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FLOATING BUILDINGS REVIEW AND DESIGN APPROACHES

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Abstract. In recent years the shortage of housing is observed in a real estate market. The main reasons of this problem are the increasing population and deficit of building land. In many countries deficit of building land is related not only to territory size but to peculiarities of relief and climate, number of water bodies, floods possibility, etc.

Floating architecture is the modern trend in building industry, which became the solution for current problems in many districts, cities and countries. In future floating structures could be a resolution of providing with dwelling is areas subjected to consequences of rising sea level in the context of the worldwide climate change.

The main advantages of floating houses are: favorable ecological conditions for living, mobility, autonomy from city service lines, absence of necessity to allocate land for the construction and opportunity to use of renewable energy sources (water, solar).

The experience and the future projects of building on water, peculiarities of floating house structure and design are presented in the paper.

Floating structures review. Floating structures have been developed in such countries as Netherlands, France, Italy, Canada and others, as an alternative to traditional land-based housing. The pioneer of this field of building industry is the Netherlands which half territory lies below sea level and is protected from flooding by numerous dykes and dams. About 200 floating homes per year are built in the Netherlands at the present time.

One of the largest projects of construction on the water is experimentally district Ijburg (Netherlands) by architectural bureau Marlies Rohmer [1]. Floating houses are constructed at the dockyard and then transported to a place of mooring (fig. 1, a).

The largest companies of floating structures design in Europe are Attica Architekten, Architectenbureau Marlies Rohmer, Aquatecture, Waterstudio, +31 Architects (Netherlands), AquaDomi (France), Marinetek (Finland). Their projects are buildings of different purposes and various architectural and design solutions. The most widespread are civil buildings (commercial, sports and entertaining complexes, hotels, offices, etc.) and private low-storey dwelling houses for one or two families (fig. 1, b, c) [2, 3].

The quite new direction in this field of industry is construction of completely self-sufficient floating cities which would be located at the open sea (fig. 2). Such futuristic projects are proposed by Vincent Callebaut (France) [6], Seasteading Institute (the USA), Shimizu (Japan) and others as possible solution of many environmental problems, like rising sea levels, increasing temperatures and dwindling resources. The floating city would use the renewable energy

technologies, including solar, thermal, wind, tidal, and biomass to produce more energy than it consumes. One floating city can accommodate up to 50 thousand people.

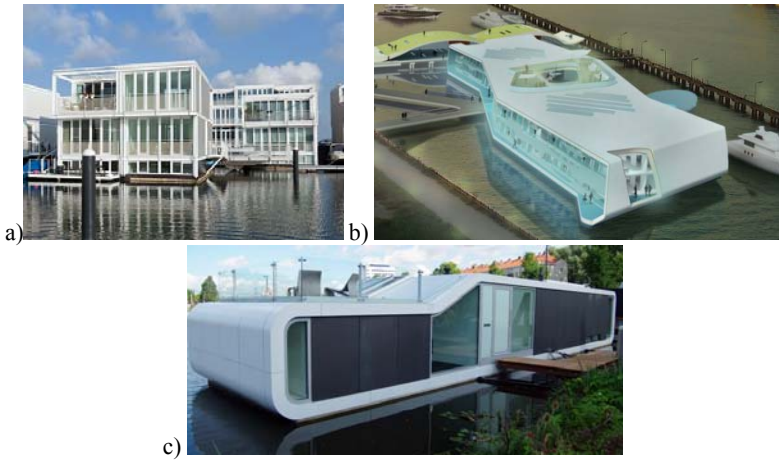

Fig. 1. Floating buildings designs: a) district Ijburg (Netherlands); b) floating hotel (AquaDomi, France), c) private dwelling house (+31 Architects, Netherlands)

Fig. 2. Floating city "Lilypad" (Vincent Callebaut, France)

As the solution of the over-population in modern megacities the creation of the global system of cities in the sea was proposed by American engineer Jacque Fresco [4] in the context of The Venus project (fig. 3). Apartment water-based building would be built of concrete, steel, glass, and a wide variety of new synthetic materials in the accordance to the principles of sustainable development. These

structures could accommodate many millions of people and relieve the land based population pressures. Buoyancy of floating city elements ensures by air chambers in the inner constructions.

Fig. 3. The Venus Project – Cities in the Sea (the USA)

Many authors, such Erica Williams [5], Vincent Callebaut [6] et al., also have suggested that the construction of autonomous floating cities in the future could become a solution of the housing problem in island countries and many coastal cities that are subjected to flooding due to rising sea levels.

The concept of floating disaster-proof lens-type house was proposed by Shauki Bagdadi, Sergey Ermolchik (Russia) [7]. This project provides the increased protection from natural disasters. Lens-type house is a reinforced ellipsoid shell, which is used for private low-storey dwelling house or for disaster-proof communities organization (fig. 4).

Fig. 4. Floating disaster-proof lens-type house (Russia)

I. Ekonomov [8] presents the design principles of modern architectural design solutions and technological organization methods of low-rise residential buildings on the water. Author also considered the possibility of floating houses application for safety dwelling construction in the regions with complicated hydrological situation owing to floods

In recent years the construction of floating buildings and structures is gaining popularity in Ukraine too. From the existing world experience, the construction on water is very promising branch of industry. At the same time the questions of design, erection and exploitation of these structures are not developed.

General design approaches. The characteristic feature of the floating building is integration of the functional characteristics of the traditional land-based house and boat. There are two structural parts in the floating house – under-water and above-water (fig. 5). Under-water part is the floating platform, which is the foundation of the building. Above-water part is the superstructure, in which living quarters is situated.

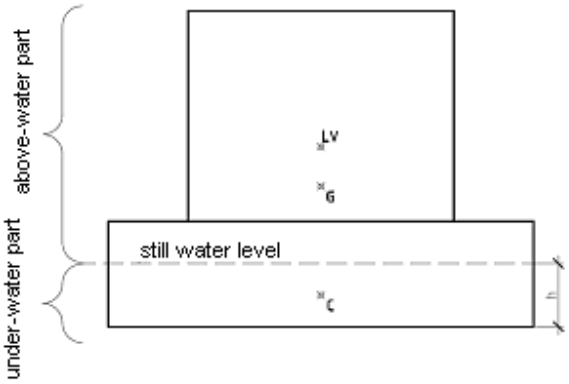

Fig. 5. Geometrical parameters of floating house

The analysis of the existing architectural and structural solutions of floating houses have shown that the superstructure is the standard, in respect to construction industry, low-storey building, which satisfies the modern demands to inner area planning and ensures comfort conditions for habitation.

On the one hand, the purpose of any house design is to provide its strength, stability, durability and energy efficiency. But from the other hand, in accordance to Shipping Register of Ukraine classification, the floating house is a dumb vessel. Thus the main objective of floating house design, in addition to just listed demands, is to provide the safe exploitation in compliance with shipbuilding standards.

Floating building is designed in accordance to “Code of small vessels classification and construction” [9] if its length does not exceed 24 meters and

accommodate no more than 12 persons. In a case of exceeding these parameters, the house is designed in accordance to “Code of inland waters vessels classification and construction” [10].

According to shipbuilding codes, the main exploitation characteristics of floating building are listed below.

Buoyancy is the ability to float with certain water-line and minimum acceptable free-board for prescribed placing region, dimensions and construction in a state of maximum loading.

Stability is the ability of floating house, which is overbalanced with any external influence, to return to original state after the termination of this impact.

Floodability is the ability of floating house to maintain buoyancy and stability in a case of flooding of one or several modules, which is created by watertight bulkheads. This characteristic is provided with the reserve of buoyancy.

Reserve of buoyancy is the value of watertight building volume, which is located above the still water level.

The main geometric parameters of floating house are given below.

Draught (h) is the distance from the bottom of under-water part of floating building to the still water level.

Gravity center (G) is the point of resultant gravity forces of floating house elements application.

Center of buoyancy (C) is the point of Archimedes force application, which coincides with gravity center of under-water part.

Windage center (LV) is the gravity center of floating house superstructure projection onto longitudinal (diametric) surface.

Windage area is the area of above-water part projection onto surface which is normal to the still water level.

The calculation and control of buoyancy, floodability, stability, free-board, windage area, different and heel are carried out during the floating house design. The calculations are taking into account the maximum weight of building including equipment, furniture and maximum number of persons.

In comparison with land-based buildings, the constructions of floating house are subjected to intensive external influences which are caused with wind, snow, waves, ice and solar radiation. Consequently the particular requirements are made for strength, corrosion resistance, watertightness, frost-resistance of the structures of floating house.

Despite the popularity of buildings on the water, currently a small number of scientific works devoted to the researches of the design and construction of floating buildings.

For the design of floating structures CAD systems are used. The most widely used are CATIA (France), NAPA (Finland), ShipConstructor (Canada), Sea Solution, Anchored Structures (Russia) etc. Program modules of these systems allow to calculate and analyze the characteristics and loads on floating structures, to carry out the calculations of overall and local strength of steel hull and its parts. But listed-above systems are used for industrial and transport floating structures design (cruise ships, transport ships, pontoon cranes, barges, etc). Thus the possibilities of

such CAD systems can not be used for floating dwelling houses design in full measure.

Conclusions. Floating houses are designed with taking into account the demands of building and shipbuilding industries. Science-based criteria for the rational design of such buildings are actually absent. Unified design code of floating house elements does not exist. Consequently, for application of floating house there is a need to development of normative-technical documentation and common design methods for floating dwelling buildings.

REFERENCES

1. Architectenbureau Marlies Rohmer. Waterdwellings IJburg. http://www.rohmer.nl/?view=detail&pageAlias=projecten&subAlias=highlights&naamLetter=&jaarId=&werkveldId=&stadLetter=&landId=&projId=24.
2. AquaDomi™ est le bateau-logement de l'avenir. http://aquadomi.fr
3. +31Architects. Waterwilla de Omval. http://www.plus31architects.com/default.asp?menu=project&id=29&n=1.
4. The Venus Project. Cities in the Sea. http://www.thevenusproject.com/en/technology/cities-in-the-sea.
5. Williams, Erica, "Aquatecture: Architectural adaptation to rising sea levels" (2009). Graduate School Theses and Dissertations. http://scholarcommons.usf.edu/etd/85.
6. Lilypad, a Floating Ecopolis for Climate Refuges. http://vincent.callebaut.org/page1-img-lilypad.html.
7. Катастрофоустойчивый дом – Концепция. http://www.dom-linza.ru/ru/concept.
8. Современная типология архитектурных объектов на воде. / Экономов И.С. // ACADEMIA . Архитектура и строительство. - 2010. - №4 С. 47-52.
9. Правила постройки и классификации малых судов (в 4-х томах). – К.: Регистр судоходства Украины.
10. Правила постройки и классификации судов внутреннего плавания (в 4-х томах). – К.: Регистр судоходства Украины.