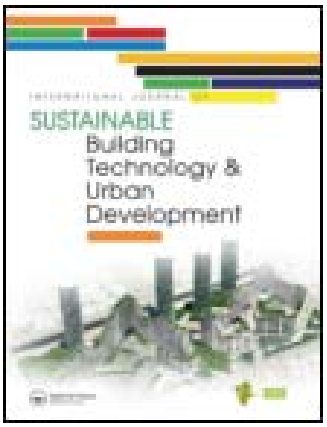

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Three dimensions of sustainability and floating architecture

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Three dimensions of sustainability and floating architecture

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This paper focuses on the sustainability of floating architecture. Compared to usual buildings on land, floating buildings on water have great advantages in terms of sustainability. Sustainability in architecture has primarily dealt with physical aspects, but discussions of sustainability need to be extended to non-physical aspects because buildings are to be used by people with various purposes and meanings. Sustainability of floating architecture in three dimensions can be summarised as durability to a rise in water level, long term usage due to movability and relocation, use of local material, and various applications of renewable energy sources in the environmental dimension; economic advantages due to prefabrication and modular construction, and economic efficiency due to high utilisation rate through global mobility in the economic dimension; and residents' psychological comfort, strengthened security against crime, and high sense of community in the social dimension.

Keywords: floating architecture; sustainability; architectural trend; renewable energy; modular construction

1. Introduction

Owing to the increase of economic income level, people want to live and enjoy leisure activities near or on the water. And due to climate change, recently there have been severe and frequent natural disasters such as heavy rain, hurricanes and flooding. Proper countermeasures in terms of architecture are needed and diverse floating architecture may be an emerging and realisable alternative.

This paper aims to discuss the sustainable features of floating architectures, where usual buildings on land are not feasible, to investigate the sustainable characteristics of floating buildings from the view point of environmental, economic and social dimensions, and suggest some ideas for the reference of design and construction in new floating architecture projects.

Research methods include the site-visits of some floating buildings in Europe, Canada and USA, the review of related literatures, and the navigation of sustainability and floating building related homepages.

2. Concept of sustainability and floating architecture

2.1 *Concept of sustainability*

According to Wikipedia, 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. Sustainability of architecture has been discussed mainly in terms of physical issues like energy and ecology, but the concept of sustainability needs to be extended to the non-physical aspects like residents' psychology and social life.

For humans, sustainability is the potential for long-term maintenance of well-being, which can have environmental, economic, and social dimensions. In this paper the sustainability of usual buildings on land will not be discussed, only that of floating buildings on water will be analysed and investigated based on environmental, economic, and social dimensions as references [1].

2.2 *Concept of floating architecture*

Floating architecture can be defined as a building for living/working space that floats on water via a floatation system, is moored in a permanent location, does not include a water craft designed or intended for navigation, and has a premises service (electricity, water/sewage, gas) system served through connection by a permanent supply/return system between the floating building and land [2], or has self-supporting service facilities for itself.

3. Three dimensions of sustainability in floating buildings

3.1 *Environmental dimension*

A floating building on the water can endure a continuous but slow rise in sea or river level, due to climate change like global warming, and a sudden rise of water level due to natural disaster like flooding and hurricane. Floating and floatable buildings on the water level would be available according to the site condition between bank and water.

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Figure 1. Four Seasons Hotel. (Source: http://www.mtkumgang.com/, 2013.9)

Especially, floating and/or floatable architecture would be very useful in case of flooding for coastal/river and lowlands areas.

A floating building is movable by barge and can be relocated to different places as required, and can be used by different people for a long time. Long term usage in different places by different people can contribute to the conservation of environment due to resource savings. For example, the Four Seasons (Great Barrier Reef) Hotel was built in Singapore in 1988, moved to and operated in Australia, moved to Vietnam in 1989 and operated until 1997, returned and remodelled in Singapore in 1997, and bought by Hyundai Asan and moved to North Korea in 2006. This floating hotel has been moved four times and operated in three different countries for more than 20 years (see Figure 1) [3].

'A floating building has easy access to various renewable energy sources because there are no obstacles in the sea or river'. More solar and wind energies can be obtained on the water than on urban land. Especially, hydrothermal use of sea/river water beneath the floating building might be a great advantage because the temperature of the water is lower than that of air in summer and the reverse in winter. Therefore hydrothermal energy can be used as air-conditioning in tropical regions and heating in cold regions.

In the case of the IBA Dock in Germany, the international building exhibition IBA had a slogan 'City in a Climate Change' with a goal of CO2-neutral city development and multiple possibilities were tried, to provide energy supply from the water temperature of the Elbe combined with solar energies like solar heat panels and solar photovoltaic cells (see Figure 2) [4].

Figure 2. IBA Dock.

Figure 3. Salt & Sill Hotel. (Source: http://www.yatzer.com/The-first-floating-hotel-in-Sweden, 2013.9)

In the Salt & Sill Hotel in Sweden, heating energy is actually generated from the warm sea water underneath the floating building in winter. The Salt and Sill Hotel was built using local raw materials such as pine wood from Swedish forests, and only environmentally friendly paint. They have even used the left over quarrying stone to build a new lobster reef under the concrete pontoon in consideration of the environment (see Figure 3) [5].

3.2 *Economic dimension*

A floating building usually employs a prefabrication and modular system in the design and construction process. Most parts are manufactured in a factory, transported, and assembled and installed on site. 'Depending on the company or the project, a floating building which is fully assembled in the factory may be towed and moored at the site'. Maximum savings in construction waste can be made and the floating building can be easy and economical to maintain. The prefabrication and modular system in a floating building can contribute to its economic sustainability (see Figure 4) [6].

A floating stadium was proposed for the FIFA World Cup 2022. A floating offshore stadium can be relocated to seaside places across the oceans in the world. Therefore this kind of floating stadium can be used by more effectively than the usual onshore stadium. Its global mobility, long-term utilisation and various economic efficiencies show great advantages and so can be a new model for 21st century sports facilities, especially for small countries.

Once a big sports event such as a World Cup or Olympic Games is completed, operation and maintenance of the stadium raises economic problems due to low

Figure 4. Modular construction, IBA Dock. (Source: http://www.archdaily.com/288198/iba-dock-architech/, 2013.9)

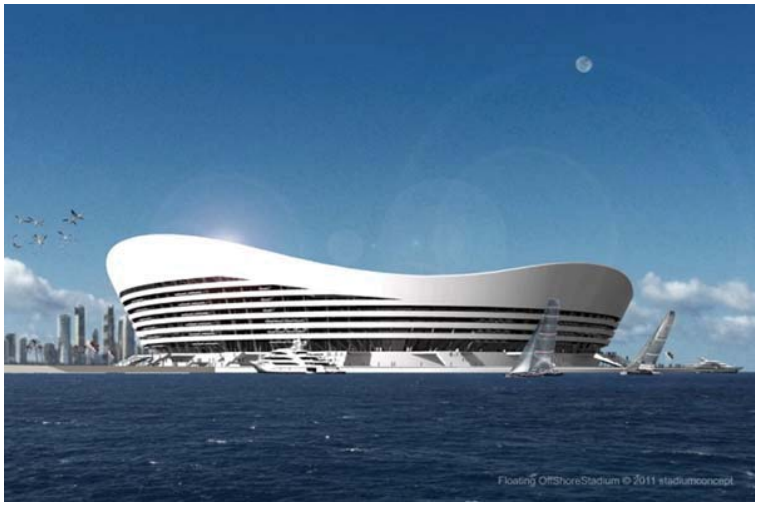

Figure 5. Floating stadium. (Source: http://www.archdaily.com /138162 /floating-offshore-stadium-stadiumconcept/, 2013.9)

utilisation. 'Therefore large-scale floating buildings for big events can maintain good economic sustainability through their global mobility' And also this kind of floating offshore stadium can be eco-efficiently powered by a blend of hybrid energies such as water, wind and solar power (see Figure 5) [7,8].

3.3 *Social dimension*

The concept of social sustainability encompasses issues such as social equity, liveability, health equity, community development, social capital, social support, human rights, labour rights, place-making, social responsibility, social justice, cultural competence, community resilience, and human adaptation [9]. Some factors of social sustainability can be applied to the floating architectures.

In a 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 and trees, grain fields, and water without any artificial features. Some floating home communities have a good view to the river or lake, a distant mountain, ebb, and migratory birds' habitats. Connection to nature is likely to generate positive states of well-being and health.

When the residents were asked what the first reason was for wanting to live there, they usually answered that they liked the peaceful environment and good neighbours. They enjoy sunrise and sunset with a water and mountain background. There should be psychological sustainability among the residents and neighbourhood.

The residents have great interest in conserving the natural environment like wild birds and watershed vegetation, have to cooperate in managing natural disasters like flooding and typhoons, have to cope with fire and escape, and should negotiate legal regulations with the city officers and get administrative/financial support from the city government. Solid social sustainability is essential and easily achieved in a floating home community (see Figure 6) [10].

A floating home community is usually more secure against crime than housing sites on land. Because the residents know each other, the entrance is controlled, and the community is surrounded by water, unwanted guests cannot easily access the floating home community. This kind of housing condition can enhance social sustainability.

4. Conclusions

Due to climate change, people's preference to live in a water space, and frequent natural disasters, like flooding and earthquakes, floating architecture can be a strong and attractive alternative. This paper aimed to investigate the sustainable characteristics of floating architecture in terms of environmental, economic, and social dimensions.

Comparing with the usual buildings on land, floating buildings on water have great advantages in terms of sustainability. Sustainability in architecture has mostly dealt with physical aspects so far, but discussion of sustainability need to be extended to non-physical aspects like social sustainability, because floating buildings are to be used by people with various purposes.

Sustainability of floating architecture can be summarised as durability to a rise in water level, long term usage due to movability and relocation, and various applications of renewable energy sources in the environmental dimension; economic advantages due to prefabrication and modular construction, and economic efficiency due to high utilisation rate through global mobility in the

Figure 6. Oregon Yacht Club.

economic dimension; and residents' psychological comfort, security against crime, and high sense of community in the social dimension.

Disadvantages of floating architectures should be investigated in depth and countermeasures to overcome these are suggested for further study. For example, a wet environment may cause residents health problems and deterioration of the building exterior material. Therefore some measures of dehumidification and wetproof building materials are to be considered. Sometimes a floating building on the water may have negative effects on the eco-system. Floating buildings cast shadows onto the water and are sometimes obstacles to the paths of fish like salmon. So the appropriate distance between floating buildings needs to be identified and appropriate types of pontoon and mooring systems need to be considered.

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