects around the water space. Research methods include the site visits of floating building in Europe, some interviews with project...
designers, reviewing the related articles on line, and navigating the relevant homepages. In this research, representative floating buildings like office, student dormitory, swimming pool, exhibition building and a house are to be analyzed in terms of architectural characteristics.

2. Definition & Description of Floating Building

Floating building can be defined as a structure for living/working space that floats on the water with floatation system, is moored in a fixed place, doesn't include a water craft for navigation, and has a premises service system (electricity, water/sewage and city gas) served through the connection by permanent supply/return lines between floating building and service station on close land (British Columbia, (2017)), or has self-supporting service facilities for itself.

Floating building on the water is basically endurable to a change in sea or river water level, and can be relocated to different places when necessary due to easy movable characteristics. Floating building is advantageous to utilize the various renewable energies because solar, hydrothermal, wave and wind energies can be obtained easily on the water comparing with the building on land. And also, users of floating building usually enjoy the peaceful, comfortable, and social atmosphere around the water within the natural environment. Connection to the nature is likely to generate the positive states of well-being and health for the residents and visitors.

3. Case Studies

3.1 Floating Office for Waternet, Netherlands

The floating office for Waternet (see Fig.1), built in 2010, with three stories and 875 square meter area, is the facility for the workers who manage to clean the water of Amsterdam canals. The architect office created a unique and inspiring floating office space to suit for the company’s mission. The building contains office space and a canteen on ground and second floor level, and shower and locker rooms for the workers are located in the underwater basement.

The building’s shape is common, its skin made of reed is soft and comforting. The timber frame construction and thatched facade can be disassembled into re-usable or biodegradable components completely without any waste. Furthermore, the reed of the facade represents water purification, symbolizing the very essential work of the Waternet water company. Whenever this part of the city harbor is developed as an area for new housing, the office can move to other proper required place.

Fig.1. Overview (left) and Interior (right) of Floating Office for Waternet

The building has an innovative way of heating and cooling system. In the bottom of concrete pontoon lies a heat exchanger, a liquid filled winding tube, like a reverse underfloor heating system. It takes heat or cold
energy directly from the surrounding water. A reversible heat pump provides warm or cool air. The electrical energy for the heat pump comes from solar photovoltaic panels placed on the roof (Archdaily. (2015)).

3.2 Urban Rigger, Denmark

Floating dormitory (see Fig.2) in Copenhagen old harbor, built in 2016 as a prototype project, was proposed to provide the affordable student housing because there were serious housing shortage. This dormitory not only occupies prime waterfront property downtown for urban revitalization and accessibility, but was also echo-friendly and carbon neutral building. 680 square meter modular design dormitory comprises 9 stacked shipping container units organized in a triangle to frame a centralized garden and common social area for 14 students with a bedroom, bathroom, and kitchen.

To achieve the carbon neutral status, the floating dormitory is powered by solar photovoltaic energy and a hydrothermal system that draws on seawater as a natural source of heat. Special aerogel is used to insulate the interiors, while energy-saving pumps are installed for wastewater, heating, circulation, and drinking water. The shipping containers, made entirely of Corten steel, are upcycled to save on materials, energy, and cost (Wang, L. (2016)).

Though Urban Rigger has not explored applications outside of student housing, it could help alleviate the refugee housing crisis with a few modifications. This could be an intelligent way to relieve stressful housing situations in a way that's not just putting up tents but really creating completely safe, completely secure high-standard living spaces. As with the availability of and rights to use waterfront land, this scenario is also dependent on the goodwill of those with property rights (Budds, D. (2016)).

3.3 Hasle Harbor Bath, Denmark
The town of Hasle, a historical port of former industrial, fishing & ferry service, is located on the island of Bornholm, Denmark. The Hasle Harbor Bath (see Fig.3), built in 2013 within the network of granite breakwaters, has 500 square meter floating concrete platform with two swimming pool for younger children, 400 square meter staggered wooden seating deck with several diving boards and 60 square meter of timber clad service building which includes a sauna, washroom, and outdoor changing area.

Residents and tourists can swim in the shallow, enclosed water area of the platform, and it is also possible to dive into the deep sea water surrounding the structure. A 25 meter long ramp connects the structure to the landing, and while the slope of the ramp varies according to the water levels, it is also available for the disabled within normal water level changes.

This facility was planned to revitalize the declining harbor as a local landmark and a catalyst for new future activity in the harbor. People can experience the special waterfront atmosphere. The facility provides a place to take a rest, enjoy the natural sea view and the legendary sunsets, makes a wide variety of social activities for the local residents and outside visitors (Archdaily. (2014)).

3.4 IBA Dock, Germany

In 2010, the international building exhibition IBA had a slogan “City in a Climate Change” with a goal of a CO₂-neutral city development. The IBA Dock (see Fig.4) as the information and event center of Hamburg was constructed upon a floating concrete pontoon. The building is now being used for urban and architecture information center in Hamburg. The IBA Dock not only houses the exhibition IBA, but is also itself an exhibition of innovative building components and integrates numerous renewable energy technologies (IBA DOCK. (2017)).

The IBA Dock has 3 stories and 1,640 square meters floor area, is situated on an approximately 43m long and 26m wide concrete pontoon and the building is made of steel in prefabricated modular construction. The building suggested new standards in the area of climate protection. The building is based on “zero balance concept”, which focuses on solar energy management and systems that provide buildings with sustainable heating and cooling all year round (Archdaily. (2012)).

Solar energy captured from rooftop photovoltaic panels feeds into an electric heat pump that draws its environmental heat directly from the Elbe using a heat exchanger built into the base of the concrete pontoon. This provides both the heating and cooling requirements for the water and air conditioning of the building. The building features heating and cooling ceiling system, along with a ventilating machine that provides air exchange for the entire building. Almost no further cooling or heating energy is needed.
3.5 Autark Home, Netherlands

Autark Home (see Fig.5), completed in 2012, is a self-sufficient and passive floating home with European passive house certificate. A prototype of Autark Home was installed in the river Maas, Maastricht, but it is currently anchored in the Rijnhaven at the Port of Rotterdam, Netherlands. The floating home has two stories and 109.4 square meters floor area, outer wall with 55cm thick EPS, isolated windows with triple glass and no cold bridges.

For hot water, it has 6 solar heat panels on the roof and an isolated large water tank for 4 to 5 days. River water is converted to gray water and high-quality drinking water through a built-in water treatment system. Before the waste water returns to the river, the water is cleaned by a built-in filtration system. Each room has its own ventilation system and the incoming fresh air is heated or cooled through a heat recovery system (Autark Home, (2107)). The electrical energy, produced by solar photovoltaic cells, is stored in battery with enough electricity for 4 days for a family. The system can deliver 5,300 kWh a year. In bad weather conditions, a bio-diesel generator can supply additional electrical power (REM, (2012)).

Even though there are no service utilities to be connected around the floating building, this kind of floating building with self-sufficient system can be built and operated without any restrictions. So floating architecture with self-sufficient system such as water treatment and electricity power system can be built freely any distance away from the coastal or river side without high initial infrastructure cost.

4. Architectural Characteristics

The five cases of floating building were introduced and analyzed in terms of architectural characteristics, and the major factors can be shown in Table 1.

<table>
<thead>
<tr>
<th>Name of Building</th>
<th>Architectural Characteristics</th>
</tr>
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<tbody>
<tr>
<td>Floating Office for Waternet</td>
<td>application of re-usable/biodegradable building material, hydrothermal energy use of surrounding water, use of heat pump, use of solar photovoltaic panel</td>
</tr>
<tr>
<td>Urban Rigger</td>
<td>use of up-cycled shipping container, application of modular concept, use of solar photovoltaic panel, hydrothermal energy use of surrounding water, offering the opportunity of old downtown revitalization, provision of social support through public space</td>
</tr>
<tr>
<td>Hasle Harbor Bath</td>
<td>landmark of the island, provision of view place for beautiful sea and stunning sunset, revitalization of the old declining harbor, provision of place for various social activities</td>
</tr>
<tr>
<td>IBA Dock</td>
<td>application of modular and prefabricated system, hydrothermal energy use of surrounding water, use of heat pump, use of solar heat and photovoltaic panel</td>
</tr>
<tr>
<td>Autark Home</td>
<td>European passive house certificate and self-sufficient system, use of solar heat and photovoltaic panel, use of heat pump, provision of bio-diesel generator, application of built-in water treatment system</td>
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The architectural characteristics from the case studies can be summarized as followings; application of
re-usable & biodegradable building material, heat pump, solar photovoltaic panel, and hydrothermal heating/cooling system in floating office for Waternet; use of up-cycled building material, modular concept, solar photovoltaic panel, hydrothermal heating/cooling system, offering the opportunity of old downtown revitalization, and a place for social support in Urban Rigger; provision of the place to enjoy water leisure, natural view, landmark and social activities, revitalization of the old declining harbour in Hasle Harbor Bath; application of modular and prefabrication system, hydrothermal energy usage, solar heat and photovoltaic panel, and heat pump in IBA Dock; installation of water treatment system, heat recovery system, solar heat and photovoltaic panel for self-sufficient & passive floating home in Autark Home.

5. Conclusion

This paper analysed the 5 cases of floating building in Europe based on site-visits and the related articles on line in order to review architectural characteristics in floating building design. Main interest was to find the architectural characteristics like sustainable factors, echo-friendly approaches and so on.

Floating building is basically endurable to a change in water level in time of water related disasters and re-locatable & long-term usable due to mobility. The findings from the case studies in terms of architectural characteristics can be summarized as followings; application of modular design and construction, re-usable & upcycled building material, solar heat panel and solar photovoltaic cells, hydrothermal heating/cooling system, heat recovery system, and self-sufficient system, installation of water treatment system, providing the revitalization possibility of old urban declining area, offering the place to enjoy water-related leisure activities, natural view, and social support & activities. Therefore, floating building can have advantages from both environmental/economic and social/psychological aspects comparing with the building on land.

In addition, disadvantageous aspects of floating building such as possibility of natural disaster, blocking the sunlight to water environment, wet atmosphere to the human and building, various negative effects to the ecosystem might be investigated in depth and countermeasures to resolve need to be suggested through further study.

References