reviewed paper

Floating Architecture and Structures – an Answer to the Global Changes

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1 ABSTRACT

Currently a contradictory global situation takes place. The climate and social changes are progressing. The sea level is rising by the smelting of ice and the extension of ocean owing to the temperature rise. This means: the building ground reduces above all things in costal and river districts. On the other hand the mankind and its claims with regard to living room is growing and more building sites are necessary. A smart solution for the conflict situation is the floating architecture. This means floating settlements and cities. In the consideration should be taken also so-called amphibious and floatable houses as a solution in case of floods in river destrics. Technical and social questions must be investigated. Some examples for the problems are demonstrated in the paper.

2 INTRODUCTION

Smart me up! In case of sea level rise and increasing frequency of destroying floods the floating houses are an innovative idea for coastlines and river districts in times of global climate change (Strangfeld, 2014). The idea of floating settlements should be transfered ino the praxis. Then a lot of problems refering technique, administration and social behaviour of the user of floating equipments are to operate.

For the moving building ground there must be investigated for instance the following main points:

- Investigation and development of materials and constructions
- Selfsufficency with regard to supply and disposal
- Safety of users and construction, pontoons should be investigated with regard to fire protection, waterwaves, water chemistry and ice formation,
- Adaptation of architecture and design to the regional and national conditions
- Environmental protection
- Economic aspects

3 GLOBAL CHANGE

The statement of the last report of the IPCC is clear: sea-level rise is expected to continue both faster and more intense than previous forecast. Even with a drastic reduction of greenhouse actions of the world community, the process of sea level rise will continue for many decades and infrastructure threaten. In this process is between the cause and its effects a phase shift of up to more than a hundred years (IPCC, 2013). Regardless of the loss of human settlements owing to desert wandering and sea level rise (fig.1 and 2), the demand for land increases due to global population growth (fig. 3) and the increasing demands of the people with respect to living space and leisure culture.

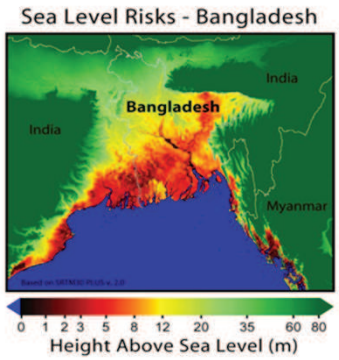

Fig.1: Examples of threaten of land by rising sea level, Fig.2: The Netherlands and Bangladesh

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Even in the industrialized nations with declining birth rate several 100ha areas are additionally sealed daily. On the other hand are available unused industrial ports, channels and newly created mining lakes for floating structures. More than 70% of the earth's surface is covered by water and this area is growing.

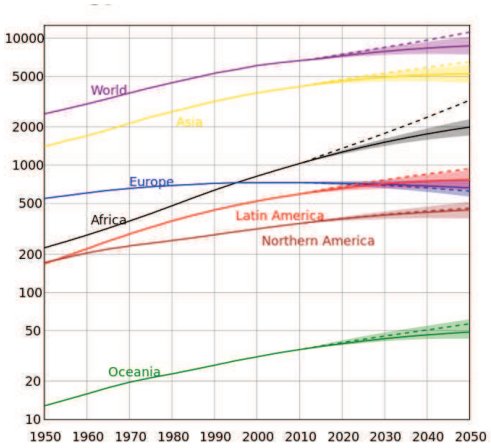


Fig. 3: Course oft the world population acc.U.N. (Bundeszentrale für politische Bildung, 2010)

According to recent research (Klingholz, 2016), the number of children per woman is clearly correlated with the educational level of a country. With education initiatives in developing countries, the absolute number of the world's population could therefore fall back even again. How teaches the situation in the industrialized nations the requirements for building ground, including the infrastructure will continue in spite of everything to grow. This means in context with the climate change, a settlement from water surfaces is expected to continue

4 FLOATING ARCHITECTURE

4.1 History

The global history of floating houses is very complex and widespread almost all continents (Stopp, 2012). The technique and architecture of these buildings all over the world depend on the climate boundary conditions, the culture and the raw materials, which were available at the different local places, e.g. (fig 4). The historical situation in Europe is relatively simple: at the beginning there were houseboats, which were in many cases originally used as barges before. Asia has much longer history of floating architecture. Yet owing to the Asian mentality the documentation is very meagre and the records are only rarely available.

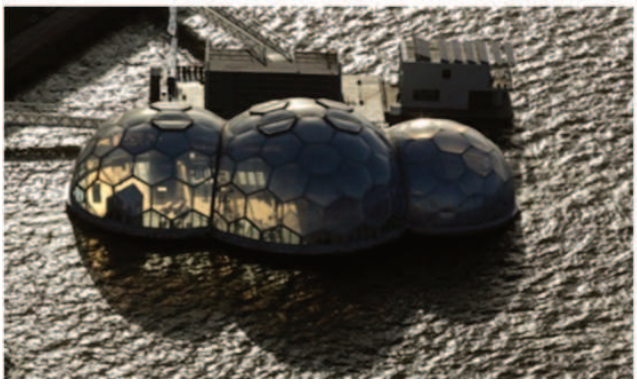
Fig. 4:“Life on the water in Asia“, photography: Gerold Noack

4.2 Current situation

All over the world there are efforts underway the image of districts to impove by means of the floating architecture. Modern floating buildings are constructed with accordance to all sanitary requirements and are made with the newest technologies and materials, compared with floating houses-boats, fishmarkets and other traditionall floating constructions (Völker, 2015).

Following figures represent views of the most extraordinar and functional contemporar residential and non-residential products (e.g. congress centre Rotterdam, fig. 5) of floating architecture. A very interesting idea

could be a floating stadium, fig.6. After the use of the world cup it is possible to transfer to anorher place in order to use for the next event. Unlike many other sport facilities by this the utilization is increased. Another one unique object is a floating research station. It is situated nearby river Rhine- the first “plus energy house on waterr”, which aims to win energy only from environmental sources (fig. 7). The floating church in figure 8 was erected at the ground before the water was coming. It was fixed by means of long steel chains on concrete cubes. With the flooding the object was rising. Touristic examples, shown in the figures 9 and 10, demonstrate the situation of the Lusatian Lakeland in the eastern part of Germany.



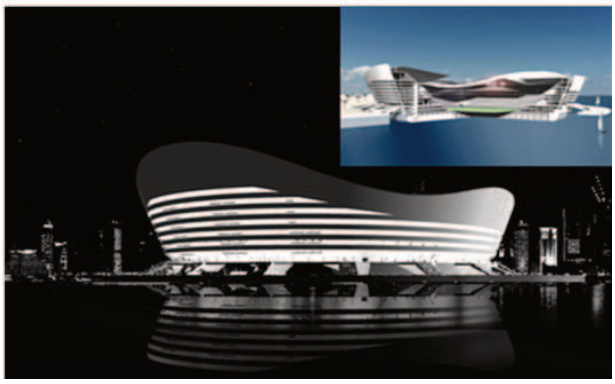


Fig. 5: Floating Pavillon, Rotterdam J.W. Roel, FlexBase, Fig. 6: Floating soccer stadium, world Cup 2022 in Quatar, designed by Peter Knoebel, Düsseldorf

Fig. 7: Floating research station on a former opencast gravel mining, nearby Kleve/ Rhine, Fig. 8: Floating church installed in area of “Neu-seenland” nearby Leipzig

Fig. 9: Lusatian landscape, the largest artificial created Lakeland in Europe, Fig. 10: Floating house typ „Ar-che”, Lusatian landscape, marina Geierswalder Lake

Being the world leader in producing of floating constructions and accepting floating objects by laws The Netherlands has not only world famous “boat- houses”, appeared at the end of 19th century, but also a lot of modern communities on the water and non-residential floating objects with annual constant production of 300 nowadays. “IJburg neighborhood” is a community on water in the capital of the country for more than 45000 residents.

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5 SCIENTIFIC TASKS

As shown in the chapter before up to now the floating architecture is erected and designed with a hightech style. In most cases the supply and disposal is carried out by means of the infrastructure of landside. But if we look for settlements with thousands of people we have to develope a self-sufficient community. This means new ideas of construction, new materials and above all things inexpensive products including infrastructure.Having unusual boundary conditions floating architecture causes new problems to be investigated and solved. Among of them there are themes of balance on the water, fire protection, energy supply and smart implementation of environmental sources, ice formation protection and utilisation. The scientific group of the Institute for floating buildings IfSB of the BTU Cottbus carries out experiments and scientific studies to improve conditions in floating constructions and its safety.

5.1 Safety of users and construction

The building ground, partly strong moving and sometimes covered by ice, must be considered by the people. It is most important for children, old humans and also guests. The techniques for this demands must be developed and installed. On the other hand the picture in the fig. 11 symbolizes the possibilities of the adaptation of the man to his environment. It is demonstrated the two-handed activity and at the same time the locomation across the lake by an active leg. The adaptation is also necessary with regard to the waste in context with a very sensitive natural environment.

Fig. 11: Inle Lake in Myanmar, so-called one-leg angler when fishing. Photography Andrea Staar

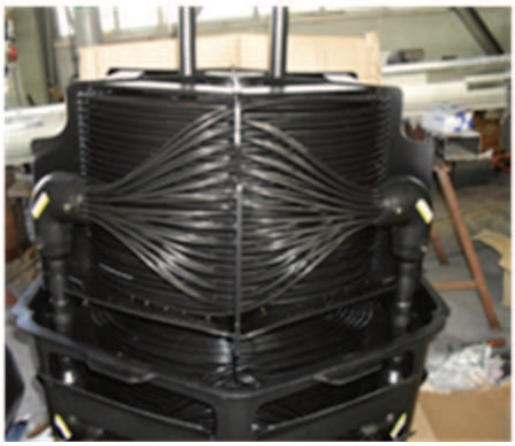
5.2 Selfsufficency with regard to supply and disposal

One of the undeniable advantages of floating objects is their location direct on water – a huge energy source under the floor. By having high comfort requirements modern floating houses should be supplied with energies of different types and levels. The investigations of the IfSB are aimed at optimizing the heat- and mass transfer processes of underwater heat exchangers to improve the energy efficiency of the whole heat-supplying system. Two types of heat exchangers have been examined, (Malakhova, 2016).

“Compact” heat exchanger can be described as a coil of thin plastic pipes in figure 12 with a whole length of about 1040m, constructed in plastic envelope and installed in different depths under water.

“Spiral” heat exchanger is a spiral- formed pipe with a diameter of pipe, diameter of spiral and whole length of 30mm, 0,65m and 44 m correspondly. Two spirals of this heat exchanger are constructed directly between three parts of the pontoon in figure 14 of the floating house represented in figure 10.

Experiments on heat exchangers are assisted by theoretical investigations and simulation of thermodynamic processes, which helps to optimize form, materials, mass flow rate and heat-storage medium in underwater applications and to minimize the measurements and experimental investigations.



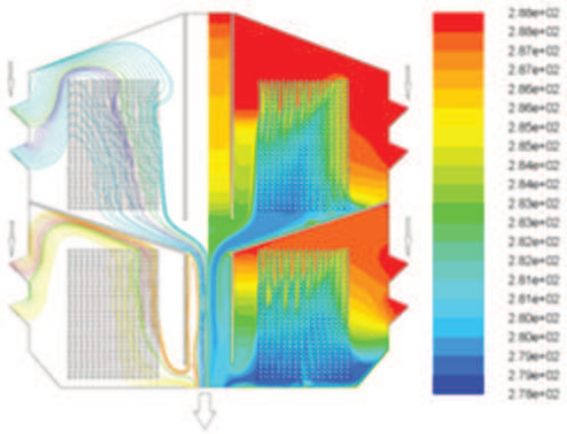


Fig. 12: “Compact” heat exchanger without envelope, Fig. 13: Approximate two- dimensional numerical simulation of the temperature distribution

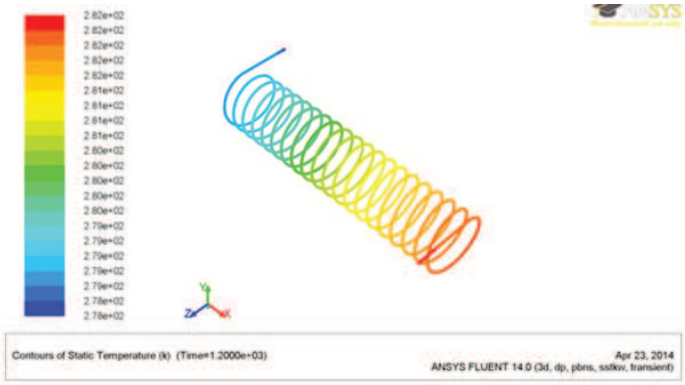
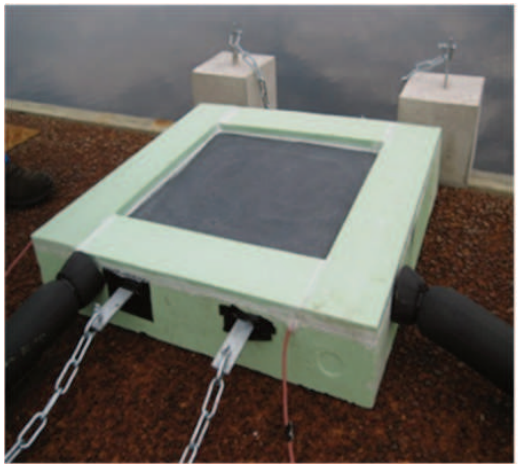


Fig. 14: Process of constructing of two spirals- heat exchanger between of three parts of pontoons, Fig. 15: Simulation of heat- mass transfer processes in spiral underwater heat exchangers in software ANSYS FLUENT 13.0

Another scientific study in the field of sustainable energy supply of floating houses is a plate heat exchanger with concrete elements which is integrated in underwater envelope of house or in underwater part of pontoon to win energy from lake water as an innovation for floating houses (Kiesche, 2016).



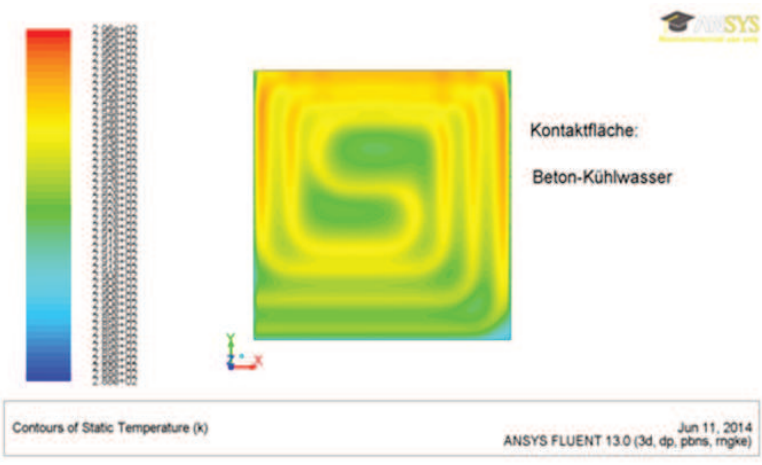


Fig. 16: Plate-shaped underwater heat exchanger with anchor and thermally insulated flow and return pipe, Fig.17: Simulation of heat and mass transfer processes in plate-shaped underwater heatexchangers in software ANSYS FLUENT 13.0

5.3 Ice protection

Pontoons of floating houses on the Geierswalder Lake (fig.10) are attached at vertical metallic beams in the water, which are making it possible for pontoons to move vertically up and down. This need is caused by changing of water level in lake. Ice formation on water surface in winter can be dangerous and problematic

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for free moving of pontoons and their connections. As a solution to predict and escape ice formation, it is proposed a solution by means of the heat pipe method, fig. 18, 19. This application is based on thermodynamic properties of a special water- alcohol mix, which is holding on the temperature of the water around of beams on non-freezing level.

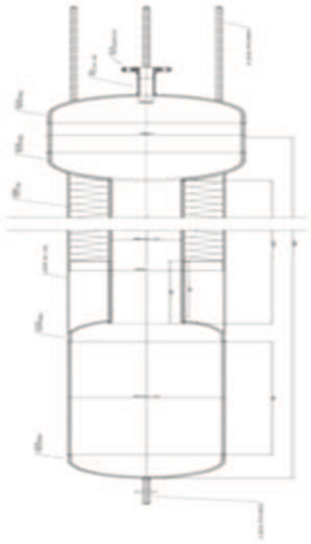
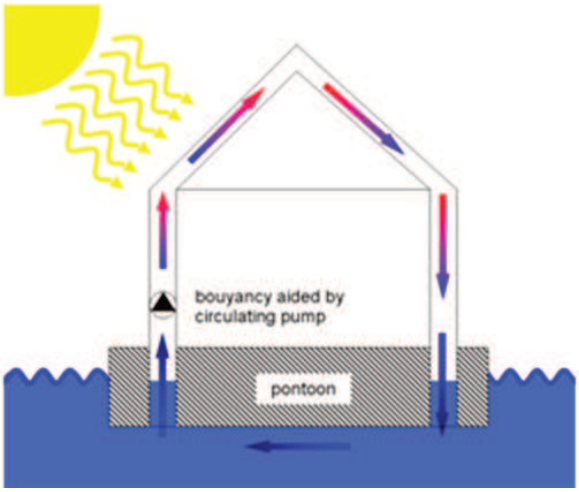


Fig. 18: Heat pipe of vertical beam for predicting of water freezing, Fig. 19: Scheme of heat pipe

5.4 Thermal activation of construction's elements

Lake water can be used for heating during the cold season and cooling of buildings in summer time. The system consists of pipes with lake water inside, integrated in elements of outside constructions. Solar radiation power on pitched roofs is not symmetrical with respect to both sides, what causes difference of temperature and, therefore, difference of water density in different parts of outside envelope. Low density of water on heated side and high density in another one activate moving in cooling circle, which is supported by additional pumps. In this way the process of circulating of water in elements of outside construction is going.



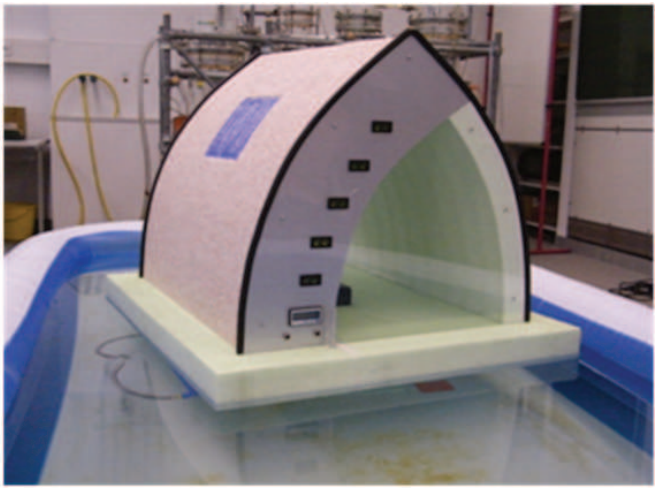


Fig. 20: Schedule of water circulation in cooling system, Fig. 21: Mini- model of floating building with active thermal components

5.5 Underwater part: investigation and development of materials and constructions

The most important but also the most sensitive element of construction is the pontoon of a floating house. This part of building should not only hold the balance on the water in case of water waves, but also be protected from aggressive lake water of former open cast minings or other industrial waters. The contact by water can be dramatically. The figure 22 shows results of permanently mounted floating concrete elements. So the water-air changing zone is independent from the water level of the lake.

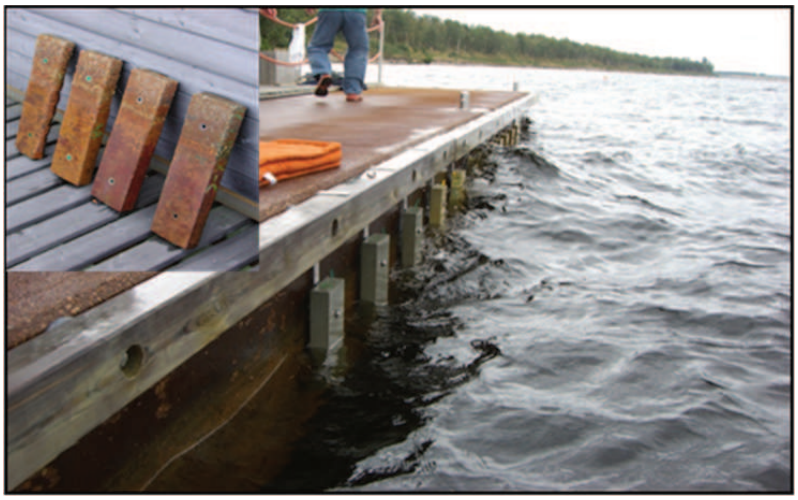


Fig. 22: Concrete samples produced by different concrete formulation after two years contact with water in lake of the former opencast mind

Experiments (figure 23) and simulations of mechanical behavior of pontoons regarding to water waves, carried out by Institute of floating constructions at the institution IfSB, BTU Cottbus- Senftenberg allow its scientifical group to optimize underwater parts of constructions and to predict dangerous influence of water.

Fig. 23: Experimental investigations of water wave's imitation and pontoons moving. IfSB, BTU Cottbus-Senftenberg

6 OUTLOOK + CONCLUSION

Owing to sea level rising, growing of total population of the world and its claims with regard to living space the settlement of water surfaces take place. In opposite to the need in most cases there are designed and built expensive buildings of floating architecture.

In a current project "Autartec" a new typ of floating house for the Lusatian Lakeland is developed and installed 2017. It is designed in a modern styl and represents the possibilities for a self-sufficient supply and disposal with regard to energy and water. More than 15 collaborating partners of the local industry and sientific institutions of the southern Brandenburg and eastern Saxony of Germany are looking for a sustainable solution.

Besides of residential building on water, demonstration floating nuclear power plant based on China National Nuclear Corporation's (CNNC's) with small reactor ACP100S will be built by 2019, according "World nuclear news" (World Nuclear News, 2016).

But how to become a smart city in a lot of districts of the world for the future? Above all things there must be developed and installed simple and payable floating buildings. They should be adapted to the environment with corresponding materials of the surrounding landscape. In addition the floating cities should use the

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alternative energies of the water and generate a cycle of water consumption in order to respond to the global changes properly and in time.

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