TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
ARCHITECTURE | ARCHITEKTURA
8-A/2014

LIUDMILA RUBAN*

THREE STATES OF WATER: HOW TECHNOLOGY MAKES "WATER" A CONSTRUCTION MATERIAL

ZASTOSOWANIE WODY W ARCHITEKTURZE WSPÓŁCZESNEJ: NOWE PODEJŚCIE DO MODELOWANIA PRZESTRZENI

Abstract

Analysing European buildings, the author notices a new approach to the use of water in contemporary architecture and landscape practice. The modern experience of space modelling with three states of water (solid, liquid and vapour) extends the concept of "architecture of water" incorporated into design practice in the late twentieth century. Properly shaped, technologically advanced solutions of water spaces become an important element in the formation of architecture and landscape.

Keywords: architecture, landscape architecture, architecture of water

Streszczenie

Analizując europejskie realizacje architektoniczne, dostrzega się nowe podejście do zastosowania wody w architekturze współczesnej i kształtowaniu krajobrazu. Nowoczesne doświadczenie modelowania przestrzeni w trzech stanach skupienia wody (stały, ciekły i para wodna) poszerza koncepcję „architektury wodnej" włączanej do praktyki projektowej końca XX w. Odpowiednio kształtowane, zaawansowane technologicznie rozwiązania wodnych przestrzeni stają się ważnym elementem kształtowania architektury i krajobrazu.

Słowa kluczowe: architektura, architektura krajobrazu, architektura wodna

* Ph.D. Arch. Liudmila Ruban, Kiev National University of Construction and Architecture (KNUCA), Kiev, Ukraine.

1. Introduction

Water is the key vital element to life in the Earth. It plays the great role in many aspects of human life, and in architecture and design as well. Architects, designers and, especially, landscape architects, always pay a special attention to water, as aesthetically all sufficient and decorative element of environment. At the end of 20th century we have noticed the surge of professional interest to the "architecture of water" and this interest still continues unabated. Moreover, recently emerged technologies give us an opportunity to reconsider our attitude to the "architecture of water" as not only a decorative environmental element [1]. Modern technologies show new possibilities of using water in construction – as a kind of constructive and creative material and as an informational carrier.

Water has a great number of unique properties. For instance, it is the only natural substance that appears in nature in all three common states of matter: solid, liquid, and gas. With each of these states we may encounter every day – snow, ice, water, clouds, fog and many other forms. And these three states of matter will be a departing point of our research.

2. The aims of research are:

- to explore the possibilities of new technologies of modelling the architectural space that appear on the market in the past decade, on the basis of the three states of water: gaseous, liquid and solid;
- to reveal the modern trends in architecture, landscape planning and building field on the basis of systematization of received data;
- to expand boundaries of a notion "architecture of water".

3. Water as a primary construction material

The first part is dedicated to the review of water as a primary construction material. Architects, designers, artists often put themselves highly creative goals, and modern technologies help to reach them.

3.1. *Vapour shell*

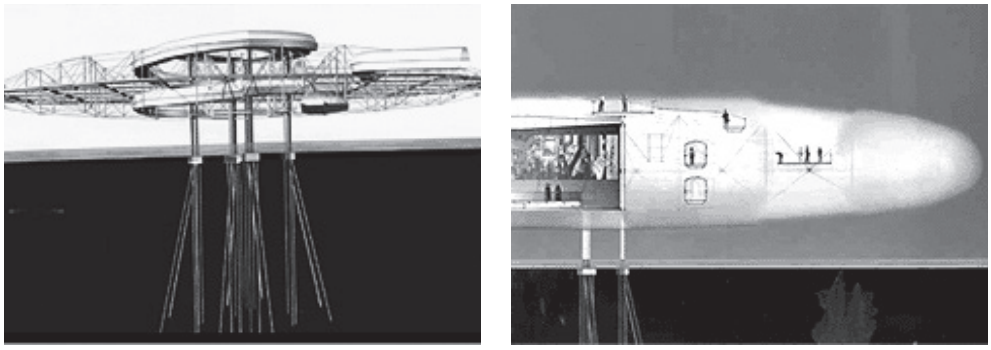
The Blur Building was a temporary media pavilion built for the Swiss Expo 2002. The authors of the idea – architects Elizabeth Diller and Ricardo Scofidio won the competition for the site in Yverdon with the idea of making an inhabitable cloud whirling above the water surface of the lake Neuchatel [2]. It is a great experience of design the construction, softly embraced by using vapourised water shell.

The idea is the following. The framework of a cloud is a system of rectilinear struts and diagonal rods cantilevered over the water. Rising out of Lake Neuchatel, a system of rectilinear struts and diagonal rods cantilevered over the water. The form is based on the work of Buckminster Fuller. The rods were fitted with over 30,000 fog nozzles shooting a fine mist pulled from the lake and controlled with a complex weather system. This fog

a) b)

Ill. 1. The Blur Building – a media pavilion for Swiss EXPO, Lake Neuchatel, Yverdon-les-Bains, Switzerland, 2002 by Diller + Scofidio + Renfro: a) computer sketch of the 'blur building' b) aerial view of the 'blur building' on lake Neuchatel, 2002 (courtesy of Diller and Scofidio) [2]

a) b)



Ill. 2. The Blur Building – a media pavilion for Swiss EXPO, Lake Neuchatel, Yverdon-les-Bains, Switzerland, 2002 by Diller + Scofidio + Renfro: a) the construction of the artificial cloud; b) longitudinal section of the 'blur building' (courtesy of Diller and Scofidio) [2, 3]

created a man-made cloud that encompassed the metal framework to create the illusion of a vaporous building measuring 300 ft. wide and 65 ft. high [3]. A built-in weather station controls fog output in response to shifting climatic conditions such as temperature, humidity, wind direction, and wind speed.

Unfortunately, contrary to the Eiffel Tower, which was also initially build as an exhibition exponent and was lucky to left forever, this perception-altering exhibition was not built to be a permanent structure, and no longer exists.

3.2. *Liquid walls*

Sometimes designers are able to create things that other people would not even dream about. Engineers from MIT (Massachusetts Institute of Technology) wanted to create a kind

of building which could be flexibly adopted and may easily transform its shape in accordance to frequently changeable needs of people. Why not to use water as a main construction material for this purpose? Indeed, water is flexible enough and usually a liquid. So, a team of architects, engineers and inventors from the MIT in cooperation with their partners have constructed such liquid building for Zaragoza World Expo 2008. The Expo's theme was "Water and Sustainable Development", focusing in part on water as a unique resource, water for life, waterscapes and shared water. To achieve such previously unbelievable level of flexibility they combined 2 extremely different themes: good old water and modern digital technologies. The construction is called Digital Water Pavilion (DWP). It was an interactive structure made of digitally-controlled water curtains with exhibition area, tourist information centre and café inside [4].

The water walls that make up the structure consist of a row of closely spaced solenoid valves along a pipe suspended in the air. The valves can be opened and closed at high frequency, via computer control. The result is a space that is interactive and reconfigurable. So, each wall can potentially become an entrance or exit, while the internal partitions can shift depending on the number of people present. The walls are composed of digitally controlled water droplets, which can generate writing, patterns or access spaces. Designers of the digital water pavilion (DWP) describe it as a "building made of water" that "features liquid curtains for walls". The water "curtains" can be programmed to display images or messages and also can sense an approaching person and open a doorway to let that person enter without getting drenched.

"All the walls of the pavilion were made of digital water, as vertical partitions on the edge of the roof and inside it. The pavilion roof, covered by a thin layer of water, was supported by large pistons and can move up and down. When the pavilion is closed, the roof just collapses to the ground" [5]. DWC is designed to be placed outdoors and endure all types of hard weather conditions: rain, wind, heat, even mildly cold weather around freezing temperatures. Wind does not affect the DWC performance.

a) b)

Ill. 3. The new digital technologies of "water walls": a) Digital Water Curtain® was created by Lumiartecnia Internacional, 2008 [4–6]; b) the AquaScript technology was created by German artist Julius Popp, 2007 [7]

"The DWP is the first attempt to use water walls on the architectural scale. Moreover, in the DWP water walls are not used merely as a decoration. In fact, they are a key element in the creation of changeable spaces and they act as a medium of communication", said Matteo Lai, a member of the design team from architectural firm Carlo Ratti Associati of Turin, Italy [4]. The Digital Water Pavilion was selected as Time magazine's "Best invention of the Year" in the field of architecture when its plans were unveiled in 2007. It was a pioneering construction of its kind and illustrated the potential of digital architecture in creating dynamically transformable spaces.

The fantastic creature of MTI wizards cognates with another interesting technology called AquacSript. Well-known English metaphor "writing on water" always used to refer to something transient quickly passed away and untrustworthy. AquaScipt has proven this old stereotype is no longer valid. It was presented to public in 2007 at Tokyo Bay Monster-fashion show by German engineer Julius Popp [7].

The AquaScript information waterfall uses bitmap-rendered water streams to show both text and images in an engaging display. The basic AquaScript module is 2 meters long with a number of magnet-valves that can expel single water-drops on demand. A proprietary computer system and software synchronizes the valves so that the falling water-drops result in a freely definable bitmap-muster. Installation of AquaScript is very flexible. The array can be mounted on a rigging truss for temporary installation using half-couplers or also be fitted with bolts for fixed installation. An 8 meter AquaDisplay will use ~60 litres (~16 gallons) of water per minute. This depends on local water pressure and the density of the bitmaps used.

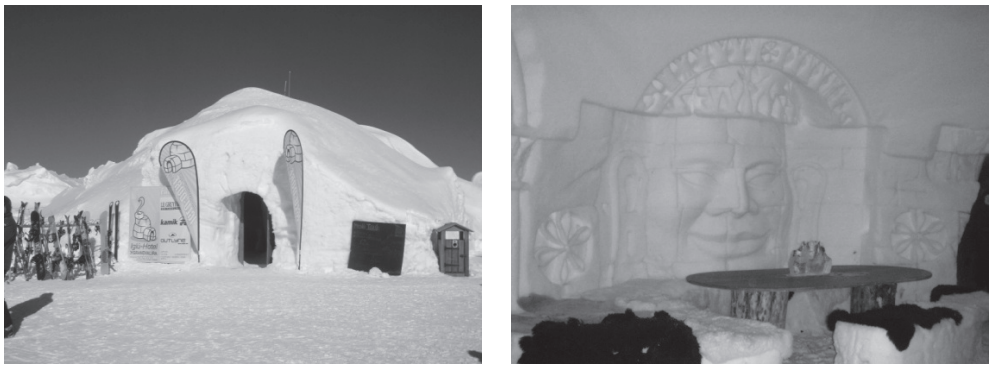
The Digital Water Curtain works as a 'water plotter', computer controlled that displays graphics, patterns and texts by switching fast acting valves on and off. This produces falling segments of water that serve as pixels, creating a surprising display that constantly scrolls downward. Digital Water Curtain® is a brand name created by Lumiartecnia Internacional [6].

3.3. *Ice constructions*

Basically, to be more precise, the usage of the water as a construction material is not purely recent invention. Water in its solid state as an ice or snow was traditionally used by people since prehistoric times. Many northern people, such as Eskimos preserved their tradition of building igloos and units often use ice caves for establishing their settlements. European people, both children and adult, always enjoyed winter season for having a chance to create ice or snow castles and other fun stuff. In fact, inside such cold chateaus it's not so cold as it may be expected.

Until recent times for most of us, the extent of life under ice has been pretty limited or extremely exotic; however, since 1980, the first four ice hotels have set out to change that. Now almost everyone has a chance to feel how to be a true Eskimos. Usually, ice hotels are temporary buildings made up of snow, sculpted blocks of ice and in some cases, some steel framing. Most of the ice hotels are reconstructed every winter, and are dependent upon constant sub-freezing temperatures during construction and operation. "The hotel is usually made (the architecture and size may vary from season to season) in arches of 16 feet (5 m) over rooms. The walls are over 4 feet (1.2 m) thick on average. All furniture is usually also made of ice: the beds, the chairs, the counters, the glasses and more" [8].

a) b)



Ill. 4. The Iglu Hotel and Bar at ski resort Grandvalira, Andorra, 2012: a) the entrance to the Ice bar; b) the interior design of main hall in Ice bar (photos by L. Ruban)

During last decade the Ice Hotels were opened in Sweden, Canada, Alaska (USA), Norway, Japan, Germany, Romania etc. Very often they provide additional après-ski facilities at some ski resorts, for example, in Andorra, Sweden, Norway, Canada etc.

Another popular type of ice-made attraction is ice bar. Today you can warm-up in a cold atmosphere of ice bars in almost all major cities, such as London, New York and others. And you can visit them any season. In Las Vegas, for example, sophisticated technology of maintaining the cold and new generation of insulating materials permitted to locate an ice bar in a middle of a desert – area with 40 C plus degree heat.

Beginning of the 21st century shows a steady development of the Ice Architecture Sector, the appearance of new buildings and facilities, a steady increase in demand for this type of vacation. Strong competition in tourism lead to emerging of new exotic ice objects such as elements of spa centres, churches, chapels, museums, sculptures etc. [8, 9]. The range of ice architecture is constantly expanding and does not seem to stop.

4. Water as the habitat (environment of habitation)

For the complete disclosure of a subject it's necessary to discuss three water states as habitat and design for mankind needs.

4.1. *Ice landscapes*

In 21 century the permafrost territories and glaciers became an attractive location for setting constructions which require natural subzero temperature conditions. Some companies establish their remote computer data centres where computers are cooled naturally without high power consuming cooling systems.

One of considerable events in the development of glaciers became a construction of a Global Seed Vault in Norway, 2008. It became a really distinguished construction not only from an architectural point of view but also for its purpose. The Svalbard Global Seed Vault (Norwegian: *Svalbard globale frohvelv*) is a secure seedbank located on the Norwegian island of Spitsbergen in the remote Arctic Svalbard archipelago, about 1,300 kilometres (810 mi) from the North Pole.

Spitsbergen was considered ideal due to its lack of tectonic activity and its permafrost, which will aid preservation. The storage is located in rocky subsoil at a depth of 120-meter and an altitude of 130 m above sea level, where temperature of –18°C is constantly maintained. Such location ensures that the site remains dry even if the icecaps mel.t According to developers of the project, even in case of a flood, falling of a meteorite or nuclear winter, the bank will be able to keep viability of all samples of a collection. Locally mined coal provides power for refrigeration units that further cool the seeds to the internationally recommended standard –18°C (0°F). Even if the equipment fails, at least several weeks will elapse before the temperature rises to the –3°C (27°F) of the surrounding sandstone bedrock [10].

Each country has own part in the storage. The variety and volume of seeds stored will depend on the number of countries participating – the facility has a capacity to conserve 4.5 million sorts of plants. Svalbard Global Seed Vault ranked at No. 6 on *Time's* Best Inventions of 2008.

4.2. *Underwater spaces*

Life under water always excited admirers of creativity Jules Verne. At the beginning of 21 centuries it became possible thanks to the developed complicated technical solutions and emergence of new composite materials. Many of them were applied at construction of the underwater hotel of a Poseidon Undersea Resorts chain at Fiji (2008). The project was to be the world's first permanent one-atmosphere seafloor structure. 24 undersea suites are accessible by an elevator that takes guests 40 ft. below the surface. Nearly 70 percent of these rooms will be wrapped in 4-inch-thick clear acrylic, providing guests with a more-than-panoramic view of the ocean around them, and guests can use an in-room control console to encourage marine life to their windows with external feeding and lighting options [11]. All guests can use a submarine or a special tunnel from the beach to get into the underwater restaurant, bar, a library, conference room, wedding chapel or spa. Poseidon was conceived and developed by L. Bruce Jones, president of U.S. Submarines, Inc.

The first underwater hotel, which was built in 1986, was Jules' Undersea Lodge located in Key Largo, Florida. However its guests had to scuba dive to get to their room at a depth of 21 feet (6.4 m) under water [12].

4.3. *Indoor vapour*

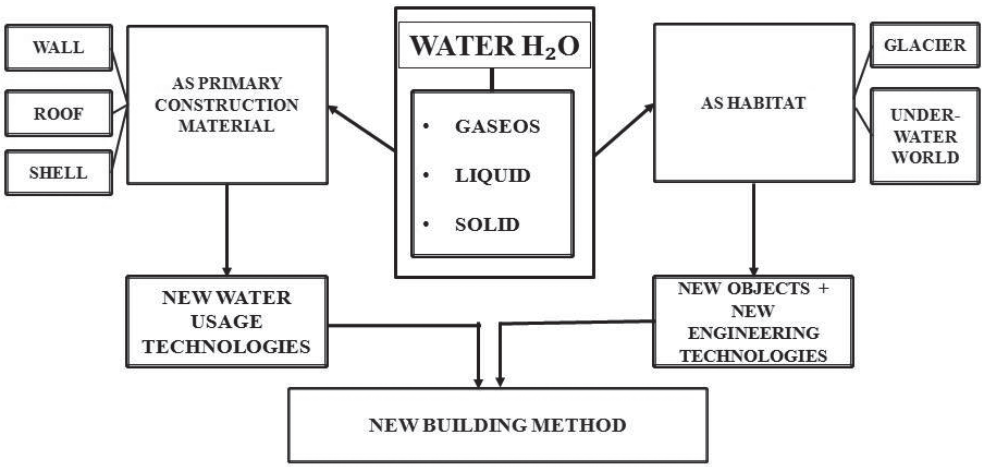
The fact of sustained usage of vapour in architecture relates to the far future. For the present it is not so easy to make a long forecast. Today, painters and sculptors widely use vapour like a creative element for art-installation. That is why the new technology of man-made vapour appeared. Creating clouds indoors is only possible through climate engineering, by applying physical principles at the building scale.

The technology of skilfully created clouds (Nimbus) inside indoor spaces was based on controlling the weather conditions of a room. It is an act that requires meticulous planning entailing carefully controlling the temperature and humidity levels of the room, constantly moistening the air inside it and adjusting the lighting to create a dramatic and realistic effect. The Nimbus was created by Berndnaut Smilde – the artist from Holland in 2010–2012 [13].

Another example of similar technology is represented by so called Cloudscapes by Tetsuo Kondo Architects and environmental engineering firm Transsolar. They have suspended a cloud inside the Arsenale exhibition space at the Venice Architecture Biennale 2010. The installation Cloudscapes was created by pumping three layers of air into the space: cold dry air at the bottom, hot humid air in the middle and hot dry air at the top. The installation formed part of the exhibition People Meet in Architecture, directed by Kazuyo Sejima of SANAA [14].

5. The results of research

We have considered the advanced experience of modelling of the architectural space by usage of water. Main highlights are summarized in the flowchart "Recent trends in the usage of 'water' in modern architecture" (Ill. 5).



Ill. 5. The flowchart "Recent trends in the usage of 'water' in modern architecture" (by author)

It became possible by using of new technologies. The modern technologies connected with the usage of water and the development of unusual environment of habitation such as Arctic permafrost or underwater space represented in the Table 1.

Table 1

Main technologies used in the modelling of architectural space (by author)

Date of appearance	Main technology	Country of realization
2002	DIMENSIONAL METAL FRAMEWORK by BUCKMINSTER FULLER	Switzerland
2002	TECHNOLOGY of ARTIFICIAL CLOUD (THE FOG HIGH PRESSURE NOZZLES)	Switzerland
2007	AQUASCRIPT TECHNOLOGY by JULIUS POPP(Germany)	Japan
2008	DIGITAL WATER CURTAIN® by LUMIARTECNIA INTERNACIONAL	Spain
Since 1980	TECHNOLOGY of BUILDING STRUCTURE MADE UP OF SNOW, SCULPTED BLOCKS OF ICE	all over the world
2008	BUILDING METHOD IN PERMAFROST	Norway, North Poll
2008	UNDERWATER BUILDING TECHNOLOGIES:	Fiji
2008	USAGE OF NEW ACRYLIC MATERIALS	Fiji
2008	TECHNOLOGY of INROOM CONTROL CONSOLE etc.	Fiji
2010	METHOD OF CREATION CLOUDSCAPES by TETSUO KONDO ARCHITECTS AND ENVIRONMENTAL ENGINEERING FIRM TRANSSOLAR (JAPAN)	Italy
2010–2012	METHOD OF CREATION OF AN INDOOR CLOUD NIMBUS by BERNDNAUT SMILDE (HOLLAND)	UK

6. Conclusions

Today it's possible to state, that the first decade of the new century is characterized by a technological shift, when water turned from decorative element into construction material. Water can be used in all its three states of matter, as it was shown by some recent constructional projects.

If, concerning usage of water in gaseous or liquid states – they're newest technologies, such as Digital Water Curtains, Aquascript etc. Water was used for making walls, roofs, vapourised water shell. Today mostly digital technologies worked out to show its potential in creating of dynamically transformable spaces. There is a trend for uniting and combination of several technologies together at the same time. For instance, iron construction may be combined with vaporized system or water flow with climate control technology may coexist with informational carrier.

But regarding solid state – it is a phase of further technological improvement and aesthetic development. Freezing technology and maintaining low temperatures, as well as the emerging of new insulating materials contribute to further spread of ice constructions. The steady occupation of its segment in the construction market is indicated together with extending the construction nomenclature.

Another interesting perspective is the developing of new habitats, like adaptation of glaciers or underwater spaces for living. This becomes possible due to further development of modern engineering technologies, computer software and introduction of new composite materials. The progress in construction technology enables the emerging of functional objects, such as computer data centres or seed storages.

Widespread of water in gas sate is possible, but it's quite a distant future. Today vapour mostly predominates in some art installations, and, traditionally, at SPAs – e.g. in hamams.

In fact, worlds Expos have always been venues to preview new and innovative architecture. Recently emerged technologies give us an opportunity to reconsider our attitude to the "architecture of water". Today the specific water technologies are used to create XXI century's architecture.

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