



Applications of Sustainable Factors in Floating Architecture

Speaker:

Changho Moon

Kunsan National University, Kunsan, Korea, mchangho@kunsan.ac.kr

Abstract: *This paper aims to investigate the applications of sustainable factors in floating architectures and to suggest some reference ideas for new projects. The applied sustainable factors in floating architecture by 3 dimensions can be summarized as follows; water resilience, renewable energy, PCM, local material, preservation of natural environment in environmental dimension; long-term usage, water reuse & treatment, natural ventilation, thick insulation in both environmental & economic dimensions; relocatable, prefabrication & modular design, heat recovery system, insulation made of recycled paper in economic dimension; solid security against crime, peaceful atmosphere, place-making, community development, livability, social support, community resilience, high sense of community in social dimension. Floating architecture has been emerging as a sustainable alternative around the waterside region, and can be regarded as one of the most sustainable building types if proper sustainable factors would be applied.*

Sustainability, Sustainable Factor, Floating Architecture, Climate Change

1. Introduction

Nowadays floating buildings can be found with easy round the world. There are almost every kind of floating building types such as individual house, row house, exhibition hall, restaurant, visitor center, ferry terminal, stadium and hotel.

As Climate change like global warming advances, level of sea rises and severe flooding sometimes results. Usable land in urban area becomes less and the price is rising due to continuous expanding development. And people want to enjoy the activities on water rather than on land according the improved level of living.

This paper aims to investigate the applications of sustainable factors in floating architectures through the analysis of samples and to suggest some reference ideas for new projects. Research method includes the site-visits, the review of related literatures, and the navigation of some homepage.

2. Concept of Floating Architecture and Sustainable Factor

2.1 Definition of Floating Architecture

Floating architecture can be defined as a building for living/working space that floats on water with floatation system, is moored in a permanent location, does not include a water craft designed or intended for navigation, and has a premises service system (electricity, water/sewage and city gas) served through connection by permanent supply/return lines between floating building and land, or has self-supporting service facilities for itself.

2.2 Concept of Sustainable Factors

Sustainability can be defined as the capacity to endure. Sustainability is improving the quality of human life while living within the carrying capacity of supporting eco-systems. For humans, sustainability is the potential for long-term maintenance of well-being, which can have environmental, economic, and social dimensions [1].

Environmental sustainability involves making decisions and taking action that are in the interests of protecting the natural world, with particular emphasis on preserving the capability of the environment to support human life [2]. Economic sustainability is the term used to identify various strategies that make it possible to use available resources to their best advantage. The idea is to promote the use of those resources in a way that is both efficient and responsible, and likely to provide long-term benefits [3]. The concept of social sustainability encompasses such as social equity, livability, health equity, community development, social capital, social support, human rights, labor rights, place-making, social responsibility, social justice, cultural competence, community resilience, and human adaptation [4].

3. Sample Floating Architectures

3.1 Floating Pavilion, Rotterdam, Netherlands, 2010

The Floating Pavilion (see Figure 1) in Rotterdam has a complex consisting of three floating half-spheres with diameters of 18.5, 20 and 24 meters respectively, and with total floor area 1,104 square meters. The pontoon is made of expanded polystyrene (EPS) combined with a grid of concrete beams.



Figure 1 & 2. Floating Pavilion & IBA Dock

Solar thermal collectors & absorption material on the roof and Phase Change Material (PCM) in wall liquefy/solidify when the auditorium warms up/cool down. The geodesic domes are covered with extremely lightweight ethylenetetrafluoroethylene (ETFE) foils. The foil-roof consists of three layers, filled with air under pressure for insulation. Air convection streams are created between windows on ground floor level and in the top of the roof. Waste water is purified and reused for flushing toilets. Even the toilet water is purified and discharged into the surface water [5].

The entire facility is designed to accommodate approximately 500 visitors. And the auditorium can be used for groups up to 150 people. Various conferences and social events can be available with its remarkable shape as a landmark.



3.2 IBA Dock, Germany, 2009

The IBA Dock (see Figure 2) as the information and event center is constructed upon a floating pontoon. The building is being used for Urban and Architecture information center in Hamburg.

The IBA Dock has 3 storeys and 1,640 square meter floor area. The building is situated on an approximately 43m long and 26m wide concrete pontoon, and the superstructures are made of steel in prefabricated modular construction. The building is setting new standards in the area of climate protection such as 25cm thick insulated outer walls

The building is based on “zero balance concept”, which focuses on solar energy management and systems that provide buildings with sustainable heat and cooling all year round. 16 solar thermal collectors with about 34 square meter on the roof are positioned facing south.

Together with solar energy, some more energy is drawn 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 through ceiling fixtures.

The heat pump, along with a ventilating machine that provides air exchange for the entire building, are powered by 103 square meter of south-facing solar photovoltaic(PV) modules located on the roof terrace and angled at 30 degrees. Because the electricity needed by the heat pump is covered by solar PV cells, no further cooling or heating energy is needed [6].

3.3 Autark Home, Netherlands, 2012

Autark Home (see Figure 3) is a self-sufficient and passive floating home with European passive house certificate. The floating home has 2 storeys, 109.4 square meter floor area, outer wall with 55cm thick massive EPS, isolated windows and doors, triple glass and no cold bridges. There is an isolated water tank with capacity of 4,000 liters and 6 solar thermal collector panels on the roof to keep the temperature of 70 to 80 degree for 4 to 5 days [7].

River water is converted to gray water through a filter. And high-quality drinking water is purified through reverse osmosis in combination with the sand and UV filter. Before the waste water returns to the river, the water is cleaned for 90% by a built-in filtration system. The incoming fresh air is heated or cooled by outgoing exhausted air through a heat recovery ventilation system.

The electricity is supplied by 24 solar PV modules. The electrical energy is stored in 24 batteries, supplying enough electricity for 4 days for a normal family. The system can deliver 5,300 kWh a year. On the display of the monitoring system in living room, solar production can be watched. In bad weather condition, a bio-diesel generator supplies the home with additional power.

3.4 Makoko Floating School, Nigeria, 2013

Makoko Floating School (see Figure 4) is a prototype floating structure with area of 220 square meters, built for the historic water community of Makoko, Lagos, Nigeria. As a pilot project, it has taken an innovative approach to address the social and physical needs of the community considering the impact of climate change and a rapidly urbanizing context.

The overall composition of the design is a triangular A-Frame section, with the classrooms located on the second tier. They are partially enclosed with adjustable louvered slats. There is a playground below, and the roof has an additional open air classroom.



Figure 3 & 4. Autark Home & Makoko Floating School

It is designed to use solar PV modules, to adapt natural ventilation, to recycle organic waste and to collect rainwater for the toilet. Bamboo and wood from the local community are used as the main material as the structure, support and finishing for the completed school. The whole structure sits on a base of typical plastic barrels. The barrels at the periphery can be used to store excess rainwater from the catchment system [8].

3.5 Brockholes Visitor Centre, UK, 2012

A new nature reserve named Brockholes (see Figure 5) was created from the abandoned remains of a quarry near Preston, UK. The 1,400 square metre floor area building sits on a 2,795 square meter concrete pontoon. The center comprised a cafe, conference center and education facilities as well as an exhibition space and retail shops. The highlight is the beautiful floating eco-village with decks for visitors to enjoy the peaceful surroundings.

Brockholes sits on a buoyant concrete raft, held by four steel posts to stop it drifting across the lake. It can rise up to 3 metres, which would only be necessary in a catastrophe, but will regularly rise up and down by 40cm over a year because the site is prone to flooding with a one-in-100-year risk of up to 3 meters and has an annual water level variation of 40cm [9].

The architect designed high, steep-pitched roofs enclosing large volumes (good for air circulation and extraction), clad in oak shakes – rough tiles. Gutters are made of copper (long-life, recyclable). Grey water system and woodchip boilers add to the green scores. Ventilation is entirely natural. Insulation is a cheap but effective material made from recycled newspapers.

The facade is an environmental system, helped by external awnings which provide the best form of shading in summer. The low-level window seats means that efficient natural ventilation and views out are not obstructed. In winter the internal space can receive

maximum daylight and passive solar heating. The deck now sits above the water with a freeboard of only 150mm, giving the feeling of intense proximity to the lake.

3.6 Oregon Yacht Club, Portland, USA, 1910

Oregon Yacht Club (OYC, see Figure 6) is a community with 38 floating homes on the Willamette River, Portland, Oregon. The close proximity of downtown with pastoral setting of OYC is regarded as one of the best floating home village in the area.

In OYC, there is a floating house with 2 storeys and 212 square meters. That is ultra-low energy house and the entire structure is made of glued laminated wood sections for swirling and curved design. This kind of construction not only makes versatile forms but also greatly reduces the overall amount of material used, and so is very light and easy to produce.



Figure 5 & 6. Brockholes Visitor Center & Oregon Yacht Club

The window wall is only for taking in amazing river views and the glass allows the solar heat and light during the day while providing natural ventilation. With the materials prefabricated and transportation by boat, the home construction required minimal amounts of energy, and most importantly, did not disrupt the atmosphere of the floating home community. The house is integrating a beautiful, modern home into its surrounding environment.

In floating home community, residents enjoy the peaceful and comfortable atmosphere on water within the natural setting. They believe the best view is seeing only the natural elements such as sky, mountain & trees, grain field, and water without any artificial features. Connection to nature is likely to generate positive states of well-being and health. They enjoy sunrise and sunset with water and mountain background. There should be psychological sustainability among the residents and neighborhood.

The residents have great interest in conserving the natural environment like wild birds and watershed vegetation, have to cooperate in managing the natural disaster like flooding and typhoon, have to cope with the fire and escape, and should negotiate the legal regulation with the city officers and get administrative/financial support from the City government. Solid social sustainability is essential and easy to be found in floating home community [10].

4. Sustainable Factors in Floating Architecture

The applied sustainable factors in floating architecture by 3 dimensions can be summarized as follows (see Table 1);

- Environmental dimension: flood resilience and adaptation to water level change, renewable energy (solar thermal collector, solar PV module, hydrothermal, biomass boiler), bio-diesel generator, PCM, use of local material, restoration & conservation of natural environment.
- Both environmental & economic dimensions: long-term usage, water reuse & treatment, natural ventilation, external awning, collecting rainwater, thick insulation, self-sufficient system, low energy house
- Economic dimension: relocatable, 3 layer ETFE, prefabrication & modular design, heat recovery system, reuse of plastic barrel, insulation made of recycled paper, prefabricated construction.

Table 1. Applied Sustainable Factors by 3 Dimensions

Name of Building	Sustainable Factors			
	Environmental Dimension	Economic Dimension	Social Dimension	
Common	- flood resilience - adaptation to water level change	- long-term usage	- relocatable	- solid security against crime - peaceful atmosphere
Floating Pavilion	- solar thermal collector & absorption - PCM	- natural ventilation - water reuse and treatment	- plan of relocation - 3 layer ETFE	- place-making for meeting & events - landmark
IBA Dock	- solar PV module - hydrothermal use	- thick insulation	- prefabrication & modular design	- community development
Autark Home	- solar PV module - bio-diesel generator	- self-sufficient system - thick insulation	- heat recovery system	- livability
Makoko Floating School	- solar PV module - use of local material	- natural ventilation - collecting rainwater	- reuse of plastic barrel	- social support - community resilience
Brockholes Visitor Center	- restoration of natural environment - biomass boiler	- water reuse - natural ventilation & external awning	- insulation made of recycled paper	- peaceful surrounding - social capital
Oregon Yacht Club	- conservation of environment	- low energy house	- prefabricated construction	- high sense of community

- Social dimension: solid security against crime, peaceful atmosphere, place-making for meeting & events, landmark, community development, livability, social support, community resilience, social capital, high sense of community

5. Conclusion

As climate change like global warming advances, level of sea and river rises. Usable land in urban area becomes less and the price is rising due to continuous expanding development. And people want to enjoy the activities on water rather than on land according the improved level of living. This paper aims to investigate the applications of sustainable factors in floating architectures and to suggest some reference ideas for new projects.

The applied sustainable factors in floating architecture by 3 dimensions can be summarized as follows; water resilience, renewable energy, PCM, local material, preservation of natural environment in environmental dimension; long-term usage, water reuse & treatment, natural ventilation, thick insulation, self-sufficient system in both environmental & economic



dimensions; relocatable, 3 layer ETFE, prefabrication & modular design, heat recovery system, insulation made of recycled paper, prefabricated construction in economic dimension; solid security against crime, peaceful atmosphere, landmark, community development, livability, social support, community resilience, high sense of community in social dimension.

Floating architecture on water has been emerging as a sustainable alternative around the waterside region, and floating architecture can be regarded as one of the most sustainable building types if proper sustainable factors would be applied.

ACKNOWLEDGMENTS

This research was supported by a grant (10 RTIP B01) from Regional Technology Innovation Program funded by Ministry of Land, infrastructure and Transport of Korean government.

References

- [1] Wikipedia, *Sustainability*, 2014. Available at <http://en.wikipedia.org/wiki/Sustainability#Definition>
- [2] Small Business Tool Kit, SmallBizConnect, *Environmenta Sustainability*, 2014. Available at <http://toolkit.smallbiz.nsw.gov.au/part/17/86/371>
- [3] wiseGEEK, *What Is Economic Sustainability?*, 2014. Available at <http://www.wisegeek.org/what-is-economic-sustainability.htm>
- [4] Wikipedia, *Social Sustainability*, 2014. Available at http://en.wikipedia.org/wiki/Social_sustainability
- [5] Jacobine Das Gupta, *ROTTERDAM FLOATING PAVILION : DUTCH ICON OF BUILDING ON WATER*, 2010. Available at <http://thegreentake.wordpress.com/2010/10/18/rotterdam/>
- [6] BES, IBA DOCK: *The floating climatic house*, 2014. Available at <http://www.bes-eu.com/en/architects-and-designers/solar-architecture/iba-dock-the-floating-climatic-house>
- [7] AUTARK HOME, 2014. Available at <http://www.autarkhome.nl/>
- [8] NLE Architects, *Makoko Floating School*, 2014. Available at <http://www.nleworks.com/case/makoko-floating-school/>
- [9] Bridgette Meinhold, *UK's First Floating Nature Reserve Visitor Centre Is Almost Complete*, 2011. Available at <http://inhabitat.com/uks-first-floating-nature-reserve-visitor-centre-is-almost-complete/>
- [10] Oregon Yacht Club, 2014. Available at <http://www.oregonyachtclub.com/>