ISRG PUBLISHERS

ISRG Journal of Arts, Humanities and Social Sciences (ISRGJAHSS)

Abbreviated Key Title: ISRG J Arts Humanit Soc Sci
ISSN 2583-7672 (Online)
Journal homepage: https://isrgpublishers.com/isrgjahss
Volume -1 Issue-1V (July-August) 2023
Frequency: Bimonthly

ARCHITECTURE ON THE WATER

Ahmet Hadrovic

Faculty of Architecture, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

| **Received:** 12.07.2023 | **Accepted:** 14.07.2023 | **Published:** 16.07.2023

*__Corresponding author:__ Ahmet Hadrovic
Faculty of Architecture, University of Sarajevo, Sarajevo, Bosnia and Herzegovina

Abstract

The work EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON WATER) is a contribution to summarizing the author's theory of Architecturally Defined Space (ADS) and the general typology of architecture. The subject covered by this paper is taught by the author at the Faculty of Architecture of the University of Sarajevo through several subjects: Architectural Physics, Bioclimatic Architecture and Conceptualization and Materialization of the Limits of Architecturally Defined Space. In the subject Bioclimatic Architecture, for example, the Author assigns the study of bioclimatic architecture in different geographical areas of the Earth as a student assignment/exam every year. However, as a student, who (in a certain school year) studies one specific location on Earth, does not have an insight into other, countless, locations around the Earth, the Author decided to publish a series of books/textbooks where students, in one place, could have a valuable overview architecture in general. The author is convinced that in this way he not only 'breaks the fear of the unknown' among students, but also encourages them to try to realize their design ideas in 'unusual natural environments', especially since this is the certain future of humanity.

Keywords: Architecturally Defined Space (ADS), Architecture on water

1. Introduction

„According to the Author's understanding of architecture as an Architecturally Defined Space (ADS) with its four basic elements - Environment, Man, Boundaries and Perspectives - a typology of architecture is also proposed according to the way its boundaries (envelope) are defined, and according to the specifics of global natural environments in which man can realize their existence: on Earth (type E) in open space (type S) and on other celestial bodies (type SB)“ [1], (Figure 1).

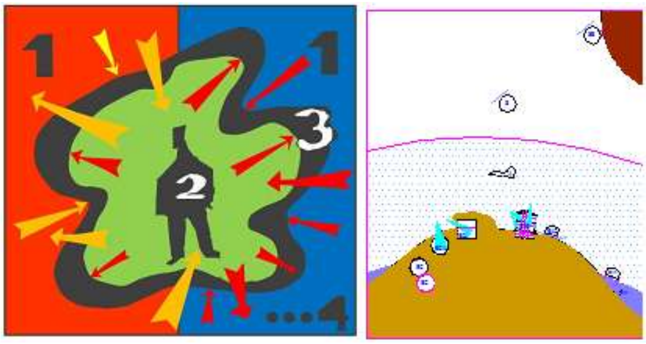


Figure 1. Architecturally Defined Space, ADS (A. Hadrovic, 1987), (left) and Typology of ADS (A. Hadrovic, 2011), (right)

Almost all terrestrial animals have the innate ability to float (swim) on water, and some of them even walk (Figures 2,3). These skills can be explained by purely physical laws, Archimedes' principle and the surface tension of liquids.

Figure 2. The water snake, Halobat (left) and the lizard Jesus Hrish (right) walk on the water

Source: https://bs.thinkfirsttahoe.org/2641-ocean-water-strider.html, Accessed: July 11, 2023.

Source: https://www.facebook.com/JOANIBIZ/photos/a.2082338291992694/2082343611992162/?type=3, Accessed: July 11, 2023.

Figure 3. An elephant (left) and a polar bear (right) swim in the water

Source: https://www.abposters.com/posters/elephant-swim-steve-bloom-v5600, July 11, 2023.

Source: https://www.jonaa.org/content/2019/07/polar-bear-or-aqua-bearAccessed: July 11, 2023.

Man has been in contact with water since his inception, and because of his survival, he not only developed the technique of swimming on water, but also designed various aids (vessels) to overcome water obstacles easier, faster and more efficiently. The people of the Bajau tribe (an area of scattered islands in the sea, on the territory of the Philippines, Malaysia and Indonesia) live in symbiosis with water: they build their houses on the water, the sea is their source of food, and boats are their basic means of transportation [2]. In some parts of the Earth, in the belt of the equator (with a favorable tropical climate), you can still see traditional settlements built over water where people live in close symbiosis with the sea. The sea is a key life resource here, so all segments of people's lives have developed from this fact.

The Bajau people (Bajo), also called Sea Nomads or Sea Jypsies, is a common name for several ethnic groups living in Southeast Asia (mainly the Philippines, Malaysia, Indonesia and Brunei), (Figures 4,5,6). For most of their history, the Bajau lived a nomadic life, sailing around the islands. In Indonesia, the Bajau have lived since the 18th century, spreading across Sulawesi, Kalimantan, the Sunda Islands, the Maluku Islands, the Raja Ampat Islands and the Togeans. In the modern Togeans, most of the Bajau settled and formed small fishing villages. They usually build wooden houses on stilts above the sea along the coast of the island. For centuries, they lived from fishing, and many of them still do it today, although due to extensive industrial fishing, the sea can no longer provide for all families. Bajau are excellent divers. They are able to dive deeper than most people without additional equipment. The most picturesque village is Pulau Papan near Malenge Island [2]. Almost all present-day Bajau claim to be Sunni Muslims. Still, many-mostly the maritime, nomadic Bajau-retain spiritually based religious practices that predate any major religion. In their religion, certain spirit mediums communicate with the spirit world in ritualistic rites of celebration, worship, and exorcism-in which, for example, spirit boats sail the open sea to banish an offending spirit from their community. They also worship the Sea God, Omboha Dilaut.

Figure 4. Children of the Bajau people in boats and diving, in an authentic living environment

Source: https://abysseofficial.com/blogs/journal/the-amazing-story-of-sea-nomads-thebajau-people, Accessed: July 9, 2023

Source: https://www.pinterest.com/pin/120049146286748774/, Accessed: July 9, 2023

Figure 5. Left: a village of the Bajau people. Right: Bajao men spend about 14 hours a day (24 hours) gathering food underwater

Source: https://www.pinterest.com/pin/321233385892939422/, Accessed: July 9, 2023

Figure 6. Left: Bajau boys gather coral. Right: Bajao people praying in the mosque

Source: https://invisiblechildren.com/wpcontent/uploads/2013/03/bajau-lautthe-coral-triangle.png, Accessed: July 9, 2023

Source: https://invisiblechildren.com/wpcontent/uploads/2013/03/bajau-laut-ina-mosque.png, Accessed: July 9, 2023

In the deltas of large rivers, sea lagoons and shallow lakes, settlements of floating islands and sojenicas have sprung up, as a forced refuge or a consciously chosen place of life. Among these settlements are the reed islands of the Uros people on Lake Titicaca, soybean farms in the Mekong Delta in Vietnam, on the Amazon in Iquitos...

Ganvie is a village in Benin, Africa, located in Lake Nokoué, near Cotonou (Figure 7). With about 20,000 inhabitants, it is probably the largest lake village in Africa and is very popular among tourists [3]. The village was created in the sixteenth or seventeenth century by Tofinu people who went to the lake to escape Fona warriors who were capturing slaves to sell to European traders. Making the shallow waters and islands of Lake Nokoue a haven, the villagers of Ganvie are often referred to as the 'water people' and the area itself is often referred to as the 'Venice of Africa'. Ganvie in Benin is a village on the slopes of Sojenica with thirty thousand inhabitants. The Ueme River forms Lake Nokoué, actually a large lagoon that touches the ocean. The lake is shallow near the shore, about a meter deep. The locals of Ganvije push dried palm branches into the bottom, around which fish gather looking for food, and once a week they collect the catch with roller nets. The city on the water of Ganvija has everything a city should have, except for streets, electricity, water supply and sewerage. It has a church, a mosque, a school and hotels, built on earthen foundations brought from the mainland. The houses are raised on stilts two meters above the water; the houses are reached by boats, and they

*Corresponding author: **Ahmet Hadrovic**

are entered via a wooden ladder. The walls are made of wicker, and the roofs are made of reed or tin. Laundry is dried on windows without glass or on poles next to the house. Some families have a garden made of packed earth surrounded by a fence, which also serves to teach children to walk. Traffic on the canals between the houses is very lively, because private visits to the neighborhood are also made by boat. Boats are steered very skillfully by both women and children, rowing or pushing on the bottom with long sticks. Women take the children to school, if the grown-up boys do not do it themselves, go to the market on the coast and supply the households with water from several wells drilled in the bottom. Life in harmony with nature has limitations imposed by the environment. The lake renews its water slowly, so the pollution is high, aquatic weeds are slowly conquering its surface, and there are fewer and fewer fish.

Figure 7. Selo Ganvie u Beninu
Source: https://globalgaz.com/visiting-ganvielake-village-benin/, Accessed: July 9, 2023
Source: https://stock.adobe.com/search?k=ganvie&asset_id=7609242, Accessed: July 9, 2023

Uru or Uros is an indigenous people of Peru and Bolivia (Figures 8,9). They live on an estimated and still growing 120 self-created floating islands in Lake Titicaca near Puno [4]. They form three main groups: Uru-Chipaya, Uru-Murato and Uru-Iruito. The Uru-Iruito still inhabit the Bolivian side of Lake Titicaca and the Desaguadero River. The Uru use bundles of dry reed totora to make reed boats (balsas) and to make the islands themselves. A dozen families live on the larger islands, while the smaller ones, only thirty meters wide, house only two or three families. The islands are made of several natural layers harvested from Lake Titicaca. The base is made of large pallets of floating totora-reed roots, which are tied together with ropes and covered in multiple layers of totora reeds. These dense roots that the plants develop and intertwine form a natural layer called khili (about one to two meters thick), which are the main devices for flotation and island stability. They are anchored by ropes attached to large eucalyptus poles driven into the bottom of the lake; each floating block of khili measures 4 x 10 meters. These blocks used to be harvested with eucalyptus wedges, but are now procured using 1.5 meter custom hacksaws made for the purpose. After the khili-pallets are connected and anchored, more layers of cut cane are added. The bottom layer of cover cane rots quite quickly so new cane is constantly added on top, about every two weeks to three months, depending on the weather. This is especially important in the rainy season when the cane rots much faster.

Figure 8. Left: The Uros floating islands seen from the air, about 5 km off the coast of Puno. Right: Uros harvest totora trisk on Lake Titicaca near the city of Puno
Source:
https://en.wikipedia.org/wiki/Uru_people#/media/File:Uros-floating-islandspuno-peru-aerial.jpg, Accessed: July 9, 2023

Figure 9. All the physical structures the Urosi build are made of totor trisk
Source:
https://www.thestar.com/life/travel/2010/02/25/a_precarious_life_on_the_islands_of_lake_titicaca.html, Accessed: July 9, 2023

Until the 16th century, the Mekong Delta was an area of swamps and forests. Wetland areas were gradually restored and a canal network was built for the cultivation of rice, fish, soybeans, corn, peanuts, tobacco and melons. The Cai Be area is known for its coconut palms and orchards (mango, longan, bananas and citrus fruits), (Figure 10).

Figure 10. Sojenices and market boats in the Mekong Delta in Vietnam
Source: https://www.luxurycruisemekong.com/blog/houses-in-the-mekong-delta/, Accessed: July 9, 2023
Source: https://www.viator.com/en-GB/tours/Ho-Chi-Minh-City/Private-Mekong-Delta-Can-Tho-Discovery-2-days-1-night/d352-18564P6
Accessed: July 9, 2023

Iquitos is a city in the Amazon that has no road connecting it to other cities, making it the largest, most isolated city on any continent. The city can only be reached by plane or boat, with the exception of the road to Nauta, a small town approximately 100 km to the south. It is considered that the city was founded in 1757. It was founded as a Jesuit mission. Iquitos began to grow and prosper through the 'rubber boom' of the first decade of the 20th century. Here, people began to produce rubber from a natural resource - the rubber tree that grows in the Selva Amazon. Plantation owners or

*Corresponding author: **Ahmet Hadrovic**

rubber barons were rich and built themselves luxurious houses, which gave the city a unique style (Figure 11).

Figure 11. A settlement on the Amazon river in Iquitos
Source:https://upload.wikimedia.org/wikipedia/commons/6/6b/Amazonas_floating_village%2C_Iquitos%2C_Photo_by_Sascha_Grabow.jpg
Accessed: July 9, 2023
Source: https://www.perunorth.com/news/2016/4/25/visiting-an-indigenous-villagegood-or-bad, Accessed: July 9, 2023

Man used watercraft for communication in everyday life, but also for work, warfare against other people, for adventures, and later for scientific research (Figures 12-15).

Figure 12. Karavele Christophera Columbusa: Nina, Pinta i Santa Maria
Source: https://www.history.com/news/christopher-columbus-ships-caravels, Accessed: July 11, 2023.

Figure 13. The naval battle of Salamis (480 BC) between the confederation of Greek city-states under Themistocles and the Persian king Xerxes (artistic illustrations)
Source: https://naval-encyclopedia.com/navalbattles/battle-salamis-480-bc.php, Accessed: July 11, 2023.

Figure 14. Left: Ancient Roman warship trireme with movable bridge. Right: Jacques-Yves Cousteau's ship, Calypso, with which he carried out his scientific research of the sea
Source: https://www.worldhistory.org/image/13833/greek-trireme-model/, Accessed: July 11, 2023.
Source: https://www.cousteau.org/news/calypso-renovation-faq/, Accessed: July 11, 2023.

Figure 15. Left: Symphony of the Seas is a cruise ship with 18 decks, currently the largest passenger ship in the world (its length is 362 meters). It is owned by the Norwegian company Royal Caribbean Cruise Line (RCCL). Right: USS Enterprise, aircraft carrier (342 meters long)
Source:
https://www.usatoday.com/story/travel/cruises/2018/03/24/royal-caribbeansymphony-seas-cruise-firstlook/449661002/
Accessed: July 11, 2023.
Source: https://www.seaforces.org/usnships/cvn/CVN-65-USS-Enterprise.htm, Accessed: July 11, 2023.

The content of the work EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER) is focused on architecture, which until recently was considered an exhibitionist approach to architecture, and which, it is certain, will be the main form of architectural expression in the future. Dutch architecture studio Waterstudio has designed a 40 meter high floating tower made of CLT for the city of Rotterdam. CLT, which stands for Cross Laminated Timber, is a sustainable upcoming material in architecture (Figure 16). Wood is a renewable resource, and by converting it to CLT, even wood less suitable for construction, such as softwood, can be turned into a material with high structural performance. In this way, lighter structures can be built than, for example, steel or concrete, which makes it particularly suitable for floating architecture. A white leaf floats above the water on a transparent layer with vegetation. It is supported by a V-shaped wooden column structure. The tower is pushed asymmetrically from the deck, which creates an opening in the middle of the building. This opening functions as an atrium on the lower level, providing light and a feeling of spaciousness. The foundation of the building consists of three concrete barges. The tower itself will be built in three parts on the pier and assembled on site. The main function of the tower is to house offices. However, the ground floor forms a public level of mixed use, just above the water level. It was conceived as a public green park. Located in the port of Rotterdam, the FloatingTimberTower uses as little energy as possible. The building runs on solar energy and reuses heat produced by the physical structure of the building or extracted from the surrounding water [5].

Figure 16. FloatingTimberTower, Rotterdam (architect: Koen Olthuis - Waterstudio)
Source: https://materialdistrict.com/article/worlds-first-floating-timber-tower/, Accessed: July 11, 2023.

*Corresponding author: **Ahmet Hadrovic**

2. Environment

"Environment is a fundamental characteristic of Architecturally Defined Space (ADP). As a complex expression of human struggle, architecture is simultaneously a strictly defined empirical phenomenon that is always realized in a concrete natural environment in which it must survive as a physical structure, resistant to more or less aggressive natural influences. At the same time, many inputs from the social environment give architecture the characteristics of a concrete society in the historical-time period context" [6].

2.1. Natural environment

When we talk about the natural environment, we mean „those parts of the visible world that were not created by man and that we can discern with our senses". The term 'nature' refers to all physical phenomena, from microscopic to macroscopic dimensions, from matter and energy to the Universe [6].

2.1.1. Water on planet Earth

The origin of water on Earth is the subject of research in the fields of planetary science, astronomy and astrobiology [7]. Earth is unique among the rocky planets in the Solar System in that it is the only planet known to have oceans of liquid water on its surface. Liquid water, which is essential for life as we know it, continues to exist on Earth's surface because the planet is at a distance known as the habitable zone, far enough from the Sun that it does not lose water, but not so cold that temperatures cause all the water on the planet to freeze. It has long been thought that water on Earth does not originate in the planet's protoplanetary disk region. Instead, it was assumed that water and other volatiles must have been delivered to Earth from the outer Solar System later in its history. More recent research, however, shows that hydrogen inside the Earth played a role in the formation of the oceans. The two ideas are not mutually exclusive, as there is also evidence that water was delivered to Earth by impacts from icy planetesimals of the asteroid-like system at the outer edges of the asteroid belt.

Water inventory on Earth. While most of the Earth's surface is covered by oceans, these oceans make up only a small fraction of the planet's mass. The mass of the Earth's oceans is estimated at 1.37 × 1021 kg, which is 0.023% of the total mass of the Earth, 6.0 × 1024 kg. It is estimated that there is an additional 5.0 × 1020 kg of water in ice, lakes, rivers, groundwater and atmospheric water vapor. A significant amount of water is also stored in the Earth's crust, mantle and core. Unlike molecular H2O found on the surface, water in the interior exists primarily in hydrated minerals or as traces of hydrogen bound to oxygen atoms in anhydrous minerals. Hydrated silicates at the surface transport water into the mantle at convergent plate boundaries, where oceanic crust is subducted beneath continental crust. Although the total water content of the mantle is difficult to estimate due to limited samples, approximately three times the mass of Earth's oceans can be stored there. Similarly, the Earth's core could contain four to five oceans worth of hydrogen [8].

Hypotheses about the origin of Earth's water [9]. Water has a much lower condensation temperature than other materials that form the terrestrial planets in the solar system, such as iron and silicates. The region of the protoplanetary disk closest to the Sun was very hot early in the history of the Solar System, so it is not possible that oceans of water condensed with the Earth as it formed. Farther away from the young Sun, where temperatures were lower, water could condense and form icy planetesimals. The boundary of the region where ice could form in the early Solar System is known as the frost line (or snow line), and it is located in the modern asteroid belt, about 2.7 and 3.1 astronomical units (AU) from the Sun. Therefore, it is necessary that objects that form outside the frost line-such as comets, trans-Neptunian objects, and water-rich meteoroids (protoplanets)-deliver water to Earth. However, the delivery time is still questionable. According to one hypothesis, Earth accreted (gradually grew by accumulating) icy planetesimals about 4.5 billion years ago, when it was 60% to 90% of its current size. In this scenario, Earth managed to retain water in some form during accretion and large impacts. This hypothesis is supported by similarities in abundance and water isotope ratios between the oldest known carbonaceous chondrite meteorites and the Vesta meteorite, both of which originate from the asteroid belt of the Solar System. One problem with this hypothesis is that the isotope ratios of the noble gases in Earth's atmosphere are different from those of its mantle, suggesting that they originated from different sources. To explain this observation, the so-called 'late veneer' theory has been proposed, in which water was delivered much later in Earth's history, after the impact that formed the Moon. However, current understanding of Earth's formation allows less than 1% of Earth's material to have accumulated after the formation of the Moon, implying that the material collected later must have been very water-rich. Models of the early dynamics of the Solar System have shown that icy asteroids could have been delivered to the inner Solar System (including Earth) during the period that Jupiter migrated closer to the Sun. A third hypothesis, supported by evidence from molybdenum isotope ratios, suggests that Earth got most of its water from the same interplanetary collision that gave rise to the Moon.

Geochemical analysis of water in the Solar System. Carbonaceous chondrites, such as the Allende meteorite, likely supplied much of Earth's water, as evidenced by their isotopic similarities to ocean water. Isotopic ratios provide a unique 'chemical fingerprint' used to compare Earth's water with reservoirs elsewhere in the Solar System. One such isotopic ratio, the deuterium-to-hydrogen (D/H) ratio, is particularly useful in the search for the origin of water on Earth. Hydrogen is the most abundant element in the Universe, and its heavier isotope deuterium can sometimes take the place of a hydrogen atom in molecules like H2O. Most of the deuterium was created in the Big Bang or in supernovae, so its uneven distribution across the protosolar nebula was effectively 'locked in' early in the formation of the Solar System. By studying the different isotopic ratios of Earth and other icy bodies in the Solar System, the probable origin of water on Earth can be investigated.

2.1.2. Natural (physical) laws (principles) of floating and navigation of bodies on water

The creation of physical structures on water, those that float ('in one place') and those that sail, is an extremely complex process, where you need to know the specifics of the natural environment, i.e. the laws/principles of the relationship between created physical structures and water. EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER) is based on these principles. When considering the natural (physical) laws (principles) of floating and navigation of bodies on water, it should be borne in mind that water (water surface) is not an isolated

*Corresponding author: **Ahmet Hadrovic**

system, but is always in complex relations with its environment: the coast (forest, rocks, sand or gravel. ..) and air/atmosphere.

Archimedes principle. Archimedes' principle, the physical law of buoyancy, which was discovered by the ancient Greek mathematician and inventor Archimedes [10], stating that any body partially or completely immersed in a liquid (also in a gas) at rest is acted upon by an upward force or buoyancy whose magnitude is equal to the weight of the liquid that the body squeezes out (Figure 17). The volume of the displaced liquid is equivalent to the volume of an object completely immersed in the liquid, or that part of the volume below the surface for an object partially immersed in the liquid. The weight of the displaced part of the liquid is equivalent to the magnitude of the buoyant force. The buoyant force on a body floating in a liquid or gas is also equivalent in magnitude to the weight of the floating object and is in the opposite direction; the object neither rises nor sinks. For example, a ship on water sinks until the weight of the water it displaces is equal to its own weight. As the ship is loaded, it sinks deeper and deeper, displacing more water, so the magnitude of the buoyant force constantly corresponds to the weight of the ship and its cargo [10].

Figure 17. Left: Archimedes' principle. Right: A paper ship model floating on water
Source: https://www.britannica.com/science/Archimedes-principle, Accessed: July 11, 2023.

If the weight of the object is less than the weight of the displaced liquid, the object rises, as in the case of a block of wood released below the surface of water or a helium balloon released into the air. An object weighs more than the amount of liquid it displaces, and has an apparent weight loss equal to the weight of the liquid displaced. In fact, some accurate weighings must be corrected to compensate for the buoyancy effect of the surrounding air. The buoyant force, which always opposes gravity, is nevertheless caused by gravity. Fluid pressure increases with depth due to the (gravitational) weight of the fluid above. This increased pressure exerts a force on the submerged object that increases with depth. The result is buoyancy (Figure 18).

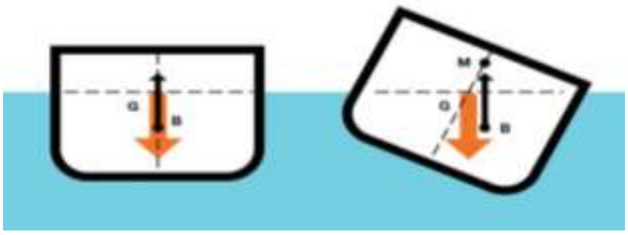


Figure 18. The weight of the ship acts through the ship's center of gravity (G). It is opposed by buoyancy - the force of displaced water - acting upwards through the center of buoyancy (B). When the ship is upright (left), the forces are in direct opposition. When the ship tilts (right), B moves to the low side. Buoyancy then acts through the metacenter (M), the point on the centerline of the ship above G.
Source: https://www.britannica.com/science/Archimedes-principle, Accessed: July 11, 2023.

Hydrostatics. It is generally known that the pressure of the atmosphere (about 105 N/m^2) is a consequence of the weight of the air above the Earth's surface, that this pressure decreases as (man) climbs up, and that, accordingly, this pressure increases as he dives deeper into the lake (or comparable body of water). Mathematically, the rate at which pressure in a stationary fluid varies with height (z) in a vertical gravitational field of strength (g) is:

$$\frac{dp}{dz} = - \rho\, g$$

If (ρ) and (g) are independent of (z), as is more or less the case in lakes, then the equation is:

$$p\,(z) = p\,(0) – \rho g z$$

This means that, since (ρ) is about 103 kilograms per m3 of water, and (g) is about 10 m/s2, the pressure is already twice the atmospheric value at a depth of 10 meters. Applied to the atmosphere, equation (2) would mean that the pressure drops to zero at an altitude of about 10 kilometers. In the atmosphere, however, the variation of (ρ) with (z) is far from negligible and (2) is therefore unreliable (a better approximation is given below in the Hydrodynamics: Compressible Flow in Gases section).

Differential manometers. Instruments for comparing pressures are called differential manometers, and the simplest such instrument is a U-tube containing a liquid, as shown in Figure 1A (Fig. 1.5). The two pressures of interest, (p1) and (p2), are transmitted to the two ends of the liquid column through an inert gas - whose density is negligible compared to the liquid density (ρ) and the height difference (h) measured by the two menisci. The consequence is that:

$$p_1 - p_2 = pgh$$

A barometer for measuring absolute atmospheric pressure is simply a manometer in which (p2) is zero or as close to zero as possible. The barometer, which was invented in the 17th century by the Italian physicist and mathematician Evangelista Torricelli (1608-1647), and which is still used today, is a U-tube closed at one end (Figure 19, B).

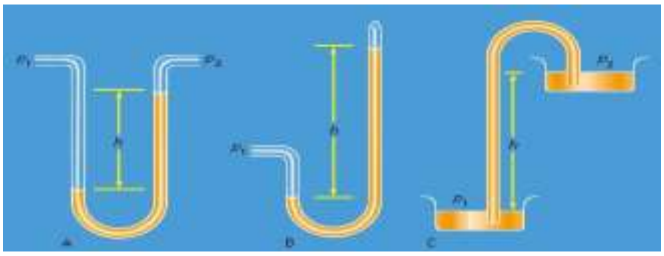


Figure 19. Schematic representations of: (A) differential manometer, (B) Torricelli barometer and (C) siphon
Source: https://www.britannica.com/science/Archimedes-principle, Accessed: July 11, 2023.

Surface tension of liquids. Surface tension is a property of the surface of a liquid that allows it to resist an external force, due to the cohesive nature of its molecules [11] (Figure 20).

*Corresponding author: **Ahmet Hadrovic**

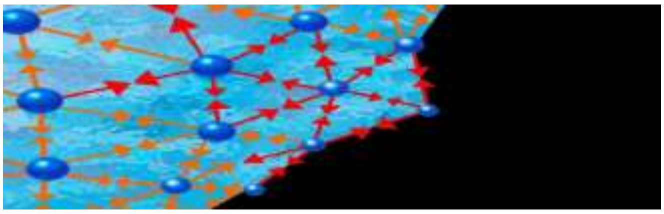


Figure 20. Explanation of surface tension
Source: https://www.britannica.com/science/fluid-mechanics/Hydrostatics#ref611686, Accessed: July 11, 2023.

Of the many hydrostatic phenomena in which the surface tension of liquids plays a role, the most significant is capillarity [12] (Figure 21). Let's see what happens when a narrow-bore tube, often called a capillary tube, is dipped into a liquid. If the liquid 'wets' the tube (with zero contact angle), the surface of the liquid inside the tube forms a concave meniscus, which is a nearly spherical surface with the same radius (r) as the inside of the tube. The pipe experiences a downward force of magnitude ($2\pi rd\sigma$), where (σ) is the surface tension of the liquid, and the liquid experiences a reaction of equal magnitude that raises the meniscus by a height (h) such that:

$2\pi r\sigma = \pi r^2 h\rho g$ that is, until the upward force due to surface tension is balanced by the weight of the column of liquid that has been lifted. If the liquid does not wet the tube, the meniscus is convex and pressed at the same distance (h). A simple method for determining surface tension involves measuring (h) in one or other of these situations.

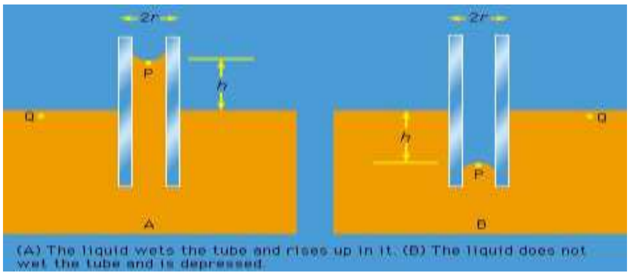


Figure 21. Capillarity
Source: https://www.britannica.com/science/fluid-mechanics/Hydrostatics#ref611686, Accessed: July 11, 2023.

The pressure at point P, just below the meniscus, is different from the pressure at point Q (Figure 21):

$$\rho gh = \frac{2\sigma}{r}.$$

The pressure at point P is less than the pressure at point Q in the case referred to in Figure 21,A and greater than the pressure at point Q in the other case. Since the pressure at Q is just atmospheric pressure, it is equal to the pressure at the point just above the meniscus. So, in both cases there is a pressure difference of ($2\sigma/r$) between the two sides of the curved meniscus, and in both cases the pressure is higher on the inner side of the curve. Such a pressure difference is a condition of equilibrium wherever the liquid surface is curved. If the surface is curved but not spherical, the pressure difference is:

$\sigma (r_1^{-1} + r_2^{-1})$

where (r_1) and (r_2) are the two main radii of curvature. If it is cylindrical, one of these radii is infinite, and if it is curved in opposite directions, they should be treated as having opposite signs.

Hydrodynamics. Hydrodynamics is a branch of physics that deals with the movement of fluids and the forces that act on solid bodies immersed in fluids and moving in relation to them [13]. Here we are talking about fluids that are in constant motion so that the speed of the fluid at each specific point in space does not change with time. Any flow pattern that is stable in this sense can be viewed in terms of a set of flows, the paths of imaginary particles suspended in the liquid and carried along with it. In steady flow, the fluid is in motion, but the currents are fixed. Where the currents converge, the fluid velocity is relatively high; where they open, the liquid is relatively stagnant. When Euler and Bernoulli laid the foundations of hydrodynamics, they treated fluid as an idealized invisible substance in which, as in a fluid at rest in equilibrium, the shear stresses associated with viscosity are zero and the pressure (p) is isotropic. They arrived at a simple law relating the variation (p) along the current to the variation (v), (the principle is credited to Bernoulli, but Euler seems to have arrived at it first), which serves to explain many phenomena in which real fluids in the representation constant movement. Bernoulli's law indicates that if an inviscid fluid flows along a pipe of varying cross-section, then the pressure is relatively low at constrictions where the velocity is high and relatively high where the pipe opens and the fluid stagnates. Paradoxically or not, predictions based on Bernoulli's law have been well verified by experiment. Two practical devices that hydraulic engineers use to monitor the flow of fluids, albeit pipes, are based on Bernoulli's law. One is a venturi tube, a short length with a taper of a standard shape (Figure 22, A), which can be inserted into the tube. If the velocity at point P, where the pipe has a cross-sectional area (A_P), is (v_P), and the velocity at the taper, where the area is (A_Q), is (v_Q), the continuity condition (the condition that the mass flowing through the pipe in unit time must be the same at all points along its length) suggests that $\rho_P A_P v_P = \rho_Q A_Q v_Q$, or that $A_P v_P = A_Q v_Q$ if the difference between (ρ_P) and (ρ_Q) is negligible.

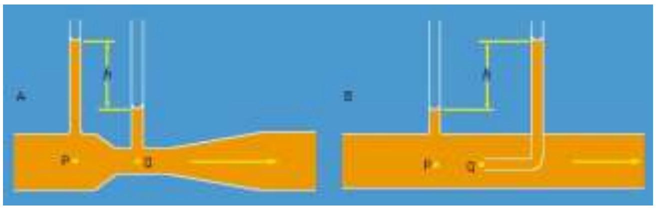


Figure 22. Schematic representation of (A) venturi tube and (B) pitot tube
Source: https://www.britannica.com/science/fluid-mechanics/Hydrodynamics, Accessed: July 11, 2023.

Waves on shallow water. Imagine a layer of water with a flat base that has a small step at the surface, dividing the region where the water depth is uniformly equal to (D) from the region where it is uniformly equal to D ($1 + \varepsilon$), with $\varepsilon << 1$. Let the water in the shallower region flows towards the step with some uniform velocity (V), and let this velocity be sufficient to keep the step in the same position, so that the flow pattern is constant one [14] (Figure 23). The continuity condition (the condition that as much water flows out to the left per unit time as flows in to the right) indicates that in the deeper region the water velocity is V ($1 + \varepsilon$) −1.

*Corresponding author: **Ahmet Hadrovic**

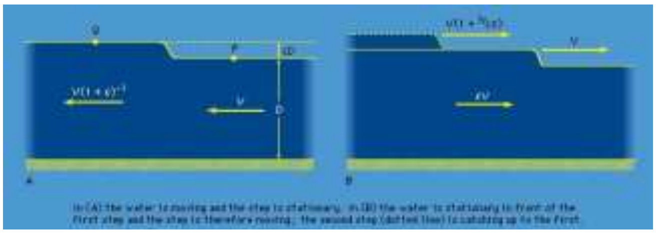


Figure 23. Footsteps on the surface of shallow water
Source: https://www.britannica.com/science/fluid-mechanics/Hydrodynamics, Accessed: July 11, 2023.

Obviously, waves approaching the shelves should slow down as D decreases. If they approach them at an angle, the deceleration effect bends or breaks the wave crests so that they are almost parallel to the shore by the time they finally break.

Compressible flow in gases. Compressible flow refers to flow at speeds comparable to or greater than the speed of sound. Compressibility is relevant because at such speeds the variations in density that occur when the fluid moves from place to place cannot be ignored [15]. It should be noted that the formula for the speed of sound in gases can be proven in other ways, and Newton came close to it a century before Bernoulli's time.

Viscosity. To discuss the cases in which the flow is not steady, an equation of fluid motion is needed, and it cannot be written without facing the problems posed by viscosity [16]. The property of a fluid that resists the relative sliding of its particles during its flow is known as viscosity or internal friction. The force of friction determines that the layer of liquid, which moves faster, pulls the neighboring layer, which moves more slowly, behind it, and this is one of the most important properties of the fluid. Viscosity is caused by intermolecular cohesion forces in the fluid and adhesion forces between the fluid and the solid body through which the flow takes place.

Stresses in laminar motion. The concept of viscosity was first formalized by Newton, who considered that shear stresses are likely to occur when a fluid undergoes so-called laminar motion with the type of velocity profile suggested in Figure 24, A; the laminae here are planes normal to the axis (x_2) and move in the direction of the axis (x_1) at a speed (v_1), which increases linearly with (x_2). Newton proposed that as each lamina slides over the lower one, acting on it in some way as a frictional force in the forward direction, in which case the upper lamina must experience an equal reaction in the backward direction. The strength of these forces per unit area constitutes the shear stress component, which is usually written as σ_{12} (not to be confused with surface tension, for which the symbol σ is used above). Figure 24, B shows, in elevation, a magnified view of an infinitesimal cubic fluid element, and the directions of forces experienced by that cube associated with σ_{12} are indicated by arrows. The other arrows show the directions of the forces associated with the so-called normal stresses σ_{11} and σ_{22}, which in the absence of liquid movement would be equal to -p according to Pascal's law. Now σ_{12} is clearly zero when the rate of variation of the velocity, $\partial v_1/\partial x_2$, is zero, because then there is no slip, and it presumably increases monotonically as $\partial v_1/\partial x_2$ increases.

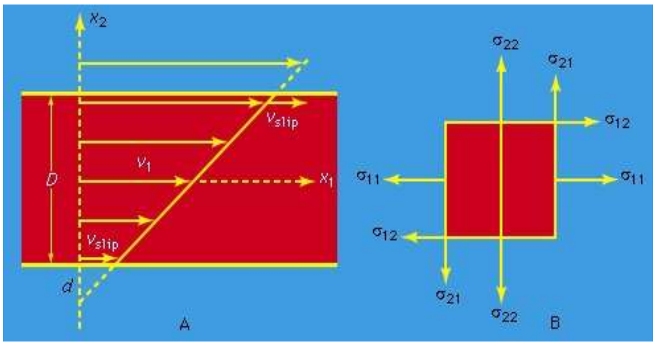


Figure 24. Laminar motion and associated stresses
Source: https://www.britannica.com/science/fluid-mechanics/Viscosity, Accessed: July 11, 2023.

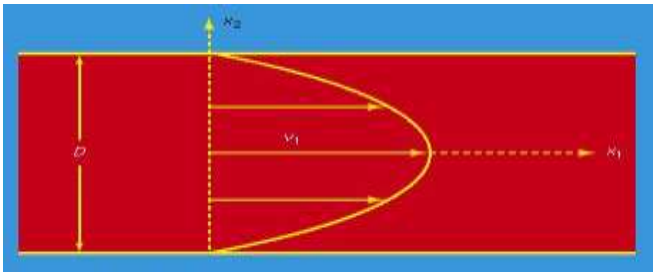


Figure 25. Velocity profile for laminar flow between two plates (or inside a cylindrical tube), driven by a pressure gradient
Source: https://www.britannica.com/science/fluid-mechanics/Viscosity, Accessed: July 11, 2023.

Potential flow. In fluid dynamics, the potential flow describes the velocity field as the gradient of a scalar function: the velocity potential. As a result, the potential flow is characterized by an irrotational velocity field, which is a valid approximation for several applications. The irrotation of the potential flow is a consequence of the twisting of the gradient of the scalar, which is always equal to zero. Non-eddy flow or potential flow would be of rather limited interest were it not for the theorem, first proved by William Thomson/Lord Kelvin (1824-1907), that in a body of fluid which is initially free of eddies, the vorticity remains zero as the fluid moves. This theorem seems to open the door to relatively painless solutions to a large number of problems. Physicists and mathematicians who developed fluid dynamics during the 19th century relied heavily on this reasoning. They have based great achievements on it, and a notable example is the theory of waves in deep water.

Potential flow with circulation: vortex lines. In the physical sense, eddies are special phenomena that arise from fluid movement, by the rotation of fluid elements (Figure 26). Images of such organized structures are found all around us, from abstract cosmic phenomena, which we cannot notice, to very simple and easily observable ones: spiral galaxies in the Universe, red spots on Jupiter, hurricanes and tornadoes, vortices created by aircraft movement, vortex rings that appear in the plume of nuclear explosions, the eddies that appear when a certain amount of water is allowed to pour down a drain, for example. Vorticity, which is a property of fluids, plays an important role in aerodynamics and rotating flows. A vortex line is a line in the fluid, so that at every point of the given line the vorticity vector is tangent to the line. More precisely, the vorticity line is parallel to the vorticity vector at every point. The strength of the vorticity vector is not the same everywhere along the vortex line, just as the velocity vector is not inevitably constant along the streamline.

*Corresponding author: **Ahmet Hadrovic**

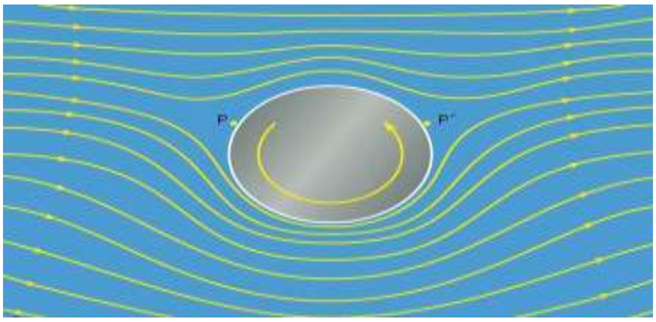


Figure 26. Implications for potential flow with circulation past a rotating cylinder. The cylinder experiences a downward Magnus force (see text)

Source: https://www.britannica.com/science/fluid-mechanics/Navier-stokes-equation, Accessed: July 11, 2023.

Waves on deep water. Waves in deep water are dispersive. A storm in the middle of the ocean disturbs the surface in a chaotic manner (a way that would be useless for surfing), but as the constituent waves travel towards the shore they separate; those with long wavelengths move ahead of those with short wavelengths because they travel faster. As a result, the waves look beautifully regular by the time they arrive. Anyone who has watched the waves behind a moving ship will know that they are confined to a V-shaped area of water, with the ship on top. Waves are particularly prominent on the arms of the V, but can also be discerned between these arms where the crests of the waves curve in the manner shown in Figure 27. Thomson (Lord Kelvin) first explained this, so the V-shaped area is now known as the Kelvin Wedge.

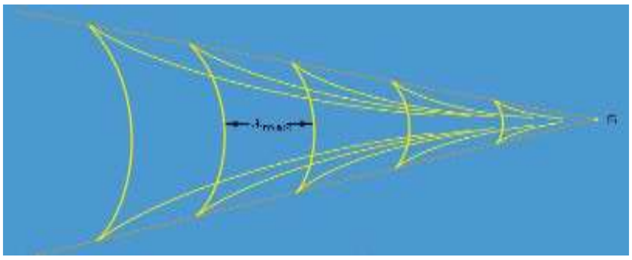


Figure 27. Wave crests in the Kelvin wedge behind a source S that is constantly moving from left to right. The maximum wavelength λmax depends on the source velocity, but the wedge angle does not (see text)

Source: https://www.britannica.com/science/fluid-mechanics/Waves-on-deep-water, Accessed: July 11, 2023.

Boundary layers and separation. Vorticity can enter a liquid that initially passes through a potential flow where it comes into contact with a solid, and also on its free surface. The way in which it spreads after entering can be illustrated by a simple example. Let us imagine a large body of liquid, initially motionless, which is set in motion by the movement in its plane of a large solid plate immersed in the liquid [17]. Motion is transferred from solid to fluid action by frictional forces that prevent sliding between the two (see discussion of viscosity), and a velocity profile of the shape suggested in Figure 28 is established.

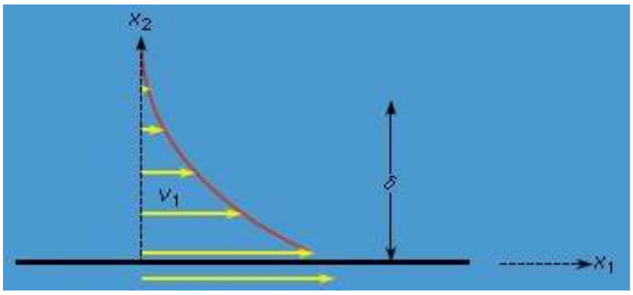


Figure 28. Velocity profile established by moving a plate through a stationary fluid

Source: https://www.britannica.com/science/fluid-mechanics/Waves-on-deep-water, Accessed: July 11, 2023.

Load. The fluid current exerts a drag force FD on any obstacle in its path, and the same force occurs if the obstacle moves and the fluid is stationary. How big it is and how it can be reduced are questions of obvious importance for designers of mobile vehicles of all kinds, and equally for designers of cooling towers and other buildings who want to be sure that the structures will not collapse under the influence of the wind [18].

Lift. If an aircraft wing or airfoil is to fulfill its function, it must experience an upward lift force, as well as a drag force, when the aircraft is in motion. The lift force occurs because the speed with which the displaced air moves along the top of the profile (and along the top of the attached boundary layer) is greater than the speed with which it moves along the bottom and due to the pressure acting on the profile from below it is therefore greater than the pressure from above. However, this can also be seen as an inevitable consequence of the finite circulation that exists around the airfoil. One way to establish circulation around an obstacle is to rotate it, as seen earlier in the description of the Magnus effect. However, circulation around one profile is created by its forward movement; it is formed as soon as the transient profile moves fast enough to shed its first vortex [19]. The lift force on an airfoil moving through stationary air at a constant speed v_0 is equal to the lift force on an identical airfoil at rest in air moving at v_0 the other way; the latter is easier to depict graphically. Figure 29, A shows a series of currents representing the potential flow past a stationary inclined plate before any eddies are shed. The pattern is symmetrical and associated pressure changes create neither drag nor lift. However, on the back side of the plate, currents diverge quickly, so there are conditions for the formation of a vortex, and the sense of its rotation will be counter-clockwise. It grows more easily and sheds faster because the edges of the board are sharp. Figure 29, B shows some currents for the same plate a moment after shedding when a separate vortex, known as the initial vortex, is still visible. The circulation around the closed loop shown by the broken curve in this diagram was zero before the vortex formed and, according to Thomson's theorem, must still be zero. Passing through this loop, there must be a vortex line that has a clockwise (-K) circulation to compensate for the (+K) circulation of the initial vortex. This second line, known as the bound eddy, is not immediately visible in the diagram because it is attached to the plate, so it remains attached as the initial eddy is dragged downstream. This is shown, however, in a change in the flow pattern immediately behind the plate, where the currents no longer diverge as in Figure 29, A. Since the difference is eliminated here, no further eddies are likely to arise.

*Corresponding author: **Ahmet Hadrovic**

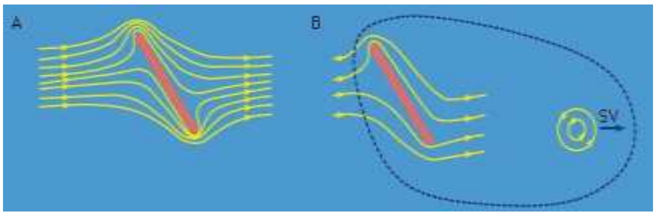


Figure 29. Generation of lifting force
Source: https://www.britannica.com/science/fluid-mechanics/Drag, Accessed: July 11, 2023.

When a yacht sails into the wind, her sail acts as an airfoil whose mast is the leading edge, and the considerations that favor long aircraft wings also favor tall masts.

Turbulence. Turbulence (lat. turbulentus: restless, turbulent) is an irregular swirling motion that appears in liquids and gases when currents pass by solid objects or when their flow velocity exceeds a certain limit. Turbulent flow is characterized by the fact that in addition to the mean speed of the entire flow, each particle of liquid or gas also has an additional speed that can be partly in the direction of the main flow, partly opposite to the direction of the flow. This distinguishes turbulent flow from laminar flow, in which there are no additional velocities. In the atmosphere, the flow of air (wind) is always turbulent; the wind blows almost regularly in gusts and its direction constantly changes. The result of turbulent air movement is the interaction of air layers of different speeds; the faster layer affects the slower one and vice versa (turbulent friction). Heat transfer, distribution of water vapor and dust in the atmosphere also depend on wind turbulence. Experiments and theoretical works have shown that, if a fluid undergoes regular laminar motion (for example related to Poiseuille's law) at sufficiently high shear rates, small periodic disturbances of these motions can grow parasitically. Smaller-scale perturbations continue to grow parasitically on those first established, until the flow pattern is so perturbed that it is no longer useful to define the fluid velocity for every point in space; the flow description must be statistical in terms of mean values and correlated fluctuations around the mean value. Then the flow is said to be turbulent [20].

Convection. Here we are talking about situations in which temperature differences in the liquid result in its movement [21]. Let's imagine a situation where the same two plates are horizontal and not vertical; in such a case, convection cannot occur if the hot plate is above the cold one, and it is not obvious that this occurs in the reverse situation. Whether it will do so or not depends on the size of the temperature difference through a dimensionless combination of some relevant parameters, $\rho g \alpha D_3$ $(T_1 - T_2)/\eta\kappa$, which is known as the Rayleigh number. If the Rayleigh number is less than 1,708, the liquid is stable - or it would be more accurate to say unstable - even though it is hotter at the bottom than at the top. However, when 1,708 is exceeded, a pattern of convective rolls known as Bénard cells is established between the plates. Evidence of the existence of such cells in the convective atmosphere is sometimes seen in the regular columns of clouds that form over regions of rising air. Their periodicity can be astonishingly uniform. Macroscopic instabilities of a convective nature, of which the formation of Bénard cells is just one example, are a feature of the ocean as well as the atmosphere and are often associated with salinity gradients rather than temperature gradients. A serious discussion of Earth's atmospheric and oceanic circulation requires, however, a more detailed examination of the dynamics of rotating fluids than is provided here.

2.1.3 Air currents over the water surface

Wind is the natural movement of air or other gases relative to the surface of the planet. Wind occurs on different scales, from storm currents that last tens of minutes, to local breezes that are created by heating land surfaces and last for several hours, to global winds that are a consequence of the difference in the absorption of solar energy between climate zones on Earth. The two main causes of large-scale atmospheric circulation are the different heating between the equator and the poles and the rotation of the planet (Coriolis effect)[1], (Figure 30). Within the tropics and subtropics, low-level thermal circulations over the terrain and high plateaus can drive monsoonal circulations. In coastal areas, the sea breeze/land breeze cycle can define local winds [22]; in areas with variable terrain, mountain and valley breezes may prevail. Winds are usually classified according to their spatial scale, speed and direction, the forces that cause them, the regions in which they occur, and their effect. Winds have different aspects: speed (wind speed), density of gas involved, energy content or wind energy. Wind is also a critical means of transport for seeds, insects and birds that can travel thousands of kilometers on wind currents. In meteorology, winds are often named according to their strength and the direction from which the wind blows. Short bursts of high-speed wind are called gusts. Strong winds of medium duration (about one minute) are called storm surges. Long-lasting winds have different names related to their average strength, such as gale, gale, and hurricane. In the Universe, the solar wind is the movement of gases or charged particles from the Sun through the Universe, while the planetary wind is the evaporation of light chemical elements from the planet's atmosphere into the Universe. The strongest observed winds on a planet in the Solar System occur on Neptune and Saturn. In human civilization, the concept of wind was explored in mythology, influenced historical events, expanded the range of transportation and warfare, and provided a source of energy for mechanical work, electricity, and recreation. Wind propels sailing ships across the Earth's oceans. Hot air balloons use the wind for short trips, and powered flight uses it to increase lift and reduce fuel consumption. Areas of wind shear caused by various weather phenomena can lead to hazardous situations for aircraft. When the winds become strong, trees and man-made structures are damaged or destroyed. Winds can shape landforms through various aeolian processes, such as the creation of fertile soil, for example loess, and through erosion. Dust from large deserts can be transported long distances from the source area by prevailing winds; winds that are accelerated by rough topography and associated with dust outbreaks have been given

---

[1] In physics, the Coriolis force is an inertial or fictitious force that acts on objects moving within a frame of reference that rotates relative to the inertial frame. In a reference frame with clockwise rotation, the force acts to the left of the object's motion. In one with counterclockwise (or counterclockwise) rotation, the force acts to the right. The deflection of an object due to the Coriolis force is called the Coriolis effect. Although previously acknowledged by others, the mathematical expression for the Coriolis force appeared in an 1835 article by the French scientist Gaspard-Gustave de Coriolis, regarding the theory of water wheels. At the beginning of the 20th century, the term Coriolis force began to be used in connection with meteorology.

*Corresponding author: **Ahmet Hadrovic**

regional names in various parts of the world because of their significant effects on those regions. Wind also affects the spread of fire. Winds can disperse seeds from different plants, enabling the survival and spread of these plant species, as well as populations of flying insects. In combination with low temperatures, the wind has a negative impact on livestock. Wind affects animal food stores as well as their hunting and defense strategies.

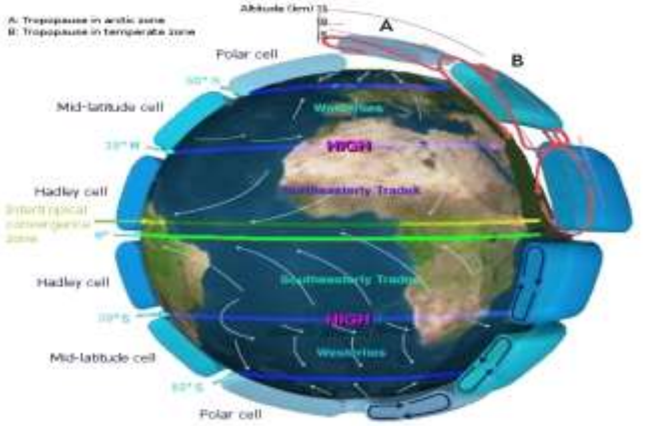


Figure 30. Winds are part of the Earth's atmospheric circulation

Source: https://www.wikiwand.com/hr/Vjetar, Accessed: July 11, 2023.

Breezes from land and sea are caused by differences in temperature compared to land and water. Sea breeze occurs during the day when the land surface heats up faster than the water surface (Figure 31). This is why the pressure on land is lower than the pressure on water. The pressure gradient is often strong enough to blow wind from the water onto the land. A land breeze blows at night when the land cools down. Then the wind blows toward a warm, low-pressure area over the water. Land and sea breezes are very local and affect only a narrow area along the coast.

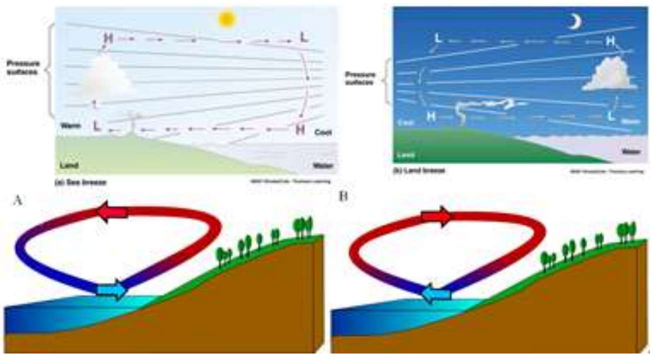


Figure 31. Sea (A, during the day) and land breezes (B, during the night)

Source: https://www.weather.gov/source/zhu/ZHU_Training_Page/winds/Wx_Terms/Flight_Environment.htm, Accessed: July 12, 2023.

2.2 Social environment

”A social environment (society) is a group of individuals involved in more or less permanent social interaction or a large social group sharing the same geographic or social territory, usually subject to the same political authorities and dominant cultural expectations. Societies are characterized by patterns of relationships (social relations) among individuals who share a distinctive culture and institutions. A given society can be described as the sum of such relationships between its constituent members. In the social sciences, the larger society often exhibits patterns of stratification or dominance in subgroups. Societies construct patterns of behavior by considering certain actions or speech as acceptable or unacceptable. These patterns of behavior in a certain society are known as social norms. Societies and their norms are subject to gradual and constant changes” [23].

2.2.1History of construction on water

Stilt houses (also called pile dwellings or lake dwellings) are houses raised on stilts ('piles') above the surface of the ground or body of water. Given the fact that the houses on stilts were built from organic materials (wood, bamboo, leaves), they were exposed to fires, so they disappeared already at the time of their construction. Those that survived, after a change in the way of life, decayed due to atmospheric influences. Hence, there are few archaeological finds of the original solutions of these houses. One of such sites is the wider area of the Alps, which is now a UNESCO World Cultural Heritage [24]. The remains of these settlements are a good basis for studying the way of life of their builders, including the reasons for building houses on stilts in the water. A new excavation and analysis of three crannogs[2] in the Outer Hebrides clearly showed that they originate from the Neolithic (Figures 32, 33, 34). There are more than 570 cranes found in lochs and bays across Scotland, with over 170 in the Outer Hebrides alone (a number of cranes are also found in Ireland and one in Wales). They were previously thought to have been built, used and reused over a period of 2,500 years, spanning from the Iron Age to the post-medieval period. In the 1980s, excavations at Eilean Dòmhnuill in the north of Uist revealed that this islet was actually built during the Neolithic. Despite this great discovery, no other Neolithic crannogs were discovered in the following decades of search. In 2012 Chris Murray, a resident of the Isle of Lewis and a former Royal Navy diver, dived around an islet and discovered Neolithic-style pots lying on the lake. Joining Mark Elliott of the Eilean Museum in Stornoway, they then searched several other islets on the Isle of Lewis, finding similarly well-preserved collections of Neolithic pottery. To confirm whether these water deposits are related to the construction of the crannog, Duncan Garrow of the University of Reading and Fraser Sturt of the University of Southampton carried out extensive research on three of them: those in Loch Arnish, Loch Bhorgastail and Loch Langabhat. Using several different techniques, Duncan and Fraser wanted to identify how these islets were built, when they were built, and for what purposes. Both the islets of Bhorgastail and Langabhat were built on natural elevations in the lake, and in the Neolithic would have been surrounded by shallow water on three 'sides', with deeper water on the fourth. In order to stabilize the structure built of boulders on the deeper side, it was discovered that in Bhorgastail wood was used to cover the edges of the islets. In addition, Duncan and Fraser found that large quantities of pottery found around Bhorgastail and Langabhat were likely deliberately deposited directly into the water surrounding the islet, supporting the idea that these sites were used during the Neolithic. To confirm this, radiocarbon dating was used on the charred remains from vessels found at each of the three crannogs, as well as the wooden cladding from Bhorgastail. The results confirmed that all three

[2] Crannogs are a type of ancient ponds found throughout Scotland and Ireland. Most seem to have been built as individual houses to accommodate extended families. Similar settlements are found in the rest of Europe.

*Corresponding author: **Ahmet Hadrovic**

islets were indeed used in a narrow time frame during the Neolithic, 3640-3360 BC.

Figure 32. Aerial view of the islet in Loch Bhorgastail

Source: https://i2.wp.com/archaeology.co.uk/wp-content/uploads/2019/08/Figure-5-FINAL-1.jpg?ssl=1, Accessed: July 12, 2023.

Figure 33. Crannog Center on the north shore of Loch Tay at Dalerb, Scotland

Source: https://www.undiscoveredscotland.co.uk/kenmore/crannogcentre/index.html, Accessed: July 12, 2023.

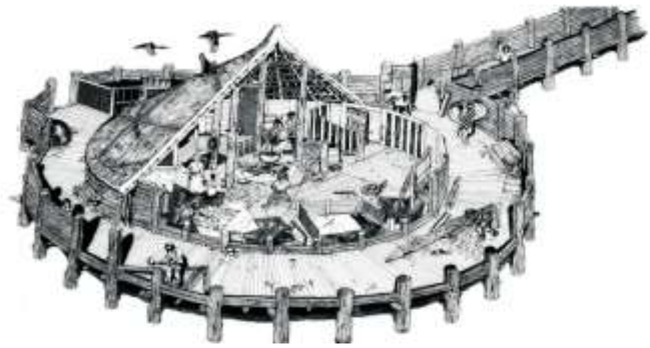


Figure 34. Spatial-constructive structure of a typical crannog

Source: https://www.highlandperthshire.com/things-to-do/attractions/the-scottishcrannog-centre/cranno-drawing/, Accessed: July 12, 2023.

It is already known (according to a comparison of similar, contemporary, settlements around the world) that such settlements were built as protection against floods, enemies, various pests... The connection between modern buildings on stilts (especially those in Southeast Asia) and their ancient models can be read from the symbols carved into the wooden elements of contemporary buildings and from the language of autochthonous buildings on stilts. Following contemporary constructions on stilts (columns) around the world, it can be concluded that this type of construction is suitable for all geographical areas of the Earth, since man, wherever he lives, has the same basic needs, and architectural and construction solutions adapt to the specific natural and social environment. In some parts of the Earth, in the conditions of the climate of rain forests, construction on stilts is also common on land. This is the way man conceived and materialized the house, his life frame, in order to ensure comfort in the conditions of a tropical climate [6]. Hence, there is a lot of symbolism in the (usual) design of these houses. The symbolic image of the sacred house among the Ngaju Dayak is expressed as a pile, the foundation of which is supported by the water snake 'Naga', and on the roof of which birds rest (Figure 35). In its cultural context, the water snake is identified with the female symbol 'Jata' or the deity of the underworld, while the roof is with the male symbol 'Mahatala' or the deity of the upper world. The same cosmological interpretation of the house is quite popular for the symbolic approach to the study of Indonesian houses. In Nias, many animal figures depicted on house members are also explained as 'reflections of the cosmos, upper and underworld, bird - snake, ATUMBUCHA ('right') - AECHULA ('left'). In fact, four human heads are buried under four corner pillars in the substructure of one of the chief's houses in southern Nias. They are considered to be offerings to 'Lature Dano', the God of the Underworld. On the other hand, an unspecified number of heads hung near the reef serves as an offering to 'Lowalani', the God of the upper world [25].

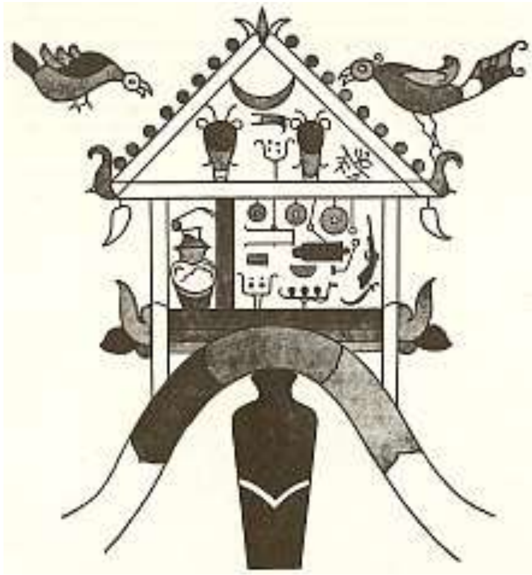


Figure 35. Ngaju Dayak: the house as the tree of life and the primeval mountain

Source: http://www.sumai.org/asia/refer/sem9102.htm, Accessed: July 12, 2023.

2.2.2 Contemporary legislation related to the sea and watercourses

The most important document at the world level that governs the relationship with the World Sea (oceans and seas) is the United Nations Convention on the Law of the Sea, which was adopted by the United Nations on December 10, 1982 [26]. States that reach the sea, open or closed, and states and cities that have rivers, regulate their relationship to watercourses through special laws and decisions. These documents are spatial plans (state, region, city) and more detailed documents (urban and regulatory plans), (Figure 36). The laws and decisions related to the construction of floating structures on water are particularly important for the topic of this book [27].

Figure 36. Rafts on the Danube (Belgrade)

*Corresponding author: **Ahmet Hadrovic**

Source: https://www.politika.rs/sr/clanak/395447/Beograd/Cekaju-se-nove-mere-zabezbednost-splavova, Accessed: July 12, 2023.

3. Man

„On the life scale of every person, the image of the 'objective world' changes, and he himself changes, his 'software and hardware' with which he perceives objective reality and forms his judgments about it. It is the result of the 'natural' default of the world“. This is a quote from the author's book „Man, something or nothing“ [28], which has a philosophical content, but is suitable as a pretext for this chapter of the paper, whose content is of an empirical-scientific nature.

3.1. Comfort assurance requirements

When it comes to humans, it is very important to know that there is an exact and measurable range of external influences (elements of the natural environment) that humans experience as physiologically pleasant. Outside of that (optimal) range, a person feels more or less discomfort, which sometimes rises to, for him, a deadly level. At the global level, the issue of human thermal comfort is regulated by appropriate standards.

The following standards are the most relevant:

- ISO 7730:1994 Moderate Thermal environments - Determination of the Predicted Mean Vote (PMV) and Predicted Percentage Dissatisfied (PPD) indices and specification of the conditions for thermal comfort. This standard has been revised: ISO 7730: 2005,
- ASHRAE 55 (2007), including a calculation methodology based on the PMV/PPD ratio,
- CEN 15251(2005): Criteria for indoor conditions including thermal conditions, indoor air quality, lighting and noise.

The CEN standard defines minimum ventilation requirements, minimum and maximum indoor air temperatures that are included in the energy calculation.

PMV (Predicted Mean Vote) index – evaluates the level of (dis)pleasure → predicts the subjective evaluation of the pleasantness of being in the environment by a group of people (determined from complex mathematical expressions according to ISO 7730)

PPD (Predicted Percentage of Dissatisfied) index → predicts the percentage of dissatisfied people (determination from a simple mathematical expression, function of PMV).

Knowledge of the 'defining areas of human physiological comfort' is of elementary and essential importance for architecture. The basic task of architecture, in fact, is to ensure the physiological comfort of man within the limits that he himself designs and builds. Only after fulfilling this requirement, we can continue to search for the realization of other dimensions of architecture. This elementary dimension of architecture was more or less understood throughout its entire past, but it was often neglected, at the expense of some other architectural values. It could even be said that the biggest internal conflict in architecture has always been between its elementary purpose and the architects' desire to communicate that purpose in a beautiful way. It seems that the just-mentioned conflict was at the same time the greatest internal strength of architecture, which led it towards the realization of new values. Man paid the highest price for this internal antagonism in architecture through energy costs (heating and cooling), or, as we have already seen, by endangering the natural environment in the last instance. Architecture necessarily had to turn to the principles of bioclimatic organization, and that path in the 21st century became global. Definitional areas of human physiological comfort within the boundaries of the Architecturally Defined Space have been well researched, and as given values, they have been translated into national, regional and world standards. The most important dimensions of the environment whose intensities determine human comfort can be classified into three basic areas:

1. The field of thermodynamics in architecture,
2. The field of lighting in architecture, and
3. The field of architectural acoustics.

In the field of thermodynamics in architecture, the most important quantities whose intensity determines the area of human comfort are: the temperature of the outside air (t_e), the temperature of the air inside the room (t_i), including the vertical gradient of the air temperature inside the room, the temperature of the inner surfaces of the outer enclosure surfaces (υ_j) , relative humidity of the outside air (φ_e), relative humidity of the air inside the room (φ_i), air flow velocity (c_z), CO_2 concentration and odor concentration.

In the area of lighting in architecture, the most important quantities whose intensity (quality) determines the area of human comfort are: spectral composition of light, light color climate, light color temperature (T, in K), light flux (light flux, W/s), light strength (intensity, c_d), illuminance (l_x), uniformity of illumination, brightness (luminescence, cd/m^2), brightness distribution, glare limitation, phototechnical properties of materials and surfaces: reflection (ρ), absorption (α), transparency (τ) , refraction (index of refraction, n). In the area of architectural acoustics, the most important quantities whose intensity (quality) determines the area of human comfort are: sound intensity (W/m^2), sound power (W) and sound energy density (Ws/m^3), sound pressure level, types of sound impulse, sound resonance, sound interference, directional characteristics of a sound source, doppler effect, phenomena that threaten sound propagation (reflection, diffraction, absorption, refraction), reverberation, echo flutter in a room, room reverberation, reverberation time (s), room volume (m^3) , specific acoustic volume of the room (m^3/person) and noise [29].

The speed of sound is the distance traveled by a sound wave per unit time during propagation through an elastic medium. At 20 °C, the speed of sound in air is about 343 meters per second. It depends a lot on the temperature, as well as on the medium through which the sound wave propagates. In colloquial speech, the speed of sound refers to the speed of sound waves in air. However, the speed of sound varies from substance to substance: usually sound travels slowest in gases, faster in liquids and fastest in solids. For example, while sound travels at a speed of 343 m/s in air, it travels at a speed of 1481 m/s in water (almost 4.3 times faster than in air) and 5120 m/s in iron (almost 15 times faster). In an extremely rigid material, such as diamond, sound travels at 12,000 meters per second - about 35 times the speed of air and about the fastest it can travel under normal conditions. The fact that EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER) was created on the border of two different environments, water and air, gives the people who live in it incredible possibilities in mutual (sound) communication ('through water'), as well as a number of other effects which will be researched together for the development of the design of this type of architecture.

3.2. Aesthetic and psychological requirements

*Corresponding author: **Ahmet Hadrovic**

EARTH WATER AIR ARCHITECTURE was created a long time ago. The reasons for the creation and individual solutions of this architecture were the result of man's clear needs for security and self-sustainable life. Although the architectural realizations (which will be presented in this work) as well as the solutions of navigable bodies, are distinguished by their sui generis beauty, due to the fact that they were created on natural (physical) principles that are 'pure truth', the latest architectural realizations, as the basic reason for their creation , they have man's need for the beautiful, the need for adventure, for new psychological and aesthetic experiences that will distance him from everyday 'routine' life, give him strength and will to work and prepare him for unpredictable life challenges. In the mentioned author's book “Man, something or nothing” (2019), as well as in the book “Biography of an architect, Part 1” (2020), the author talks about his own life experience, where life by the water (river Krivaja) was of great importance for his understanding of the world as a whole. Even before he learned about the scientific explanation of Archimedes' principle and Bernoulli's principle, he also used them abundantly in his life with water. EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER), for people accustomed to 'life on the ground', represents the unknown, adventure and the framework of life 'on the edge of the impossible'. The author had the intention (guided by the theory of Architecturally Defined Space) to present this architecture as 'normal architecture' created by man from prehistory to the present day.

4. Boundaries: architecture as a framework of life

In accordance with the previously mentioned concept of architecture as an Architecturally Defined Space (ADS, Figure 1), Boundaries (3) are the one (of the four basic) elements of ADP that, with its concept and materialization, reflect the result of harmonizing the requirements of Man (2), from one , and conditions of the specific Environment (1), on the other hand. As man is a very complex being, and as the possible combinations of conditions of the concrete environment are practically unlimited, the possible physical appearance of the boundaries of ADS is also unlimited. The boundary that demarcates the complex system of needs in the environment is also built by other living beings, sometimes with such skill that not even humans can achieve (termite mounds, bee combs, bird's nests, cobwebs...). However, despite their perfection, we do not consider such borders to be architecture, since architecture is the exclusive creation of man. According to the presented definition of borders, one could carelessly conclude that borders are created 'automatically' by matching the demands of man and the input of the environment. Some examples of vernacular architecture around the planet almost confirm this. However, as architecture is created by humans, and each one is different from the other in a population of several billions, the 'solutions to the same architectural task' obtained by any number of architects will be different. Moreover, the same architect, at different times, will give different answers to the same architectural task. The just-mentioned complexity and controversy characteristic of architecture are those specificities that distinguish architecture from the world of other sciences, arts and philosophy and make it a total human creation [30].

4.1. Structures on stilts (piles) in water

In this subchapter, some rigid physical structures built on water, from prehistory to the present, will be presented. Prehistoric Pile Dwellings around the Alps is a group of 111 small individual sites comprising the remains of prehistoric pile dwellings (or houses on stilts) in and around the Alps built from around 5000 to 500 BC on the edges of lakes, rivers or marshes. Excavations, carried out only in some places, have yielded evidence that provides insight into prehistoric life during the Neolithic and Bronze Ages in Alpine Europe and the way communities interacted with their environment. Fifty-six locations are located in Switzerland. The settlements are a unique group of exceptionally well-preserved and culturally rich archaeological sites that represent one of the most important sources for the study of early agrarian societies in the region [31]. The exceptional conditions of preservation of organic materials provided by submerged sites, combined with extensive underwater archaeological research and research in many areas of the natural sciences, such as archaeobotany and archaeozoology, in recent decades have combined an extraordinary detailed perception of the world of early agrarian societies in Europe. Precise data on their agriculture, animal husbandry, metallurgy development in a period of more than four millennia coincides with one of the most important phases of recent human history - the dawn of modern societies. Given the possibilities of accurate dating of wooden architectural elements by dendrochronology, the sites provided exceptional archaeological sources that enable the understanding of entire prehistoric villages and their detailed construction techniques and spatial development over very long periods. They also reveal details of trade routes for flint, shells, gold, amber and pottery across the Alps and in the plains, transport evidence from excavated canoes and wooden wheels, some equipped with two-wheel axles from around 3400 BC, some of the oldest preserved on world, and the oldest textile in Europe dates back to 3000 BC. This cumulative evidence provided a unique insight into the domestic lives and settlements of some thirty different cultural groups in the alpine lake landscape that allowed the mounds to flourish. The physical remains are well preserved and documented. The remarkable survival of organic remains allows the highest level of definition in relation to the use and function of the site. However, the ability of sites to demonstrate their value is difficult as they are mostly completely hidden underwater, meaning their context in relation to lakes and riverbanks is important to convey the nature of their surroundings. This context is to some extent threatened in those places that survive in intensively urbanized environments. Since places cannot be openly presented in situ, they are interpreted in museums. A comprehensive presentation framework that enables coordination between museums and an agreed standard of archaeological data needs to be developed to ensure an understanding of the value of the whole property and how individual sites contribute to that whole [31].

Lake Dwellings (German: Pfahlbauten) are 'mound structures', the remains of prehistoric settlements within the present-day lake rim in southern Germany, Switzerland, France and Italy (Figures 37,38,39). According to a theory put forward by Swiss archaeologist Ferdinand Keller (1800-1881) in the mid-19th century, the dwellings were built on platforms resting on piles above the surface of the water, and all look very similar in construction. First, wooden piles, the ends of which were burned to the ground, were driven deep into the mud and surrounded by heavy stones. A lace of trees and smaller branches is built over the piles, forming a platform; one- or two-room rectangular huts with floors made of beaten clay were built on the platform. Although clay floors were used specifically as a precaution against fire, the vast majority of pile dwellings seem to have ended in fire-

*Corresponding author: **Ahmet Hadrovic**

accidental or as a result of enemy attack. Both cattle and sheep were raised on the platforms [32]. Since the lake dwellers usually rebuilt a new village on top of the remains of an old one, archaeologists were able to work out a cultural sequence for Central Europe and in the process confirm what the Danish archaeologist Christian Jürgensen Thomsen (1788-1865) had posited for Scandinavia - that the Stone Age followed the Bronze Age. Pile dwellings continued to be built during the Bronze and Iron Ages. Anthropologists now believe that the pile houses may have been built over the wetlands on the shores of the lakes rather than over the water of the lakes themselves. Similar houses and storage buildings on platforms supported on wooden piles or stone foundations are used today in humid subtropical and tropical areas (in Malaysia, for example).

Figure 37. Original piles in Lac de Chalain, rive occidentale (FR-39-02) with a reconstruction of a Neolithic dwelling in the background. Prehistoric dwellings cluster around the Alps (Austria, France, Germany, Italy, Slovenia, Switzerland).
Source: https://whc.unesco.org/en/list/1363/, Accessed: July 12, 2023.

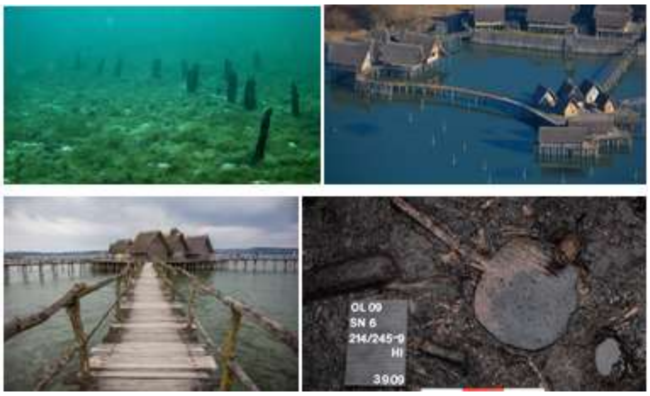


Figure 38. Prehistoric Pile Dwellings around Lake Constance
Source: https://www.bodensee.eu/en/what-todo/culture/unesco-world-heritage/piledwellings, Accessed: July 12, 2023.
Source: https://www.worldheritagesite.org/list/Prehistoric+Pile+Dwellings, Accessed: July 12, 2023.

Figure 39. Predhistorijski stanovi na štulama u širem prostoru Alpi (rekonstrukcija)
Source: https://www.pinterest.com/pin/317222367493920738/, Accessed: July 12, 2023.

4.1.1. Venice

The floating city of Venice, one of the most unusual cities in the world, is built on 118 islands in the middle of the Venetian lagoon at the head of the Adriatic Sea in northern Italy (Figures 40,41). It seems impossible for such a large city to float in a lagoon of water, reeds and marshland. Why would anyone want to live on a flat, muddy, marshy island in the middle of a lagoon? The reason is - fear. People fled their homes on the mainland when barbarian invaders ravaged Italy in the 5th century BC. They used the marshy lagoon for protection and found refuge among the poor fishermen who lived there. As the invasions continued throughout Italy, more and more refugees joined the first settlers, and the need to build a new city grew. The city of Venice was 'born' on Friday, March 25, 421, and that was the beginning of the long and rich history of this city. The most fascinating story is how Venice was built. When new settlers arrived on the islands around 402, they were faced with the need for more space and a stronger foundation for living. They had to find ways to strengthen the islands, drain them, enlarge them and protect the fragile environment. They dug hundreds of canals and lined the banks with wooden posts. They also used similar wooden posts as foundations for their buildings. Settlers hammered thousands of wooden piles into the mud, so close that they were touching. They then cut off the tops and created solid platforms for the foundations of their homes. Since the wood was under water, it did not rot. Even today, there are many buildings in Venice that still stand on piles of wood that are 1000 years old. Today, some people say that Venice should be called a sinking city, not a floating city. But Venice began to sink at the moment of construction. From the beginning, the weight of the city pushed down the dirt and mud on which it was built, displacing water and compacting the soil. This phenomenon, along with the natural movement of the tides, causes occasional flooding in the city, creating a sinking feeling. In the middle of the 20th century, a series of artisanal wells were opened all over the city. Built on a lagoon and surrounded by the salty Mediterranean Sea, the city has always struggled to find drinking water. To serve these wells, deep holes were drilled, next to the piles and into the hard clay on which the piles stood. This disorder has dire consequences. By changing and weakening the structural integrity of the wood, the city began to sink faster and faster. The city quickly stopped once they realized the error of their ways, however, it was too late to undo the damage. Today, drilling is prohibited. Another impact on Venice is erosion caused by ships in the canals. Today, the number of motor vessels in the canals is twice as high as ten years ago. These motor vehicles create much more disturbance and turbulence in the water than earlier boats and rowing boats. More than 60% of the buildings along the Grand Canal are believed to have been damaged by increasing waves. This water disturbance leads to an increased rate of erosion on already old buildings. In the last 100 years, the city has sunk nine centimeters. Some experts warn that global warming will cause sea levels to rise and eventually cover the Adriatic coast and the city of Venice by 2100. Several initiatives, such as the MoSE project, have been proposed to combat the crisis facing Venice. In particular, the MoSE project receives a lot of attention. The plan consisted of building nearly 80 movable gates that could help control the flow of water into the Venetian lagoon. These devices were placed in the three main entrances of the Lagoon. The initiative has had a turbulent history,

*Corresponding author: **Ahmet Hadrovic**

but the system was first tested in July 2020. However, it is not expected to be ready for several years. Venice is an enchanting city, and its foundations may be the most fascinating part of its history. The famous Russian writer, Alexander Herzen (1812-1870) said: „To build a city where it is impossible to build a city is just madness, but to build one of the most elegant and largest cities is the madness of genius“ [33].

Figure 40. Venice, a city built on water
Source: https://placesallover.files.wordpress.com/2012/06/venecia-aerea.jpg, Accessed: July 12, 2023.
Source: https://www.livitaly.com/how-wasvenice-built/, Accessed: July 12, 2023.

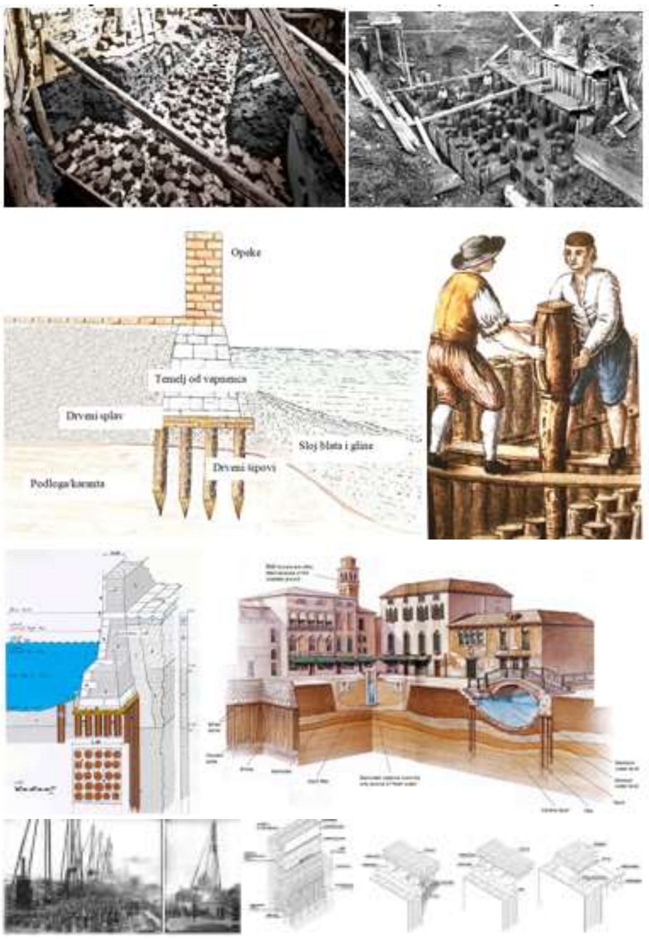


Figure 41. The physical structures of the city of Venice are based on wooden piles
Source: http://veniceatlas.epfl.ch/networkanalysis-of-venices-citizens-socialgraph-based-on-the-garzoni-font/, Accessed: July 12, 2023.
Source: https://climateandmoney.com/p/9-what-is-the-value-of-money-in-a, Accessed: July 12, 2023.
Source:https://www.researchgate.net/figure/Schematic-representation-of-a-piledfoundation-of-a-large-city-palace-in-VeniceAfter_fig36_239526106https://ars.elscdn.com/content/image/1-s2.0-S1350630717300961-fx1_lrg.jpg, Accessed: July 12, 2023.

4.1.2 Amsterdam

Amsterdam is a city (with about 852,000 inhabitants), the largest municipality and the capital of the Netherlands located in its western part. The name of the city comes from its location on the river Amsel (Amstelredamme, 'dam on the river Amstel'). From a small port in the 12th century, Amsterdam in the 17th century (the 'golden age of the Netherlands') became the most important port in the world and the world's leading financial and diamond trading center. During the 19th and 20th centuries, the city expanded significantly. The exceptional urban-architectural values of the city (Amsterdam's canals from the 17th century and its defensive lines towards the sea from the 19th and 20th centuries) were included (2010) in the UNESCO list of world cultural heritage [34]. The Amsterdam Stock Exchange (located in the historic center of the city) is the oldest in the world. Today, Amsterdam is one of the most developed cities in Europe and the world [35], where over 500 of the world's largest companies are headquartered (including Philips, AkzoNobel, TomTom and ING, Uber, Netflix, Tesla...). Amsterdam was (2009) in third place in the world according to innovations [36] (Figure 42).

Figure 42. Aerial view of Amsterdam
Source: https://www.roundtheworldmagazine.com/2-days-in-amsterdam/aerial-viewof-amsterdam-netherlands/, Accessed: July 12, 2023.

There is no evidence that there was a settlement in the area of today's Amsterdam before the 10th century. At that time, there was a peat bog there, and works were carried out to fill defensive embankments facing the sea in order to provide space for the construction of a settlement. The earliest mention of the town in written documents dates back to 1275, when the inhabitants of the settlement were exempted from paying tolls to Count Floris V (1254-1296, Count of Holland and Zeeland) on the bridge and dams, with freedom of movement in the Netherlands. Amsterdam received city rights in 1300 [37]. Since the 14th century, the city has been developing particularly intensively, thanks primarily to trade. In the 16th century, there was a rebellion in the Netherlands against Philip II (Philip II (1527-1598, King of Spain (1556-1598), King of Portugal (1581-1598), King of Naples and Sicily (1554), jure uxoris King of England and Ireland (during his marriage to Queen Mary I (1554-1558), ruler of the province of Holland, from 1555) which turned into the Eighty Years' War and ended with Dutch independence (1581) [38] and the establishment of the Dutch Republic. Thanks to religious tolerance, the Netherlands attracted a large number of Jews from the Iberian Peninsula, Huguenots from France, successful merchants from Flanders and religious refugees from what is now the Netherlands, which at that time was still under the rule of Spain. The seventeenth century is considered the 'golden age' of the Netherlands when Amsterdam became the richest and the most desirable city in the Western world.At that

*Corresponding author: **Ahmet Hadrovic**

time, ships with goods sailed from Amsterdam to the Baltic countries, North America, Africa, Indonesia, India, Sri Lanka, Brazil (...), making their routes the backbone of the trade network in the world at that time. Merchants from Amsterdam had the largest share in the world's largest trading companies at the time (Dutch East India and West India Company), which acquired vast overseas possessions that later became Dutch colonies. The American office of the Dutch East India Company opened (1602) the first world stock exchange with its own shares, and the Bank of Amsterdam began its work in 1609. Wars with England and France during the 18th and 19th centuries significantly weakened Amsterdam, and during the Napoleonic Wars (1804-1815), when the Netherlands became part of the French Empire, Amsterdam reached its lowest point of development and overall power in its history. . The establishment of the Kingdom of the Netherlands (1815) marked the end of Amsterdam's dark ages.

The end of the 19th century is often called the "second golden age" of Amsterdam. The city then expanded and received many new facilities that enriched the life of its citizens: new museums, the railway station and the Concertgebouw, the Amsterdam-Rhine Canal, the North Sea Canal... In the First World War, the Netherlands was neutral, and this circumstance (preservation from war destruction) favored the development of Amsterdam in the post-war period, with limited social tensions and unrest caused by a general food shortage (known as the Aardappeloproer, i.e. the 'Potato Rebellion'). The Netherlands welcomed its freedom on May 8, 1945. After the Second World War, further expansion and progress of Amsterdam took place, when its new settlements were built: Osdorp, Slotervaart, Slotermeer and Geuzenveld. The main feature of these settlements are spacious, green public areas and apartments with lots of natural light and semi-open areas (loggias and balconies). The metro in Amsterdam was opened in 1977, which amortized the burden of cars in the old city center. Above the metro, the construction of a highway was planned, which was supposed to connect the old part of Amsterdam with its surrounding settlements along the same route (this project has not been realized to date). At the same time, the reconstruction of the old part of the city began, especially the quarters where Jews lived until the Second World War. The restoration of the old part of the city led to the inclusion (2010) of some of its parts on the UNESCO list of world cultural heritage.

For centuries, the Dutch perfected the technique of 'grabbing the land from the water', that is, they drained marshy areas and also built dams towards the sea and gradually expanded the land towards the open sea. Later, this knowledge was applied around the world, and in recent decades in the United Arab Emirates, where the construction of artificial islands became particularly popular. Previously, oak logs were used to make piles, and in recent times, reinforced concrete piles are preferred. The piles should reach the clay or, in most cases, a more stable layer of soil. In the area of Amsterdam, the load-bearing layers are at a depth of about 15-25 meters (the first 10 meters are only peat and soft clay). One could say that Amsterdam was literally built on stilts (Figure 43). Pile foundations were laid for every building in the city (for example, more than 6,000 piles were needed to support the Central Station). You should know that the shallowest layers of soil in Amsterdam are almost 100% saturated with water, so if you do not use the piling construction technique, the building will not be stable enough. Small buildings and roads can actually work even if a layer of sand and pavement is placed on the ground. However, larger structures such as high-rise buildings or highways must be built on piles. Currently, large buildings in Amsterdam are attached to a layer of stone clay at about sixty meters. Obviously the piles are regularly maintained to keep them in serviceable condition. A similar situation with construction is also in other parts of the Netherlands, especially in its western part, in contact with the sea itself (Figures 43,44,45).

Figure 43. The author of this work in the City Hall in Amsterdam (points with his hand to the piles on which the physical structures of the city are built)
Source: Dr Elama Durmisevic (June 17, 2010.)

Figure 44. The author of this work on the Maeslantkering dam in Rotterdam. The Maeslantkering (Dutch: Maeslant barrier) is a storm barrier on the Nieuwe Waterweg, in the Netherlands. It was built from 1991 to 1997. When closed, the barrier protects a 360-meter wide Nieuwe Waterweg, the main waterway of the Port of Rotterdam
Prof. Mevludin Zecevic, MSc (April 9, 2008)

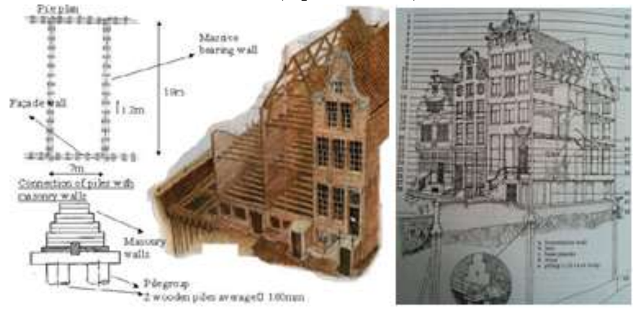


Figure 45. A typical building foundation in Amsterdam
Source: https://gr.pinterest.com/pin/92464598574316999/, Accessed: July 12, 2023.

Building on piles over water is a permanent theme of architecture and construction in Amsterdam and in the Netherlands in general. In addition, the construction of structures that float on water, as well as structures under water, are increasingly present ideas in architecture.

ZJA Zwarts & Jansma Architects received the Excellence Award for Architectural Achievement for their design for the Albert Cuyp Underwater Garage in Amsterdam (Figure 46). The prize is awarded by the International Parking & Mobility Institute (IPMI) as part of the Awards of Excellence competition. The Albert Cuyp parking garage was built to increase the quality of life in the De Pijp district of Amsterdam and improve the attractiveness of the

*Corresponding author: **Ahmet Hadrovic**

public domain. It is the first project of its kind under the Amsterdam canal [39].

Figure 46. Albert Cuyp Garage in Amsterdam, project, 2019 (architects: ZJA Zwarts & Jansma Architects)
Source: https://gr.pinterest.com/pin/92464598574316999/, Accessed: July 12, 2023.

4.1.3 Structures on stilts (piles) around the world

Houses that are built in permafrost areas are built on stilts to keep the permafrost below them from melting. Permafrost[3] can be up to 70% water (Figure 47). While frozen, it provides a stable foundation. However, if the heat radiating from the bottom of the house melts the permafrost, the house goes out of alignment and begins to sink into the ground. There are other ways to prevent the permafrost from melting, but raising the house off the ground on stilts is one of the most effective ways.

Figure 47. Permafrost
Source: https://www.nrdc.org/stories/permafrost-everything-you-need-know, Accessed: July 12, 2023.

Before the Russians came to Kamchatka, the Itelmen lived in small settlements along the rivers where salmon spawn (Figure 48). These settlements consisted of several semi-underground apartments (usually 4). Each could fit several families. Today there is only one traditional semi-underground dwelling built based on the descriptions of various researchers. This apartment is located not far from the settlement of Sosnovka on the territory of the Vera Koveinik "Pimcakh" family community. Itelmen language specialist Viktor Rizhkov put a lot of effort into building this apartment. During the fishing season, the Itelmeni move to their summer residences. They were located closer to the sea coast. These apartments are called „Meme'n" in Itelmen or „Balagan" in Russian.

[3] Permafrost is any soil that remains completely frozen (0 °C or colder) for at least two years. These permafrost lands are most common in regions with high mountains and at higher latitudes - near the North and South Poles. Permafrost covers large areas of the Earth.

Figure 48. Traditional house of the Itelmen people, Sosnovka, Kamchatka
Source: http://www.u.arizona.edu/~tatianadegai/css/wheat/dwellings_eng.html, Accessed: July 12, 2023.

Raised houses with rectangular bases are one of the cultural features of the Austronesian peoples and are found in all regions of the islands of Southeast Asia, the islands of Melanesia, Micronesia and Polynesia inhabited by Austronesians (Figure 49). The structures are raised on stilts, usually the space below is also used for storage or livestock. The elevated design had several advantages: it reduced damage during floods and (in many instances) could act as a defensive structure during conflict. Poles (stilts) usually have discs of a larger diameter on their top to prevent pests from entering buildings by climbing them. Austronesian houses and other structures are usually built in swamps and next to bodies of water, but they can also be built in the mountains or even directly on shallow water.

Figure 49. Houses on stilts of the Ifugao people, Northern Luzon, Philippines. They are derived from the design of traditional granaries
Source: https://www.flickr.com/photos/joanniebhu/1192109596, Accessed: July 12, 2023.

Houses on stilts were also built by Native Americans in pre-Columbian times. Palafito is especially widespread along the coasts of tropical river valleys in South America, especially the Amazon and Orinoco river systems [40] (Figure 50). Houses on stilts were such a widespread feature along the shores of Lake Maracaibo that Amerigo Vespucci was inspired to call the region „Venezuela" (little Venice). With the cost of hurricane damage increasing, more and more homes along the Gulf Coast are being built or converted to stilt homes. Houses on stilts are also still common in the swampy areas of northeastern Nicaragua and northern Brazil.

*Corresponding author: **Ahmet Hadrovic**

Figure 50. Palafito houses, river valleys of South America
Source:
https://commons.wikimedia.org/wiki/File:Palafitos_de_Castro.jpg,
Accessed: July 12, 2023.

Granaries on stilts are a common feature in West Africa, in the Malinke-speaking regions of Mali and Guinea, for example (Figures 51,52).

Figure 51. Granaries on stilts, Namorunyang State, Kapoeta, South Sudan to Senegal
Source:
https://www.flickriver.com/photos/mytripsmypics/49643724843/,
Accessed: July 12, 2023.

Figure 52. Granary on stilts in Senegal
Source: https://www.istockphoto.com/photo/senegal-granary-storage-gm1058542758-282916204, Accessed: July 12, 2023.

In the Neolithic, Copper Age and Bronze Age, hut settlements were common in the Alpine and Pianura Padana (Terramare) regions. The remains were found on the Ljubljana Bar in Slovenia, on the Mondsee and Attersee lakes in Upper Austria, and in the wider area of the Alps. Early archaeologists such as Ferdinand Keller thought they formed artificial islands, similar to Irish and Scottish crannogs, but today it is clear that most settlements were located on the shores of lakes and were only later flooded. The reconstructed stilt houses are displayed in open-air museums in Unteruhldingen and Zurich (Pfahlbauland). In June 2011, prehistoric mounds in six Alpine countries were declared a UNESCO World Heritage Site [31]. In Sweden, a Scandinavian dwelling made of piles, the house on the Alvastra pillar, was investigated. Herodotus in his book „Histories“ (Greek: Ἱστορίαι) described the dwellings of the 'lake dwellers' in Paeonia and how they were built.

In the Alps, similar buildings, known as 'raccards', are still used as granaries. In England, granaries are placed on stacked stones, similar to stilts, to prevent mice and rats from getting to the grain.
In Italy there are several settlements with huts, for example the one on Rocca di Manerba del Garda (Lombardy), (Figure 53).

Figure 53. Pile-Dwelling Museum of Lake Ledro (Italy)
Source: https://www.outdooractive.com/en/poi/ledro/pile-dwelling-museum-of-lakeledro/30765364/, Accessed: July 12, 2023.

Houses on stilts were built and are still being built elsewhere in the world: Diaojiaolou (houses on stilts in southern China), Kelong (built primarily for fishing, but often used for living at sea in the countries: Philippines, Malaysia, Indonesia and Singapore), Bahay Kubo (a traditional house type prevalent in the Philippines), Palafito (found throughout South America since pre-Columbian times (Figures 54,55,56). In the late 19th century, numerous palafitos were built in Chilean cities such as Castro, Chonchi and other towns in the Chiloé Archipelago, and today are considered a typical element of Chilotan architecture), Pang uk (a special type of house found in Tai O, Lantau, Hong Kong, mainly built by Tankas), Patua New Guinea house on stilt house (a type of stilt house built by the Motuans, usually found in the southern coastal area of Patua, New Guinea), Queenslander (a common type of stilt house in Queensland and northern New South Wales, Australia), Sang Ghar (a type of stilt house built in Indian to the state of Assam. Mainly found in the floodplains of the Brahmaputra river valley), Thai stilt house (a type of house often built on fresh water, Lotus Pond, for example), Vietnamese stilt house (similar to Thai, except that it has a lower entrance door for religious reasons).

Figure 54. Diaojiaolou, Tujia Village, Hunan, China
Source: https://www.asiaculturaltravel.co.uk/diaojiaolou/, Accessed: July 12, 2023.
Source:
https://www.reddit.com/r/ArchitecturalRevival/comments/e4f3ln/diaojiaolou_stilted_houses_ancient_city_of/
Accessed: July 12, 2023.

*Corresponding author: **Ahmet Hadrovic**

Figure 55. Kelong, South China Sea
Source: https://www.flickr.com/photos/oddwick/175478322, Accessed: July 12, 2023.

Figure 56. Bahay Kubo, Philippines
Source: https://1.deminasi.com/bahay-kubodesign.html, Accessed: July 12, 2023.

Contemporary stilt buildings are believed to be derived from the design of raised granaries and rice warehouses, which are very important status symbols among rice-growing Austronesians. The rice granary shrine was also an archetypal religious building among Austronesian cultures and was used to store carvings of ancestral spirits and local deities. Although rice cultivation was not one of the technologies transferred to Far Oceania, raised warehouses still survived. The Māori duck is an example. The largest ducks are elaborately decorated with carvings and are often the tallest buildings in Māori pā. They were used to store tools, weapons, ships and other valuables, while fewer ducks were used to store food. A special type of duck supported by a single tall pillar also had ritual importance and was used to isolate older children during their leadership training. Most Austronesian structures are not permanent. They are made from perishable materials such as wood, bamboo, plant fibers and leaves. Because of this, the archaeological record of prehistoric Austronesian buildings is usually limited to traces of house posts, with no way of determining the original building plans. Circumstantial evidence of traditional Austronesian architecture can, however, be gleaned from their contemporary representations in art, such as the friezes on the walls of later Hindu-Buddhist stone temples (such as the reliefs at Borobudur and Prambanan). But they are limited to the last centuries. They can also be linguistically reconstructed from common terms for architectural elements, such as posts, thatch, rafters, hearths, ladders with carved logs, storage racks, public buildings... Linguistic evidence also clearly shows that stilt houses were already present among Austronesian groups at least since the late Neolithic. There are striking similarities between Austronesian architecture and Japanese traditional raised architecture (shinmei-zukuri). Especially the buildings of the great shrine of Ise, which contrast with the pits typical of the Yayoi Neolithic period. This indicates significant Neolithic contact between the peoples of southern Japan and the Austronesians or pre-Austronesians that occurred before the spread of Han Chinese cultural influence to the islands. Rice cultivation is also believed to have been brought to Japan from the Para-Austronesian group from coastal eastern China.

4.1.4 Contemporary structures on stilts (on piles)

Piles (stakes, stilts, poles) in construction are part of the foundation that was used in prehistoric times. In modern construction, wood, steel or concrete piles are driven into the ground to support the structure [41]. Bridge columns can be supported on groups of large diameter piles (Figure 57). On unstable ground, piles are essential construction supports, and they can also be used on stable ground when dealing with extremely large structural loads. Piles are driven into the ground using special machines ('hammers') which usually consist of a tall frame with devices for raising and lowering the pile hammer or for supporting and guiding a jet or air hammer.

Figure 57. Construction on pylons
Source: https://www.britannica.com/technology/pile-construction, Accessed: July 12, 2023.

A deep foundation is a type of foundation that transfers building loads to the ground further from the surface than shallow foundations to a subsurface layer or range of depths. A pile or pile is a vertical structural element with a deep foundation, driven or drilled deep into the ground at the construction site. There are many reasons why a geotechnical engineer would recommend a deep foundation over a shallow foundation, such as for a skyscraper. Some of the common reasons are very large design loads, poor soil at a shallow depth, or site restrictions such as property lines. Various terms are used to describe different types of deep foundations, including pile (which is analogous to a column), pier, bored shaft, and caisson. Piles are generally driven into the ground in situ; other deep foundations are usually laid by digging and drilling. Naming conventions may differ between engineering disciplines and companies. Deep foundations can be made of wood, steel, reinforced concrete or prestressed concrete. Precast piles are driven into the ground using a pile driver. They are made of wood, reinforced concrete or steel. Wood piles are made from trunks of tall trees. Concrete piles are available in square, octagonal and round sections (like Franki piles). They are reinforced with reinforcement and are often prestressed. Steel piles are either stacks of pipes or some type of beam section (like an H-pylon). Historically, wood piles used joints to connect multiple segments end-to-end when the required driven depth was too long for a single pile; today, jointing is common with steel piles, although concrete piles can be joined by mechanical and other means. Pile driving, as opposed to drilling shafts, is advantageous because the soil displaced by the pile drive compresses the surrounding soil, causing greater friction against the sides of the pylons, thereby increasing their bearing capacity. Driven pile foundations often have groups of piles connected by a pile cap (a large concrete block into which the pile heads are embedded) to distribute the load that a single pile can carry. Caps and insulated piles are usually connected to beams to connect the foundation elements; lighter structural elements are carried on the beams, and heavier elements directly on the pile cap. Monopile foundations use one large-diameter foundation element to support all the loads of a large overhead structure. A large number of monopile foundations have been used in recent years for the construction of wind farms on land with a fixed bottom in shallow water subsea locations. A typical procedure for constructing a subsea monopile wind turbine foundation in sand involves driving a large hollow steel pile, approximately 4 m in diameter with walls approximately 50 mm thick, approximately 25 m deep into the seabed, through a 0.5 m layer of rock and gravel to reduce erosion around the pile.

*Corresponding author: **Ahmet Hadrovic**

The transition piece (along with pre-installed features such as vessel landing arrangements, cathodic protection, cable channels for submarine cables, bag tower flange...) is attached to the driven pile, and sand and water are removed from the center of the pile and replaced with concrete. An additional layer of even larger stone, up to 0.5 m in diameter, is applied to the surface of the seabed for long-term protection against erosion.

Caissons (parallel names: drilled shafts, drilled columns, piles drilled with holes...) are forms of foundation substructure which, when newly built, have a cavity in their body which, after being placed on site, is filled with concrete. Rotary drilling techniques permit larger diameter piles than any other stacking method and allow piles to be built through particularly dense or hard layers. Construction methods depend on the geology of the place. For end-bearing piles, drilling continues until the borehole extends to a sufficient depth (pile sleeve/crown) into a sufficiently strong layer. Depending on the geology of the site, it can be a layer of rock or a hard layer or other dense, strong layers. Pile diameter and pile depth are very specific to soil conditions, loading conditions and the nature of the project. Pile depths can vary significantly by project if the bearing layer is not level. Drilled piles can be tested using various methods to verify the integrity of the piles during installation. A wide variety of piles are used in construction, depending on the foundation conditions and the types of loads (objects) they carry: micropiles, tripod piles, sheet piles, military piles, screw piles, suction piles, adfreeze piles, vibrated stone columns, hospital piles, masonry piles, secant stacked walls, wall slurry...

Historically, wood was an abundant, locally available resource in many areas. Today, wooden piles are still more affordable than concrete or steel. Compared to other types of piles (steel or concrete), and depending on the source/type of wood, wooden piles may not be suitable for higher loads. Regarding wooden piles, it is important to consider that they should be protected from rotting above the groundwater level. The tree will last a long time below the groundwater level. Two elements are needed for wood to rot: water and oxygen. Below the groundwater level, there is a lack of dissolved oxygen even though there is enough water. Therefore, the wood will last a long time below the level of underground water[4]. Wood that will be used above the water table can be protected from decay and insects by numerous forms of wood preservation using pressure treatment (alkaline copper quarter, ACQ, chrome copper arsenate, CCA), creosote...). Joining wooden piles is still common and is the easiest of all stacking materials. A common method of joining is to drive the guide pile first, driving a steel pipe (usually 60–100 cm long, with an inside diameter no smaller than the minimum finger diameter) half its length into the end of the guide plate pile. A bunch of followers are then simply inserted into the other end of the pipe and the action continues. The steel tube is simply there to ensure that the two parts follow each other during action. If lifting capacity is required, the coupling may contain bolts, screws and studs to provide the required capacity.

Other common materials from which piles are made are steel and concrete, and their combinations. At the same time, their cross-section can be different (pipe, rolled steel profiles...). Below we give several examples of contemporary architecture on stilts (piles) in the water.

The inspiration for the design of the building "Aluminum forest" by Micha de Haas includes the lowlands of the Dutch landscape, especially the characteristic groves of poplars planted in a square arrangement with their cups fused into a single mass of leaves above the trunk (Figure 58). The architect named the project 'aluminum forest', whose light cups rise six meters above the ground and form an office building, like a piece of an aluminum smelter in which the windows are placed irregularly, like deep incisions. The building is covered with colored aluminum sheet, which also symbolizes the strength of the material as a high-tech industrial product that is environmentally conscious [42]. This is an urban design of an office building with outstanding architecture and innovative technology that gives the building a unique character. The volume is based on a 'forest of columns' with internal leakage, within the main volume, which often makes it appear larger than the actual built area. In this sense, one of the main requirements is fulfilled: visual prominence. The effect is doubled by the reflection of the building in the water, creating a bright reflection at the bottom where the silhouette of the building and the columns are made of anodized aluminum with an almost magical way of joining. Inside, in silence, a glass elevator rises six meters into the air, from ground level to a raised aluminum housing, while large courtyards receive sunlit air, light and warmth. The 'whisper' of the wind and the play of the smooth columns with the water are interesting. The concrete and steel building has an aluminum frame that rests on 368 thin columns, and the aluminum also rises 6.10 meters above the ground, suspended over an artificial lake. The close proximity of the pillars enables the challenge of building expectations and the versatility of aluminum hardness, showing innovative features, thanks in part to the results of the use of space technology. Aluminum columns with a diameter of 60 mm to 210 mm and a length of 6 m are conceived as tree trunks on the tops of which is a pure parallelepiped measuring 36 m x 31.2 x 5 m. The architectural concept of the building is a rather unusual stability that had to be provided by the columns as such, without additional supports , which the architect did not allow. Research was carried out to test resistance, stability and deformation, using different construction models, in order to decide on a load-bearing system for the final project. The first structure designed by the architect was analyzed, and later appropriate changes were made in the structural system, which ultimately resulted in the achievement of a stable structural system. Finally, the concept of fire protection, agreed with the authorities, was discussed. The building was designed according to the principles of industrial, flexible and demountable construction, taking into account sustainability and energy saving. Several technical innovations were specially designed for this project, for example, the laminated construction method and aluminum facade columns that contain multiple integrated functions.

[4] In 1648, the Royal Palace in Amsterdam was built on 13,659 wooden piles that still survive today as they were below the groundwater level.

*Corresponding author: **Ahmet Hadrovic**

Figure 58. “Aluminum forest”, Houten, Utrecht, Netherlands, 1999-2001 (Architect: Micha de Haas/abbink x de hass architectures)

Source: https://www.designboom.com/architecture/building-with-water/, Accessed: July 12, 2023.

Source: https://en.wikiarquitectura.com/building/aluminium-forest-building/, Accessed: July 12, 2023.

The ”Svart Hotel” project by the Norwegian architectural firm Snøhetta is a powerful unit in the Arctic Circle: the first hotel designed to produce more energy than it consumes (Figure 59). The name of the building (which means 'black' or 'blue' in Norwegian) refers to the distinctive color of the Svartisen glacier, which spectacularly towers over the eco-hotel, which will open its doors to guests in 2021. The circular hotel from the coast of Holandsfjorden in the municipality of Meløy circular hotel seems to float above the water on wooden poles. Svart was designed in accordance with local architectural practice to maximize sustainability. The design is inspired by the A-shaped wooden frames used for drying fish ('fiskehjell') and the traditional fishermen's houses ('rorbue') found throughout the region. The building was designed and optimized to reduce the impact on the environment. Large solar panels on the roof produce a significant part of the hotel's own energy supply [43].

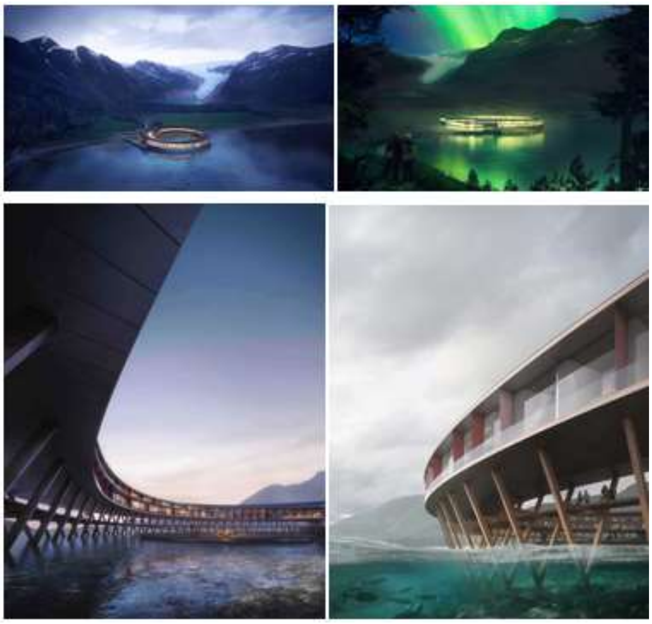


Figure 59. “Svart Hotel” (project), Holandsfjorden, Meløy municipality, Norway, 2021 (architects: Snøhetta)

Source: https://www.thestylemate.com/svartnorway-the-world-first-energypositive-hotel-hotel/?lang=en, Accessed: July 12, 2023.

The Harbin Opera House is embedded in the landscape surrounding the Chinese Songhua River, the Harbin Opera, designed by MAD Architects, is an architectural reflection of the region's monsoon climate (Figure 60). The opera house in the northern city of Harbin is one with its environment, seemingly organically shaped by wind and water. With a white, modern aluminum facade, sharp edges rise from soft contours. On walkways that appear to be carved into the building, visitors can climb the hill-like structure. At the top, the ascent is rewarded with a view of the city skyline and surrounding areas. Inside the opera house, the glass walls and ceiling of the spacious lobby are covered in a pure white honeycomb structure, casting ethereal shadows like drifts of snow across the space. Fewer than two theaters have a large panoramic window behind the stage that connects the platform to the outside world. This glass wall also serves as a natural backdrop during the performance [43].

Figure 60. Harbin Opera House, Harbin, China, 2015 (architects: MAD Architects)

Source:https://www.archdaily.com/778933/harbin-opera-house-madarchitects/56717981e58ece4c63000001-harbin-opera-house-mad-architectslongitudinal-section, Accessed: July 12, 2023.

The Wave in Vejle, Denmark, designed by Henning Larsen Architects, is a new unique residence that embraces sculptural and organic forms to become a new landmark of the city (Figure 61). It takes advantage of its position and the views it offers, while equally challenging the existing architecture of the area and its program as a residential complex. The recognizable building was chosen as the winner of the prestigious Citizen's Trust award. The awards were presented at an official ceremony at the People's History Museum on March 4 in Manchester. ”Wave shows how Danish architects are responding to global trends without sacrificing practicality or the well-crafted details that have long been a Dane signature”, wrote British reviewer Michael Webb in the architecture magazine Mark in February 2011. Henning Larsen Architects won the project in an invited competition in 2005 .with real estate company Bertel Nielsen as a client. Two award-winning waves have been completed so far, while the last three are expected to increase in the near future. The characteristic shape and material of the case allow it to be an element of the ever-changing landscape. During the day, the white waves are reflected in the sea, and at night, the characteristic profile will look like illuminated multi-colored mountains. And it imitates the landscape and stands out, changing its appearance with time and time of day. The wave is inspired and takes its shape from the characteristics of the area: the fjord, the bridge, the city and the hills. The clear and easily recognizable signature of the building connects the residential area with the sea, the landscape and the city.

*Corresponding author: **Ahmet Hadrovic**

Figure 61. The Wave, Vejle, Denmark, (architect: Henning Larsen) Source: https://www.archdaily.com/120948/the-wave-henning-larsen-architects, Accessed: July 12, 2023.

The City of Arts and Sciences in the southeast of Valencia is a visionary building (Figure 62). This cultural and leisure complex was developed by Santiago Calatrava, an architect known for his experimental designs inspired by water. The 'City' was built on a two-kilometer plot of land on the former bed of the Turia River, which was drained in the early 1990s. The 350,000 m^2 complex is now home to a series of steel, concrete and glass buildings, which are visually connected by artificial water bodies. Oceanogràfic is the largest European aquarium and a true gem of marine architecture. The mirrored surfaces reflect the water, and the curved roof resembles the movement of waves. With four concert halls and an opera house, the Palau de les Arts is the largest building in the complex. The rounded contours give it the appearance of a futuristic cruiser, moored in the harbor with the bow facing the land.

Figure 62. City of Arts and Sciences, Valencia, Spain, 1996-2005 (architect: Santiago Calatrava)
Source:https://www.mondotravel.hr/putovanjezrakoplovom-valencia-pet-dana.htmlarchdaily.com/233575/ad-interviewssantiagocalatrava/1250891759_200908220657404739263301_0, Accessed: July 12, 2023.
Source: https://www.dezeen.com/2015/05/21/calatrava-city-of-arts-sciences-valenciatomorrowland-george-clooney-bradbird/ Accessed: July 12, 2023.

4.2 Structures that float on water

Structures that float on water, as the name suggests, are maintained on the surface of the water, according to Archimedes' principle. They can be mobile (various types of boats and ships) or fixed. As for architectural objects that float on water, they can be built on site, or, which is more common, on land, after which they are immersed in water and dragged to the desired location. After that, similar to boats and ships, they are anchored, usually with steel ropes or piles along their contour on the water.

4.2.1 Vessels

In the most general sense, vessels are all bodies that float on water. In the context of the contents of this book, boats, ships and floating architectural structures will be treated as vessels.

Boats. A boat is a vessel of a wide range of types and sizes, but is generally smaller than a ship. Small boats are usually found on inland waterways, such as rivers and lakes, or in sheltered coastal areas [44]. However, some boats, such as whalers, were intended for use in a coastal environment. In modern maritime terms, a boat is a vessel small enough to be loaded onto a ship. There are anomalous definitions, as lake freighters 300 meters long are called 'boats' on the Great Lakes. Boats differ in proportions and construction methods according to their purpose, available materials or local tradition. Canoes have been used since prehistoric times and remain in use throughout the world for transportation, fishing and sports. Fishing boat styles vary widely partly to suit local conditions. Pleasure boats used in recreational boating include ski boats, pontoon boats, and sailboats. Houseboats can be used for vacation or long-term living. Barges (Lighters) are used to transport cargo to and from large ships that cannot get close to the shore. Lifeboats have rescue and safety functions. Boats can be powered by labor (rowboats, for example), wind (sailboats, for example), and engines (including gasoline, diesel, and electricity). After Homo erectus probably used vessels a million years ago, crossing the straits between the mainland [45], boats served as transportation far into prehistoric times. Independent evidence, such as the early settlement of Australia more than 40,000 years ago, finds in Crete dated to 130,000 years ago [46], and in Flores dated to 900,000 years ago, indicate that boats have been used since prehistoric times. It is believed that the earliest boats were dwellings, and the oldest boats found by archaeological excavations date from about 7000-10000 years ago. The oldest boat found in the world, the Pesse canoe, found in the Netherlands, is a dwelling made from the hollowed-out trunk of a Pinus sylvestris tree that was built sometime between 8200 and 76 BC (Figure 63). This canoe is on display at the Drents Museum in Assen, the Netherlands. Other very old boats with habitats were also found. Rafts have been in operation for at least 8,000 years. A 7000-year-old reed boat was found at site H3 in Kuwait [47]. Boats were used between 4000 and 3000 BC in Sumer, ancient Egypt and the Indian Ocean (Figures 63,64).

Figure 63. Pesse Canoe, Netherlands, circa 8200 BC (Today on display at the Drents Museum in Assen), (left) and a 7,000-year-old reed boat found at Site H3 in Kuwait
Source: https://www.marine-antique.net/Shipmodel-in-Kuwaiti-site-H3, Accessed: July 12, 2023.

*Corresponding author: **Ahmet Hadrovic**

Figure 64. Left: Ancient Sumerian (top left) and Ancient Egyptian boat (top right). A boat (today) modeled after the ancient Egyptian reed boat (bottom left). A ship of Pharaoh Cheops from the IV Dynasty, who ruled Egypt between 2609-2584 BC (bottom right).
Source: https://www.pinterest.com/pin/144396731776206621/, Accessed: July 12, 2023.
Source: https://www.ducksters.com/history/ancient_egypt/boats_and_transportation.php, Accessed: July 12, 2023.
Source: https://www.pinterest.com/pin/816277501187655995/, Accessed: July 12, 2023.

Boats played an important role in trade between the Indus Valley Civilization and Mesopotamia. Evidence of different boat models has also been discovered at various archaeological sites in the Indus Valley. Uru boats originate from Beypore, a village in South Calicut, Kerala, in southwest India. This type of mammoth wooden boat is built exclusively from teak wood, with a transport capacity of 400 tons. Ancient Arabs and Greeks used such boats as trading vessels [48]. Non-powered vessels include rafts intended for one-way downstream travel. Human-powered boats include canoes, kayaks, and gondolas. Sailboats are powered mainly by sails. Motorboats are powered by mechanical means, such as engines. The hull is the main, and in some cases the only, structural component of the boat. It provides both capacity and lift. The keel is the 'backbone' of the boat, a longitudinal structural element to which the vertical frames are attached. On most boats, the deck covers the hull, partially or entirely. The cabin can protrude above the deck forward, aft, along the centerline or cover most of the length of the boat. Vertical structures that divide interior spaces are known as partitions. The front end of the boat is called the bow, and the back end is called the stern. The right side facing forward is called the starboard side, and the left side is called the port. Until the middle of the 19th century, most boats were made of natural materials, primarily wood, although reeds, bark and animal skins were also used. Early boats include the tied-reed boat style seen in ancient Egypt, the birchbark canoe, the skin-covered kayak and coracle, and the single-log canoe.

By the middle of the 19th century, many boats were built with iron or steel frames, but still covered with wood. In 1855, Joseph Louis Lambot (1814-1887) invented ferro-cement, which led to the development of reinforced concrete (Figure 65). This is a system according to which a steel or iron wire structure is built in the shape of a boat hull and covered with cement. Reinforced with bulkheads and other internal structure, it is strong but heavy, easy to repair and, if properly sealed, will not leak or corrode.

Figure 65. Boat1 by Joseph Louis Lambot, 1855.
Source: https://hr.tripnholidays.com/1300-pyramids-of-giza-egy-giza-giza-hr, Accessed: July 12, 2023.

As British and European forests continued to be overexploited to supply the keels of larger wooden boats, and the Bessemer steelmaking process (patented in 1855) made steel cheaper, steel ships and boats became more common. By the 1930s, boats built entirely of steel, from frame to plating, were seen replacing wooden boats in many industrial uses and fishing fleets. Private steel recreational boats remain uncommon. In 1895, WH Mullins produced steel boats from galvanized iron and by 1930 had become the world's largest manufacturer of pleasure boats. Mullins also offered aluminum boats from 1895 to 1899 and again in the 1920s, but it was not until the mid-20th century that aluminum gained widespread popularity. Although much more expensive than steel, there are aluminum alloys that do not corrode in salt water, allowing a similar load capacity to steel at significantly less weight. In the mid-1960s, fiberglass boats became popular, especially for recreational boats (Figure 66). In Great Britain, fiberglass is also known as GRP, glass fiber reinforced plastic, and in the USA FRP, for fiber-reinforced plastic. Fiberglass boats are strong and do not rust, corrode or rot. Instead, they are subject to structural degradation from sunlight and extreme temperatures throughout their lifetime. Fiberglass structures can be made more rigid with sandwich panels, where the fiberglass encloses a light core, such as balsa or foam.

Figure 66. Fiberglass boat
Source: https://www.woodyboater.com/blog/2013/01/31/fiberglass-classics-are-coolthe-message-today-dontdiscriminateappreciate/
Accessed: July 12, 2023.

Figure 67 shows (one of the constructions of) a wooden boat.

*Corresponding author: **Ahmet Hadrovic**

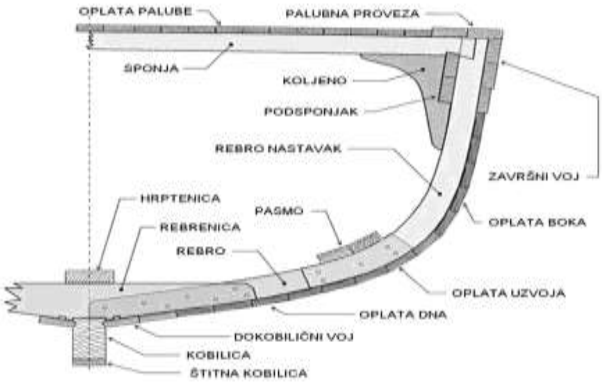


Figure 67. Construction of a boat made of wood
Source: https://www.fsb.unizg.hr/kmb/100/120/kmb120.htm, Accessed: July 12, 2023.

Cold forming is a modern construction method that uses wood as a structural component. In cold forming, very thin strips of wood are stacked over the shape. Each layer is coated with resin, followed by another directionally alternating layer laid on top. Classification of boats in the European Union. Since 1998, all new pleasure boats and barges built in Europe between 2.5m and 24m must comply with The Recreational Craft Directive (RCD). The directive establishes four categories that prescribe the permissible wind and wave conditions for vessels in each class: Class A: the boat can sail safely in any waters, Class B: the boat is restricted to navigation at sea. (Winds up to Force 8 and waves up to 4 meters), Class C: the boat is restricted to coastal navigation. (Winds up to Force 6 and waves up to 2 meters), Class D: the boat is restricted to rivers, canals and small lakes. (Winds up to Force 4 and waves up to 0.5 meters).

Ships. A ship is a large vessel that travels the world's oceans and other sufficiently deep waterways, carrying goods or passengers, or in support of specialized missions, such as defense, research, and fishing (Figure 68). Ships are generally distinguished from ships, based on size, shape, carrying capacity and tradition. In the age of sail, a 'ship' was a sailing vessel defined by its sail plan of at least three square masts and a full bow.

Figure 68. A modern passenger ship
Source: https://www.seatrade-cruise.com/shipoperations/chinese-start-buys-seaprincess-vships-leisure-manage-ship
Accessed: July 12, 2023.

Ships support exploration, trade, warfare, migration, colonization, and science. After the 15th century, new crops that came from and to the Americas via European sailors contributed significantly to the growth of the world's population. Ship transport is responsible for the largest part of world trade. As of 2016, there were more than 49,000 merchant ships, with a total weight of almost 1.8 billion tons. Of these, 28% were oil tankers, 43% were bulk carriers, and 13% were container ships [49]. The first sea sailing ships were developed by the Austronesian peoples from today's Taiwan. Their invention of catamarans, tugboats and crab claw sails allowed their ships to sail long distances in the open ocean. This led to Austronesian expansion around 3000 to 1500 BC. From Taiwan, they quickly colonized the islands of maritime Southeast Asia, then sailed on to Micronesia, Melanesia, Polynesia, and Madagascar, eventually colonizing a territory that spanned half the world [50]. Austronesian rigs were distinctive in that they had stays that supported both the top and bottom edges of the sail (and sometimes between them), unlike Western rigs which only had a stringer on the top edge. Sails are also made from woven leaves, usually from pandan plants. This was supplemented by oarsmen, who were usually placed on platforms on support posts in larger ships. Austronesian ships were complex, from simple canoes with dugouts or interwoven knots to large boats built of planks. Their designs were unique, evolving from the ancient rafts to the characteristic double hulls, single and double girders of Austronesian ships. Early Austronesian seafarers influenced the development of sailing technology in Sri Lanka and southern India through the Austronesian maritime trade network of the Indian Ocean, the forerunner of the spice trade route and the maritime silk route, which was established around 1500 BC. In the first century, the people of the Nusantara archipelago were already building large ships longer than 50 m and protruding 4-7 m from the water. They could transport 700-1000 people and 260 tons of cargo. These ships were written Kunlun bo or k'unlun (Ship of the Kunlun People) by the Chinese and kolandiaphonta by the Greeks. It has 4-7 masts and can sail against the wind due to the use of thin sails. These ships reach as far as Ghana. In China, miniature models of ships with steering oars have been dated to the Warring States period (c. 475–221 BC). By the Han Dynasty, a well-guarded naval fleet was an integral part of the army. Rudders on sternposts began to appear on Chinese ship models beginning in the 1st century. However, these early Chinese ships were riverboats and were not seaworthy. It was not until the 10th century after the Song Dynasty that the Chinese acquired the technology for sea navigation after contact with djong merchant ships from Southeast Asia. In 3000 BC, the ancient Egyptians learned to assemble wooden planks into a hull. They used woven strips to connect the planks together, and reeds or grass stuffed between the planks helped seal the seams. Agatharchides or Agatharchus (Greek: Ἀγαθαρχίδης or Ἀγάθαρχος) of Cnidus, was a Greek historian and geographer (2nd century BC) who documented shipbuilding among the early Egyptians. The ancient Egyptians were perfectly willing to build sailboats. An outstanding example of their shipbuilding skills was the Khufu ship, a vessel 43.4 m long, buried at the foot of the Great Pyramid of Giza around 2500 BC and found intact in 1954.

The oldest discovered shipwreck found at sea is the Late Bronze Age wreck of Uluburun off the coast of Turkey, dating to 1300 BC [51]. By 1200 BC. The Phoenicians built large merchant ships. In the period from the 1st to the 19th century, ships in Asia developed in the same way as in Europe. Japan used defensive naval techniques in the Mongol invasions of Japan in 1281. It is likely that the Mongols of that time used both European and Asian shipbuilding techniques. During the 15th century, China's Ming Dynasty assembled one of the largest and most powerful naval fleets in the world for diplomatic voyages and Zheng He's power projections. Elsewhere in Japan in the 15th century, one of the world's first iron wedges was developed, the 'tekkōsen', which literally means 'iron ships'. In Japan, during the Sengoku era from the fifteenth to the seventeenth century, the great struggle for feudal supremacy was waged in part by coastal fleets of several hundred ships, including atakebuns. In Korea, at the beginning of

*Corresponding author: **Ahmet Hadrovic**

the 15th century during the Joseon era, the 'geobukseon', the 'turtle ship', as it was called, was developed, recognized as the first armored ship in the world. Until the Renaissance, navigational technology remained relatively primitive compared to Austronesian cultures. This lack of technology did not prevent some civilizations from becoming sea powers. Examples include the maritime republics of Genoa and Venice, the Hanseatic League, and the Byzantine navy. The Vikings explored North America with their knares, traded in the Baltic Sea and plundered many coastal regions of Western Europe. Towards the end of the 14th century, ships such as the carrack began to develop towers at the bow and stern. These towers reduced the stability of the vessel, and in the 15th century, the caravel, designed by the Portuguese, based on the Arab qarib, which could sail closer to the wind, was increasingly used. The towers were gradually replaced by a propeller and a stern castle, as in the Santa María barracks of Christopher Columbus. This increased overpass allowed for another innovation: the release port and the artillery associated with it.

The carrack and then the caravel were developed in Portugal. After Columbus, European exploration accelerated, and many new trade routes were established. In 1498, reaching India, Vasco da Gama (1460-1524) proved that access to the Indian Ocean from the Atlantic was possible. These explorations in the Atlantic and Indian Oceans were soon followed by France, England and the Netherlands, which explored the Portuguese and Spanish trade routes into the Pacific Ocean, reaching Australia in 1606 and New Zealand in 1642.

In parallel with the development of warships, in the period between antiquity and the Renaissance, ships were also developed in the service of sea fishing and trade.

Ship constructions remained pretty much unchanged until the end of the 19th century. The Industrial Revolution, new mechanical methods of propulsion and the possibility of making ships out of metal caused an explosion in ship design. Factors including the search for more efficient ships, the end of protracted and wasteful naval conflicts, and the increased financial capabilities of the industrial powers created an avalanche of more specialized ships. Ships built for completely new functions, such as firefighting, rescue and research, also began to appear.

In 2019, the world fleet included 51,684 commercial vessels with a gross tonnage of more than 1,000 tons, a total of 1.96 billion tons [52]. Such ships transported 11 billion tons of cargo in 2018, an amount that increased by 2.7% compared to the previous year. In terms of tonnage, 29% of the ships were tankers, 43% were bulk carriers, 13% were container ships and 15% were other types [52].
In 2002, there were 1,240 warships operating in the world, not counting small vessels such as patrol boats. The USA accounted for 3 million tons of these vessels, Russia 1.35 million tons, Great Britain 504,660 tons and China 402,830 tons. In the 20th century, there were many naval engagements during two world wars, the Cold War and the coming to power of the naval forces of the two blocs. Major world powers have recently used their naval power in cases such as the United Kingdom in the Falkland Islands (2 April - 14 June 1982) and the US in Iraq (20 March 2003 - 15 December 2011).

Physical structure of the ship. Each ship consists of several interconnected parts that form a whole (Figures 69, 70). Depending on the purpose, the ship can have a very sophisticated physical structure. Suklano Fig., the following parts of the ship can be distinguished: (1) the bow, (2) the front part of the ship, the bulb-bow, is located below the bow on the ship's waterline and serves to create less resistance from the waves that cause the bow, stern and bulb, (4) the ship's hull consists of a skeleton (lattice structure composed of appropriate supports and profiles, which depends on the type of ship) and plating (the plating is fastened on the outside and inside in an appropriate way to the skeleton, depending on the type of ship). The interior of the ship's hull is divided by height into decks, and by length into transverse bulkheads, and their role is to divide the ship into the necessary areas, increase the rigidity and strength of the ship, and in case of water penetration into the ship, prevent flooding of the entire ship and its sinking, (5) propeller with propulsion plant - propels the ship while moving (behind the propeller the ship's rudder can be seen), (6) stern, the rear part of the ship under which the propulsion part of the ship is located, (8) the superstructure is everything that is on the ship above the deck. If the superstructure extends from one side of the ship to the other, it is called a superstructure, and if it is narrower, then it is called a deckhouse. As a rule, the ship's bridge with command devices for ship management is located on the highest superstructure. The superstructure contributes to increasing the strength of the ship, (9) decks. All parts on and in the ship that do not contribute to increasing the strength of the ship (interior linings, ceilings, floors, firmly installed furniture...) constitute installation. All the parts that enable the ship to move (for example, in the case of a motor ship, this includes the engine, the shaft line and the propeller), make up the propulsion part of the ship. All the devices, machines and installations that are used for the auxiliary activities of the engine room and deck (power generators, various pumps, anchor drive, wheelhouse, plumbing, electrical installations...), make up the ship's auxiliary equipment. Navigation equipment, safety equipment, mechanical equipment (...) make up the mobile equipment of the ship.

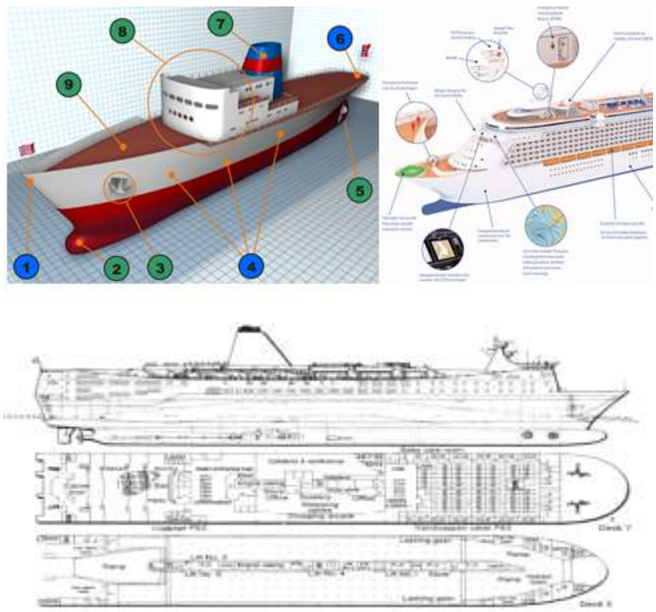


Figure 69. Main parts of the ship
Source: https://www.wikiwand.com/sh/Brod, Accessed: July 12, 2023.
Source: http://marineinfobox.blogspot.com/2017/05/different-types-of-ship.html, Accessed: July 12, 2023.

*Corresponding author: **Ahmet Hadrovic**

Ships are generally larger than boats, but there is no universally accepted difference between the two. They can stay at sea longer than boats. The legal definition of a ship from Indian jurisprudence is a vessel that transports goods by sea [53]. It is a common opinion that a ship can carry a boat, but not vice versa. A general rule of thumb for the US Navy is that ships lean outward from a sharp turn, while boats lean inward due to the relative position of the center of mass to the center of buoyancy. 19th century American and British maritime law distinguished 'vessels' from other vessels; ships and boats fall into one legal category, while open boats and rafts are not considered vessels. A series of large vessels are commonly referred to as boats. Submarines are the best example. Other types of large vessels traditionally called ships are Great Lakes freighters, riverboats, and ferries. Although large enough to carry own boats and heavy cargo, these vessels are designed to operate in inland or sheltered coastal waters. In most maritime traditions, ships have individual names, and modern ships may belong to a class of ships that are often named after their first ship.

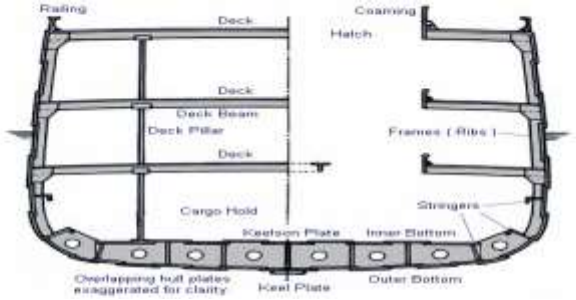


Figure 70. Construction of a modern ship

Source: https://njscuba.net/artifacts-shipwrecks/shipwrecks/hull-construction-iron-steel/, Accessed: July 12, 2023.

4.2.2 Historic floating architecture

A floating building is a construction unit with a flotation system at its base, which allows it to float on water. It is customary to define such a building as 'permanently moored' and cannot be used in navigation. Floating buildings are usually towed by another ship and cannot move under their own power. Floating buildings have environmental advantages such as insensitivity to changes in sea level and minimizing disturbance to the ecology of the harbor or seabed. They can be built off-site and then towed into place, minimizing disruption to the site. If the building is out of order, it can be moved to another location [54]. In the 19th and early 20th centuries, due to the great need for wood as a building material, as a way of transporting it from the cutting site to the sawmill or to the railway transport stations, rafting transport was intensively represented, where more or less large rafts were made from logs that the river 'carried' in its course (Figures 71,72). At the same time, the rafts were habitats for the people who serviced them. Rafting was particularly intensive in the USA. For example, in 1857, three thousand people worked in the lumber industry in Wisconsin alone. As all the lumber had to be shipped from Wisconsin and down the Mississippi, rafting grew into a big business, requiring a special kind of hardy, rough, but industrious and reliable men, who worked under the pilots of the rafts. When they reached their destination, the rafters would pass by a steamer that would go upstream and start again. When the first sawmills were established, they were usually small water-powered facilities located near timber sources that could be converted to grist mills once agriculture was established following intensive logging. Wooden rafts were sometimes of enormous proportions, sometimes up to 600 meters long and 50 meters wide, with stacked logs up to 2 meters high. Such rafts would contain thousands of logs. For the comfort of the rafters - of which there could be up to 500 - logs were also used to build cabins and galleys. The raft was controlled by oars, and later by tugboats. The construction of the raft differs depending on the water flow. Rocky and windy rivers allowed for simple rafts, and sometimes even specially thought-out constructions. For example, the front parts of the logs are connected with wooden rods, while the back parts are loosely connected. The resulting looseness allowed easy adaptation to narrow and windy waterways. Wide and quiet rivers, such as the Mississippi River, allowed huge rafts to float caravans and even be chained [55].

Figure 71. Wooden rafts on the Mississippi River in Wisconsin, USA (Photos taken by pioneer photographer H.H. Bennett while following the Arpin rafting operation in 1886)

Source:https://www.wiscnews.com/wisconsindellsevents/news/local/wisconsinforests-build-country-as-lumber-floatsdown-rivers/article_a6e9682f-9646-50e6-bb55-2d824b5306e3.html, Accessed: July 12, 2023.

Figure 72. Wooden rafts on the Mississippi River in Wisconsin (USA)

Source: https://www.thevintagenews.com/2016/01/14/46093/, Accessed: July 12, 2023.

In Bosnia and Herzegovina, timber rafting was particularly intensive during the Austro-Hungarian period, at the end of the 19th and the beginning of the 20th century. Rafting on the river Drina was especially famous (Figure 73).

Figure 73. Wooden rafts on the Drina river (near Foča, Bosnia and Herzegovina)

*Corresponding author: **Ahmet Hadrovic**

Source: https://focanskidani.wordpress.com/2016/11/16/historija-foce-poceci-turizma/, Accessed: July 12, 2023.

Mudhif (Arabic: المديف - al-muḍīf) is a traditional reed house created by the Madan people (also known as Marsh Arabs) in the marshes of southern Iraq (Figures 74,75,76). In the traditional Madan way of life, houses are built of reeds harvested from the swamps where they live. A mudhif is a large ceremonial house, paid for and maintained by a local sheikh, for use by guests or as a gathering place for weddings, funerals... Mudhif structures are one of the traditional types of buildings, built by the Arabs in the marshlands of southern Iraq for at least 5,000 years. . A carved elevation of a typical mudhif was discovered at Uruk, dating to around 3300 BC, and is now in the British Museum. Other types of reed dwellings, such as the raba (with entrances at both ends and used as family housing) or the bayt (strictly one-room dwellings) are typically smaller than the muhif and can be used for residential and other purposes. Each village sheikh had a mudhif that could accommodate at least ten people. The number of bows used in the mudhif is dictated by the tribe and family group. Sometimes the mudhif was decorated with additional bundles of reeds, arranged in decorative patterns, placed on the front, which served as a tribal identifier. The entrance to the mudhif always faces Mecca. In the construction of the mudhifa, reeds are collected and woven into thick posts; larger and thicker reeds are bent crosswise and tied to form the parabolic arches that form the spine of the building. These arches are reinforced by the prestressing of the columns, since they are initially inserted into the soil at opposite angles. A series of arches defines the shape of the building. Long transverse bundles of smaller cane bundles are laid over the bows and tied. Woven reed mats form the envelope of the building. Some mats are woven with mesh-like perforations that allow light and ventilation. The front and back walls are attached to two large vertical bundles of reed poles, and are also made of woven mats. Mudhif needs to be renewed every ten years. The most common type of reed used to build swamp muhif is ihdri. Cane has properties that make it an ideal building material - it has a high concentration of silica, which makes it waterproof, unattractive to insects and other pests, and an excellent heat and sound insulating material. It is an inexpensive material, and it is flexible and durable as a building material, which encourages creativity. The mudhif is used as a guest house or for ceremonial occasions, and must not be used for any other purpose. When a guest enters the mudhif, he will be greeted by the village sheikh, escorted to the appropriate place, and offered refreshments such as highly sweetened coffee in a ritual ceremony. In the eighties of the last century, about half a million Arabs lived in the swamps. However, around 1993, Saddam Hussein began draining the swamps in an attempt to destroy the life and culture of the southern Arabs. After Hussein's defeat in 2003, the Arab communities began to dig dikes, re-flooding the swamps and resume their traditional way of life [56].

Figure 74. A swamp in southern Iraq

Source: https://www.greenprophet.com/2013/11/mesopotamian-marshlands-crustywasteland-rehabilitation/, Accessed: July 12, 2023.

Figure 75. Women of the Arab Marshes transport reeds in May 2010. Unlike women from many other Arab tribes, Arab women from the Marshes are engaged in economic activities, such as transporting agricultural and animal products for sale (left). Men at work (right)

Source:https://www.circleofblue.org/2013/world/iraqs-first-national-park-a-story-ofdestruction-and-restoration-in-themesopotamian-marshlands/, Accessed: July 12, 2023.

Figure 76. Reed houses, swamps in Iraq, 1978

Source: https://nl.pinterest.com/hellyscholten/floating-homes/, Accessed: July 12, 2023.

Source: https://lh5.googleusercontent.com/p/AF1QipPj3vw8atoWlFlDCyMmUzNUNQRWWvlRyb7fgs8=w2560-h1440-pd Accessed: July 12, 2023.

Source: https://www.pinterest.com/esepera/temporary-precedent/, Accessed: July 12, 2023.

Source: http://www.grizedalesculpture.org/archive/2016/6/3/esme-allen-themesopotamian-marshes-of-iraq, Accessed: July 12, 2023.

The Mekong Delta is located in the south of Vietnam, downstream of the Mekong River. This is a nutritious plain with dense water channels. Here, people have chosen their nearby settlements, in order of priority: markets - rivers - friends - roads/streets/routes - and farmland. When the population increased, they began to move towards the land; because of this, their culture of life gradually changed and so did their houses. During a long history of exploitation, local residents and migrants from other parts of Vietnam and nearby countries have turned this Mekong Delta into a rich and distinctive society with different ethnic communities, cultures and beliefs, living harmoniously together. Their settlements have an identified water-based living environment that they cannot find anywhere else. The current research analyzes the peculiar morphological values of these settlements (Figures 77,78).

*Corresponding author: **Ahmet Hadrovic**

These findings help to strengthen the scientific basis for further appropriate solutions for these values under the threats of urbanization, cultural and climate changes that have been observed to have a very negative impact on these values. More than three centuries of development, from the first settlements along water channels, and some near high dry land, people in the Mekong Delta have selectively experienced in creating a sustainable living environment that always adapts to natural conditions and social cultures [57]. In order to adapt to the topographical and geographical conditions over the centuries, houses in the Mekong Delta are diverse: (a) houses on the ground, (b) houses on the ground and partly on stilts, (c) houses on stilts, (d) floating houses and (e) house-ship (Figure 77).

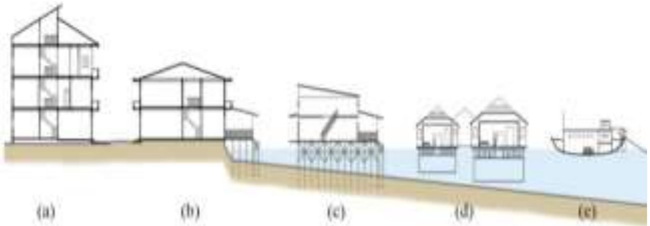


Figure 77. Housing typologies in the Mekong Delta according to ground floor structures (According to: Vu, T.H.H. & Viet Duong, V., 2016)
Source: https://www.matecconferences.org/articles/matecconf/pdf/2018/52/matecconf_esci2018_04005.pdf, Accessed: July 12, 2023.

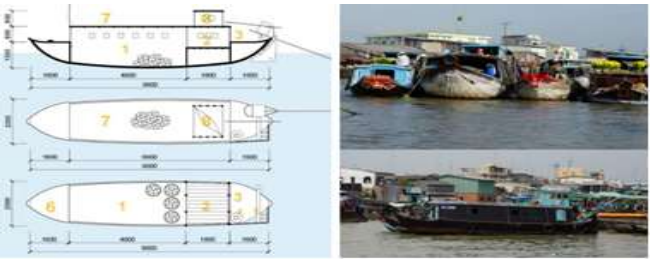


Figure 78. House-boat in the Mekong River Delta - main functional areas: (1) storage, (2) bedroom and kitchen, (3) technical room, (4) water tank, (5) toilet, (6) front part of the boat, (7) deck, (8) rear area (According to: Vu, T.H.H. & Viet Duong, V., 2016)
Source: https://www.matecconferences.org/articles/matecconf/pdf/2018/52/matecconf_esci2018_04005.pdf, Accessed: July 12, 2023.

A floating house, or sometimes called a houseboat, is similar to a houseboat, however, it does not move like a houseboat, and on flat and wider wooden or steel floats. Chau Doc Floating Village, these typologies of residential units join the pond. They also float alongside/near floating markets for the needs of the surrounding communities, such as gas supply, grocery shopping, machine repair (Figure 79).

Figure 79. Houseboat in Chau Doc Fishing Village, Mekong Delta: (1) front veranda, (2) living area: 2a-fish feeding, 2b-fish food processing area, 2c-worship table, 2d-guest bed, (3) kitchen, (4) bedroom, (5) toilet, (6) back veranda. (According to: Vu, T.H.H. & Viet Duong, V., 2016)
Source: https://www.matecconferences.org/articles/matecconf/pdf/2018/52/matecconf_esci2018_04005.pdf, Accessed: July 12, 2023.

From China to Vietnam, the Mekong River is the longest river in Southeast Asia and the 12th longest in the world. It flows through six countries: China, Myanmar, Thailand, Laos, Cambodia and Vietnam. It is located on the southeast Asian continent and flows over 4,345 km from the Tibetan Plateau to the southeast, through Laos and Thailand to the equatorial flood plains of Cambodia and Vietnam, and then finally flows into the South China Sea. The river is the lifeblood of the region (and the country as a whole) through which it flows, so many cities and villages were built next to it and on its surface, where buildings on stilts and floating structures stand out (Figure 80).

Figure 80. Floating houses on the Tonle Sap River, Phnom Penh, Cambodia, 2021
Source: https://www.straitstimes.com/asia/seasia/please-show-mercy-evicted-bycambodia-ethnic-vietnamese-stuck-atwatery-border
Accessed: July 12, 2023.

The floating house has long been a type of traditional residence for Mekong residents (Figure 81). In recent times, modern floating houses are being built in the Mekong River Delta, using traditional construction methods, with original materials such as wooden and bamboo frames and roof covering made of palm leaves. All this brings a pleasant feeling and friendly relationship to nature.

Figure 81. Floating houses on the Mekong River
Source: https://www.instantworldbooking.com/Viet-Nam-hotels/Mekong-Floating-House_Ben-Tre.htm, Accessed: July 12, 2023.

When we talk about cities, villages, towns, communities, we are used to evoking stereotypical scenarios related to streets, cars, buildings, and we often forget that there are many other

*Corresponding author: **Ahmet Hadrovic**

surprisingly unique patterns. Many people study the cities and wonder about the exact moment when they were created, given that they are open, unfinished works. Some hypothesize that their origin is due to the need for protection, which is why people abandoned the nomadic lifestyle and settled as groups in a certain land to increase their chances of survival. Such settlements can also be perceived as places with concentrated services - cultural, infrastructural, religious - that bring together different activities. In his book The History of the City (1980), Leonardo Benévolo (1923-2017) stated that what defines a settlement is the overlap of functions resulting from the various achievements of its inhabitants over time, which change the urban environment, adapting it to their needs and interests [58]. In this sense, studying human agglomerations from a wider perspective, we come across different formats - Cartesian or curvilinear, which even multidisciplinary fields of knowledge cannot understand, in a futile attempt at categorization and classification that tries to impose 'urban personalities' such as calm, agitated, violent, peaceful, among others. Ko Panyi definitely does not correspond to the stereotype of an urban agglomeration (Figure 82). To categorize or classify it would be a complex task. It would be easier to describe it as one of Italo Calvino's invisible cities, given that it is hidden in a bay in the south of Thailand and protected by a huge limestone rock about 200 meters high, its structures rising out of the water supported by long and slender stilts resembling flamingo legs, sheltered more than 360 families and a total of 1680 people. Its history began in the late 18th century following a law that restricted land ownership to only people of Thai national origin, which encouraged nomadic Malay fishermen to start a settlement built on stilts, taking advantage of the calm and rich waters of the bay. With the increase in wealth in the community, due to the growing tourism industry in Thailand, it became possible to buy land on the island itself, where they later built a school, a health center and a mosque. In Ko Panyi, nature sets the rules, and man understands and reacts to them. Although water does not have its own form, it is a physical element that carries the power of nature and is capable of creating design tensions. This tension is mainly due to the vulnerability of buildings in dangerous oceanic conditions during the rainy season, which also encourages emigration from villages. Its structural base is raised on stilts, and the houses are built of wood and bamboo. One of the main challenges of living above water is dealing with extremely limited hard surfaces, which reveals a lack of common spaces and gathering places. Therefore, it is impossible to address Ko Panyi without mentioning the collective effort of the community in creating a space for leisure and play. Inspired by the World Cup in football (Argentina, 1986), a group of children decided to build a floating field, which defied the geographical challenges of the location. The children started working after school to finish the surface with wood, nails and fishing rafts. The 16 m x 25 m area, located next to the pier, has become a national treasure, although it has already been replaced by a better one, due to the great impact of its story. Ko Panyi is far from representing a utopian future, but it still represents an alternative way of living in the community, respecting and understanding nature as it is. It is an example that encourages us to realize how much we have to learn from different forms of settlements other than the stereotypical pattern that prevails today. Examining and recognizing different forms of settlements - with their advantages and disadvantages - is a very interesting exercise, especially in this age of uncertainty, full of social and environmental challenges.

Figure 82. Ko Panyi - A Floating Village in Thailand
Source: https://www.archdaily.com/tag/floating-architecture, Accessed: July 12, 2023.

4.2.3 Contemporary examples of architecture on the water

For some architects, building on land simply isn't enough of a challenge anymore, so they've turned their design skills towards the water. The floating structures presented here (cinemas, schools, apartments and offices) can be found all over the world. Many of the designs incorporate sustainable elements, including solar panels and local or biodegradable materials. But aside from the environmental benefits, these examples of floating architecture offer a unique way to see new settings, be it a canal in Amsterdam or a river in South Korea [59]. Here are presented architectural realizations, floating structures, where each of them has a different motivation for construction. Archipelago Cinema, Kudu Island, Thailand, was built in an extremely attractive sea bay, where the very arrival to it is an 'event', an adventure. Float in Lelystad, Lelystad, Netherlands, is a settlement of relatively wealthy people who have decided to live in a completely new natural environment, which integrates them with themselves. The floating island, Han River, South Korea, is the new symbol of the city, an architectural structure that gives "character to the place and the city itself". The Makoko Floating School in Lagos, Nigeria is the ultimate expedient solution in the given natural environment where river flooding is frequent. Exbury Egg, in Beaulieu, Hampshire, England, is a scientific-research and artistic institution where, through close contact with water and nature, the living world is explored and artistic creations inspired. The residential complex Waterwoningen, Amsterdam, represents the search for a new expression of architecture, but also as a forerunner of the increasingly certain mass construction of floating structures in Amsterdam. The floating office Waternet, Amsterdam, is at the same time a rational decision to build an architectural structure - the headquarters of a company that cleans the sea - but also as a presentation of architecture that, in changed circumstances, can float to another location, like a ship.

The National Center for the Performing Arts (NCPA), colloquially described as The Giant Egg, is an arts center with an opera house in Beijing. The NCPA was designed by French architect Paulo Andrea; is the largest theater complex in Asia. NCPA has an elliptical base, the longer axis of which is 212.20 meters in the east-west direction, and the short axis of which is 143.64 meters in the north-south direction; the height of the building is 46,285 meters, the area is 119,900 m2. There are Opera Hall, Music Hall, theater and art exhibition halls, restaurants, audio stores and other related facilities. The location, west of Tiananmen Square and the Great Hall of the People, and close to the Forbidden City, combined with the theater's futuristic design, caused great controversy. Paul Andreu countered that while there is indeed

*Corresponding author: **Ahmet Hadrovic**

value in ancient traditional Chinese architecture, Beijing must also include modern architecture, as the country's capital and an international city of great importance. Its design, with large open space, water, trees, is specially designed to complement the red walls of the ancient buildings and the Great Hall, to blend in with the surroundings and not stand out against them. The exterior of the NCPA is a structural steel shell. It has a semi-ellipsoid shape. The physical structure is ten stories high. The large theater shell consists of more than 18,000 pieces of titanium metal plates, which cover an area of about 30,000 m^2. (Out of about 18,000 pieces of titanium metal plates, only four are of the same shape). The titanium metal plate is specially oxidized, and the surface metallic luster is highly textured and has a stable color for 15 years. The middle part is an involute glass curtain, which consists of about 1200 pieces of ultra-white glass. An ellipsoidal shell surrounds the artificial lake, with an area of 35,500 m2, all channels and entrances are located below the water surface. Pedestrians must enter the performance hall from an 80-meter underwater walkway. NCPA is located on the south side of Chang'an Street, in the heart of Beijing (Figure 83). According to the Beijing overall planning requirements, the height of the NCPA cannot exceed the height of the Great Hall of the People (46 meters), but the functional requirements of the NCPA cannot be loaded in the space of 46 meters, so it can only be developed underground. The underground depth of NCPA is as high as ten floors, and 60% of the construction area is underground. It is the deepest underground public building project in Beijing. The deepest place is 32.5 meters, directly below the stage of the Opera House. 17 meters underground NCPA is an ancient river channel of the Yongding River in Beijing. The subsoil of the NCPA contains abundant groundwater. The buoyancy generated by this groundwater can support a giant aircraft carrier weighing 1 million tons. Such enormous buoyancy is enough to hold the entire theater. The traditional solution is to continuously pump out groundwater, but the result of pumping out groundwater is that a 5 km wide 'funnel' of groundwater will form underground near the theater, causing subsidence of the surrounding terrain. To solve this problem, engineers and technicians conducted a detailed investigation and used concrete to pour an underground wall from the highest groundwater level to the underground clay layer of 60 meters. This huge 'bucket' made of underground concrete walls can contain the foundations of the NCPA. The water pump draws water out of the 'bucket' so that no matter how much water is pumped into the foundation, the groundwater outside the 'bucket' will not be affected and the surrounding buildings will be safe. A 6,750-ton steel frame forms the dome. The structure of the NCPA is composed of one curved steel beam. More than 18,000 pieces of titanium metal plate and more than 1,200 pieces of ultra-white transparent glass form a massive shell of 36,000 m2. The largest dome in the world is not supported by columns. The outer layer of the dome coated with nano materials, and when rain falls on the glass surface, it will not leave water stains. At the same time, nanotechnology also dramatically reduces dust adhesion. To test the noise generated by raindrops falling on the dome the size of ten football fields, scientists conducted repeated experiments that showed that if effective noise protection is not implemented, the sound throughout the dome will be like a drum when it rains. The problem of noise protection between the theater to the theater and the theater outside is solved by a technique called 'sound door'. NCPA is surrounded by an artificial lake, although winter temperatures in Beijing sometimes drop below 0 ºC, and the lake does not freeze in winter. This is achieved by using a closed circulation system, a constant temperature of underground water injected into the surface of the lake, so the water temperature of the artificial lake can be controlled above 0 ºC in winter.

Figure 83. The National Center for the Performing Arts (NCPA), Beijing, 2007 (architect: Paulo Andreu)

Source: https://hildachampion.com/the-egg, Accessed: July 12, 2023.

Source: https://architizer.com/projects/nationalcentre-for-the-performing-arts-inbeijing/, Accessed: July 12, 2023.

Archipelago Cinema, designed (2014) by Ole Scheeren, is an open-air cinema surrounded by high rocks, lush vegetation and crystal clear water of the Thai island of Kudu (Figure 84). The architect designed the structure in collaboration with the annual Film on the Rocks Yao Noi festival, which is curated by Thai filmmaker Apichatpong Weerasethakul and British actress Tilda Swinton. Scheeren modeled the structure after the floating lobster farms in the area, using a series of modular platforms to form the main seating area [60].

Figure 84. Archipelago Cinema, Kudu Island, Thailand, 2014 (design: Ole Scheeren)

Source: https://buroos.com/projects/archipelago-cinemathailand, Accessed: July 12, 2023.

The Float in Lelystad housing community was commissioned by a group of water-loving families in the Netherlands (Figure 85). The structure on the water was designed by the Amsterdam company Attika Architekten. In total, eight timber-frame houses were built for the project, all custom-made to suit the requirements of each family. The families united in a collective partnership called Drijf in Lelystad (Float in Lelystad) and commissioned Attika Architekten to design eight different but matching floating houses. The municipality of Lelystad, New Town in a polder 4.8 meters

*Corresponding author: **Ahmet Hadrovic**

below sea level, provided a location for water by widening the existing ditch (poldersloot). Since all families had their own special requirements and wishes, each apartment got its own characteristic size, color and shape. Direct contact with water was at the forefront of every design: unobstructed view, split level, abundant daylight, water reflections on walls and ceilings, water terraces on different levels and direct access to water. Facade panels are made of matching colors. The color palette allows the apartments to fit into the natural environment [61]. All apartments have two basic colors, which ensures coherence. Color accents, at the owner's choice, highlight one residence from another, giving the houses their individual character. The floating houses were built in Urk, 40 kilometers away from Lelystad. They were built in wooden frames on concrete caissons and dragged across the water to their destination. The width of the houses was determined by the size of the narrowest lock: 6.9 meters.

Figure 85. Float in Lelystad, Lelystad, Netherlands, 2012 (architects: Attika Architekten)
Source: https://www.architecturaldigest.com/gallery/floating-architecture-around-theworld-slideshow, Accessed: July 12, 2023.

Located in Seoul, South Korea, the Floating Island was conceived as part of the Han River Renaissance (Figure 86). It was a collaboration between H Architecture in New York and Haeahn Architecture in Seoul. The complex consists of three structures, which represent the three stages of flower development: seed, bud and flower. Made of glass, wood and steel, the island-like buildings house shops, restaurants and numerous venues that host festivals, shows and exhibitions throughout the year. Seoul's man-made islands are different from those common in Dubai, which are built by accumulating sand on the ocean floor. Viva and its satellite islands instead float on the surface of the river. If there is a flood, the islands rise and fall with the water level, instead of being flooded. A high-tech tracking system will alert the controller if the islands are drifting too far from their home site due to changing water levels. Supported by 24 gigantairbags, the Viva weighs 2,000 tons, but can support the construction of structures up to 6,400 tons. The island will be chained to a 500-ton concrete block to keep it in place. The three-story building that houses all the buildings is covered with 54 square meters of solar panels, which produce 6 kilowatts of energy every day, supplying electricity to the lower buildings and illuminating the facades at night. m^2 and Teru of almost 4000 m2. Together they will host international conventions, water sports events, restaurants, cultural events and exhibitions [62]. The goal of the project was to create a landmark by engineering a certain type of landscape filled with lush greenery that encompasses all the plants that can grow in Seoul. This project was clearly about creating a different kind of spectacle based on the diversity of plant life. Although the project description does not mention sustainability as a primary goal of the project, the fact that 'park or pedestrian oriented green space' is recommended indicates that the 'green' brand was considered important to the project [63].

Figure 86. Floating Island, Han River, South Korea, 2011 (architects: Haeahn Architecture)
Source: https://www.shutterstock.com/sv/video/clip-1006778215-seoul-south-korea-%E2%80%93-july-216-, Accessed: July 12, 2023.
Source: https://www.archdaily.com/252931/seoul-floating-islands-haeahn-architectureh-architecture, Accessed: July 12, 2023.
Source: https://ars.elscdn.com/content/image/1-s2.0-S2095263519300019-gr1_lrg.jpg, Accessed: July 12, 2023.

The Makoko Floating School in Lagos, Nigeria was conceived by the architectural studio NLÉ as a prototype for buildings that can be moved around coastal areas exposed to flooding (Figure 87). Based on a floating base, the three-story school, made of local bamboo and wood, includes an assembly area, four classrooms and a workshop. The A-frame structure has the capacity to support hundreds of residents in an emergency [64]. Global warming has become one of the most prominent issues in today's world. As a result, water levels are rising, and people living in coastal communities have encountered a number of challenges. However, some shouldn't worry too much about it. Some architectural options are emerging to help them adapt to these changes. Makoko Floating School is a perfect example that proves the above mentioned fact. Makoko Floating School is a floating school made of sustainable and alternative structures, which can help communities to get used to an aquatic lifestyle with ease. This school is located in Makoko, a village in Lagos, Nigeria. The entire school is built on top of the lagoon, and the structure is supported by sticks that can be seen in the water. Before the Makoko Floating School was built, children in Makoko did not have proper primary schools. They also suffered greatly from frequent floods. It was there that a Nigerian architect named Kunlé Adeyemi came up with the idea of developing a floating island. He started his concept by developing a prototype. He was then able to get help from various NGOs to complete the project. Construction of the Makoko Floating School began in 2012 and was completed the following year.

*Corresponding author: **Ahmet Hadrovic**

Figure 87. Makoko Floating School in Lagos, Nigeria, 2012-2013. (architects: architectural studio NLÉ)

Source: https://publicdelivery.org/makokofloating-school/, Accessed: July 12, 2023.

The headquarters of Arctia, the new head office of the Finnish shipping company that owns and operates a fleet of icebreakers, is located off the coast of Helsinki (Figure 88). The new headquarters of Arctia Shipping Ltd. is located in a floating office building in front of the aforementioned main building of the Finnish Ministry of Foreign Affairs, which was originally designed by C.L.Engel. Custom black steel facades refer to the black hulls of neighboring icebreakers. The interior of the black 'steel ship' is made of lacquered wood, which refers to earlier traditions of shipbuilding. The facades of the building are made of a steel profile adjusted to a wavy pattern. There is a perforated and abstract pattern on the steel profiles that refers to ice crystals and sailor textile patterns [65]. The building was built in a shipyard in western Finland and towed to the site. There is a water ballast system that will keep the floor level of the office building at the same level as the wharf. The building was designed by the architects of the design firm K2S Architects.

Figure 88. Arctia headquarters, Helsinki, Finland, 2013 (architects: K2S Architects)

Source: https://www.archdaily.com/431501/arctia-headquarters-k2s-architects, Accessed: July 12, 2023.

The Exbury Egg, named after its location in Hampshire, England's River Beaulieu (formerly known as the River Exe) and its shape, is a private residence designed by PAD Studio in collaboration with SPUD Group and artist Stephen Turner (Figure 89). Designed to have a minimal impact on the environment, the egg is maintained by photovoltaic panels that provide light and heat. Stephen Turner has been commissioned by Space Placemaking and Urban Design to work with architects PAD Studio to develop a workspace based on an artist's original concept for the River Beaulieu on the Exbury Estate, Hampshire. At Exbury, the Egg was developed as a work of art and as a place to live and work in a laboratory/studio for the creative study of stream life. The building acquired the patina of daily tides during 18 months of passing through wind and rain and bleaching from the sun. The 'blueprint' of the Exbury Egg reflects its symbolism as the blueprint of life. Aesthetically perfect, the egg contains in the embryo what is essential for a new life. From primates to plankton, they embody the idea of new birth and renewal, protection and fragility. In a 21st century urban world where we are increasingly disconnected from nature, designers have used this ancient archetypal symbol to foster a renewed fascination with the natural world, as a step towards a sustainable future. The Exbury Egg is a sculptural form that develops and changes over time as it is bleached by the sun, washed away by wind and rain, and algae, worms and shells accumulate below the waterline; an evolving form that reflects the changes of the surrounding landscape itself and turns the egg into a calendar of seasons. The interior of the structure reflects the explorer's own journey cataloged in collections of digital images, found objects, drawings and personal maps derived from a specific estuary location. "In this way, the Exbury Egg becomes the main sculptural element in the temporal event, integrating from the outside and the inside into a creative archive that reduces the distance between people and nature" [66]. The Egg was 'moored' like a boat at Exbury rising and falling with the tide. The light touch and basic nature of the Exbury Egg was intended to re-evaluate the way we live; properly consider the sustainable and future use of natural resources. Stephen Turner is interested in exploring a more empathetic relationship with nature that reveals the precious and transcendent in everyday life. The changing patina of the Egg, the influence of Stjepan's occupation on the interior and the works of art were all developed through direct experience of local natural cycles and processes and the relationship of the environment to the narratives of human activities. Climate change is already creating new coastlines and habitats. The established salt marsh is being eroded by a combination of rising sea levels and falling land, and the entire coastal environment is in a state of flux. The implications for wildlife and flora as well as humans are challenging. Raising awareness of the past and the unfolding of the present in a very special place will be a task, and that is to live in an ethical relationship with nature and walk as lightly as possible on the earth. Stephen Turner's Exbury Egg was built by Paul Baker from Lymington and received significant local support from a variety of companies including Exbury Estate, Bradley Engineering, Versa Dock, Totton Timber, Anesco Energy Services, H&DB Kitchens, Latham James, LYC Events, Lambert Brothers Haulage Ltd , Lymington Yacht Haven, Howdens Joinery Co, KJ Kilford, Marineware, Click4Internet, Etch, Nick Cox Chandler, Solent Covers, Enistic, Sign It, SJG Carpentary, Solent Cellar and Knights. The original Exbury Egg project was financially supported by public money from the National Lottery through Arts Council England, the Paul Hamlyn Foundation, the Barker Mill Foundation and Hampshire County Council.

Figure 89. Exbury Egg, Beaulieu River, Hampshire, England, 2013 (architects: PAD Studio)

*Corresponding author: **Ahmet Hadrovic**

Source: http://exburyeggtour.com/about.html, Accessed: July 12, 2023.

The residential complex Waterwoningen consists of 75 individual houses (Figure 90). It was designed by Marlies Rohmer Architects and Planners. The Amsterdam community can be reached by land or canal. Below the water, each home has a concrete base, providing a lower center of gravity for greater stability. The visible parts of the structure are made of wood with steel slats. The company managed to keep the water as the main focal point and provide an attractive view from every abode. ”Building on water is another story, water is not land - different character - tradition - romanticism - invention - freedom - system - space - pioneering - adventure - risk - free time - views - movement - sky and water - individualism - wind and clouds - violation rules - contact with the elements - feeding the swans from the kitchen window - sliding around the house. The Netherlands has a history of living closely with water and coping with its whims” [67]. Buildings are individual units and look more like ships than houses. In recent years, however, there has been an increase in the number of water-based housing that shares many characteristics with land-based housing. These floating apartments are part of urban design. Financially, they are classified as real estate, and with their interior and level of comfort, they compete with accommodations on land. New water-based development can include several forms of living with water. In addition to floating homes, these can include amphibious homes and homes that stand without water on levees or in other coastal situations. Amsterdam's IJburg district will have complete floating neighborhoods with docks instead of paved walkways and town squares. The growing enthusiasm for living next to or on the water has two pragmatic motives. First, due to rising sea levels and increased precipitation, it will be necessary to dedicate more and more land areas to water storage basins and zones of maximum overflow. Second, some believe that there is already a critical shortage of new construction land. However, not everyone shares this view: the strategic consolidation of existing cities produces a sharper contrast between the city and the countryside, making many greenfield projects redundant or even harmful. Living and working on the water is actually multiple use of space. It is also a way of renovating outdated dock areas and flooded gravel pits. Another, more aesthetic, argument in favor of life on the water is that it encourages a feeling of freedom and closeness to nature. It is the first in a series of islands that form the new city district of IJburg. The 'water neighbourhood', Waterbuurt West, is located along the IJburglaan, the main access road to IJburg that crosses the Enneus Heerma bridge. On Steigereiland, water, quays and piers form the framework of the public space. The inner basin of the island contains two districts with floating houses and dikes. Waterbuurt West is a compact urban development with a density of 100 houses per hectare. The floating houses are accessed by docks. A row of dyke houses was built along the Haringbuisdijk. Steigereiland's subsoil is relatively unstable compared to other islands, so recently drained land will take longer to consolidate. This is one of the reasons why floating houses became an important component of the construction program in the Memorandum of Understanding (1996). The plan for the island provided for a zone 100 meters wide to house a high-voltage transmission line for electricity. This resulted in a large indoor pool in the middle of the island. The architects decided to arrange the floating houses next to the jetties in an informal, loosely structured manner, within the strict geometric organization of the triangular site that emerges from the line of electricity poles diagonally crossing the watershed. By simply changing the distance between the units and aligning their roof terraces, the architects achieved a lively pattern of constantly changing groups. There is plenty of room for small boats in the water between the floating houses, and this will contribute to the informality of the layout: a pleasantly messy character, a typical atmosphere of life on the water, with movement, individualism and a boat anchored in the door. The houses on the water are protected from the busy IJburglaan by construction on the quay called Kadegebouw. All pipes, wires and services are connected. This is not always the case for a houseboat.

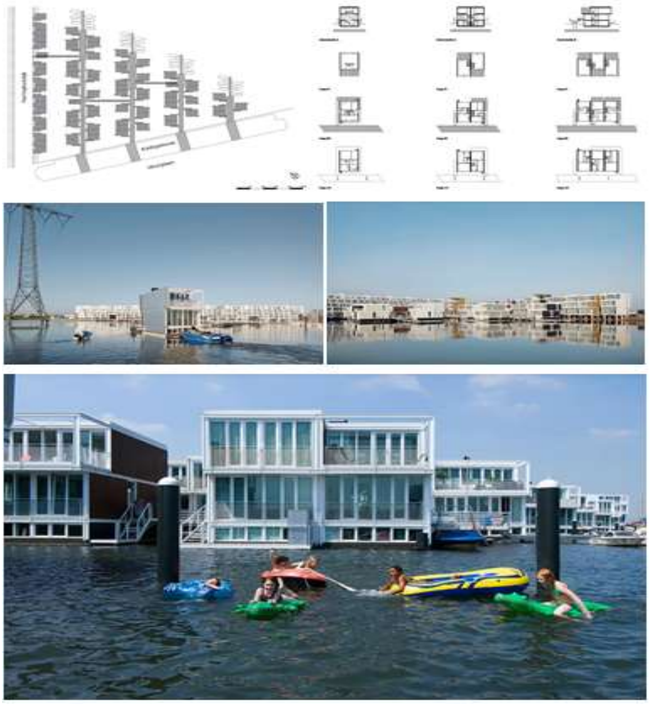


Figure 90. Waterwoningen residential complex, Amsterdam, Netherlands, 2011 (architects: Marlies Rohmer Architects and Planners)
Source: https://architizer.com/blog/inspiration/industry/waterwoningen/, Accessed: July 12, 2023.

When designing offices for the company responsible for cleaning and maintaining Amsterdam's waterways, architects Attika Architekten knew that sustainability was paramount (Figure 91). Work spaces and a cafeteria are located on the upper levels, while a concrete caisson located under the water contains changing rooms for employees. With its 9418 m^2, the office is the largest floating building in the Netherlands [68]. This office building floats in the middle of a fleet of Waternet boats that set sail every day to clear the waters of Amsterdam's canals of trash. Its current location is the northern part of the city's old harbors, left by the port industry but not yet converted into a residential area. The office program was realized in and on two connected floating concrete caissons. The building measures 31 x 12 meters and has three floors, making it the largest ark in the Netherlands. It contains office space at the level of the entrance and the first floor. A spacious double-height canteen forms the heart of the building and connects all the rooms on the ground floor and upstairs with the port. The shape of the building is basic and bold, the cane skin is soft and comforting. The wooden frame construction and thatched facade can be completely disassembled into reusable or biodegradable

*Corresponding author: **Ahmet Hadrovic**

components, leaving no waste. Furthermore, the reeds of the facade represent water purification, which is the very essence of the Waternet company. The building has an innovative way of heating and cooling. At the bottom of the concrete caisson there is a heat exchanger, a winding pipe filled with liquid, like a reverse underfloor heating system. It takes heat (and cooling) directly from the source that surrounds it, the water. The reversible heat pump provides warm or cold air. The energy for the heat pump comes from solar panels installed on the roof. In 5-10 years, this part of the city harbor will be transformed into a residential area. The office will then simply sail to its new location.

Figure 91. Waternet Floating Office, Amsterdam, The Netherlands, 2015 (Architects: Attika Architekten)
Source: https://www.archdaily.com/585536/floating-office-for-waternet-attikaarchitekten, Accessed: July 12, 2023.

The Floating Pavilion (Dutch: Drijvend Paviljoen), located on Rotterdam's Nieuwe Mass River, is a portable exhibition and conference space designed by DeltaSync and Public Domain Architecten (Figure 92). The structure is made of steel beams and transparent ETFE film, and even lights up at night [69]. A large part of the territory of the Netherlands is below sea level. Climate change is becoming more and more important, especially sea level rise. The city of Rotterdam has started to develop innovative and sustainable projects. The Floating Pavilion project is designed to reduce CO_2 emissions and reduce energy consumption. Also, the pavilion has become a symbol of the port of Rijnhaven, where it is currently located. This pavilion is only a prototype, and the city's goal is to build a whole settlement of floating houses. The floating pavilion consists of three interconnected spheres that resemble bubbles. The diameter is 18.5, 20 and 24 meters. It is made of PTFE membrane, which enables this unusual shape. The PTFE membrane is 100 times lighter than glass, so it is ideal for a floating structure. The foundations of the pavilion are made of expanded polystyrene (EPS) in combination with a grid of concrete beams. This foundation allows the pavilion to be transported to any location. The interior of the pavilion is extremely bright and is used for various events, especially when dealing with topics such as innovation, sustainability, cleanliness or the future. This project was financed from the European Fund for Regional Development of the European Union. The pavilion was designed by Deltasync and PublicDomain Architects.

Figure 92. Drijvend Paviljoen (English: The Floating Pavilion), Nieuwe Mass River, Rotterdam, 2019 (architects: DeltaSync and Public Domain Architecten)
Source:
https://www.instagram.com/p/BK6awozjQ8U/?utm_source=ig_embed&ig_rid=db45e587-c4b0-48f9-9b9f-4e7b345b9466
Accessed: July 12, 2023.
Source: https://ilcroatia.com/floating-pavilionrotterdam/, Accessed: July 12, 2023.

The Floating Lake Cabin was designed by the architects of the design firm MOS Architects [70] (Figure 93). This project intersects the typology of folk houses with conditions specific to this unique place - an island on Lake Huron. The location on the Great Lakes imposed complexity in the design and construction of the house, as well as its relationship to the place. Annual cyclical changes associated with changing seasons, along with escalating global environmental trends, cause Lake Huron's water levels to change drastically from month to month, year to year. To accommodate this constant, dynamic change, the house floats atop a steel pontoon structure, allowing it to sway along the lake. Locating the house on a remote island imposed another set of restrictions. Using traditional construction processes would be too expensive; most of the costs would be related to the transportation of construction materials to the remote island. Instead, the architects worked with the contractor to devise an assembly and construction process that made the most of the site's unique character - Lake Huron as a waterway. The construction material was instead delivered to the contractor's factory, which is located on the shore of the lake. A steel platform with built-in pontoons was first built and towed to the lake outside the workshop. A factory house was built on a frozen lake, near the shore. The structure was then pulled into place and anchored. Between the different stages of construction, the house traveled a total distance of about 80 km. The house envelope experiments with the cedar cladding of a traditional house. This familiar shape not only encloses the interior living space, but also the exterior space, as well as open gaps for direct contact with the lake. The rain screen strip wrap condenses to screen the interior space and extends either to filter the light entering the interior spaces or to screen and enclose the exterior spaces giving the house a modulated yet unique character while pragmatically reducing loads and heat gains.

*Corresponding author: **Ahmet Hadrovic**

Figure 93. Floating Lake Cabin, USA, 2005 (architects: MOS Architects)
Source: https://www.archdaily.com/10842/floating-house-mos, Accessed: July 12, 2023.

The Kota Kinabalu Mosque in Malaysia was inspired by the Prophet s.a.v.s. the mosque in Medina in Saudi Arabia with its gold and blue dome and architecture (Figure 94). The mosque is surrounded by a man-made lagoon, and visitors access it by rowing boats. The mosque can accommodate over 12,000 people. Preparations for the construction of the mosque began in 1989, and the laying of foundation piles began in 1992. The mosque was officially opened on February 2, 2000, after Kota Kinabalu was declared a city. The mosque is located on a 6 ha plot of land on Pasir Road, on the coast of the Gulf of Lika, in the South China Sea. It is partially surrounded by a man-made lagoon, hence the nickname „Floating Mosque". It has the largest capacity of 12,000 believers. The mosque has three madrasahs, a palliative care clinic and - in a joint project with Universiti Malaysia Sabah - a pond. In 2008, the mosque introduced rowboat rides, which allowed visitors to see the mosque from the water in an effort to make the mosque more relevant to community life, including religious, economic and social aspects.

Figure 94. Kota Kinabalu Mosque in Malaysia, Kota Kinabalu, 2000 (architects: Akitek Bersatu, Sabah)
Source: https://www.abouther.com/node/10206/lifestyle/travel-food/5-world%E2%80%99s-most-stunningfloating-mosques Accessed: July 12, 2023.
Source: https://mosqpedia.org/en/mosque/81, Accessed: July 12, 2023.

The idea of a temporary and floating mosque project was born in 2010 during an international workshop in Venice, considering that this city lacks a similar structure (Figure 95). The intense public discourse that continues on this very topic meant understanding the complex constellation between art, culture and architecture. The architectural heritage of Venice is the heritage of Islamic architecture. This encouraged the development of the initial idea and shaped the floating mosque as a cultural, cross-cultural meeting place, creating a new world within Venice. The process of transformation of a place like today's Venice has the ability to emphasize the symbolic changes taking place in European society. In this context, the floating mosque in Venice will emphasize the paradigm shift within this setting. Based on the classical tradition of mosques, with a courtyard and dome-shaped structure on a square foot footprint and a minaret, which are classical elements, the project needed a contemporary transformation to emphasize the paradigm shift. In the context of the theme of the Art Biennale-Creating Worlds-this cross-cultural installation made of gym balls, which are easily available on the market, and which will be distributed after the venue to the residents of Venice, the feeling that every body is part of this installation (everyone is part of this new world) - the floating mosque in Venice is an example of this 'world creation'. The reuse of balls, by distributing them to people, responds to the sustainable aspect of this installation. The project was developed in collaboration with the „Mosque for Venice", between the Dutch architects I.N.D. Inter National Design, Arman Akdogan & Felix Madrazo, Austrian studio architecture and communication, Dustin A. Tusnovics and Wael Farhat, architects from Venice.

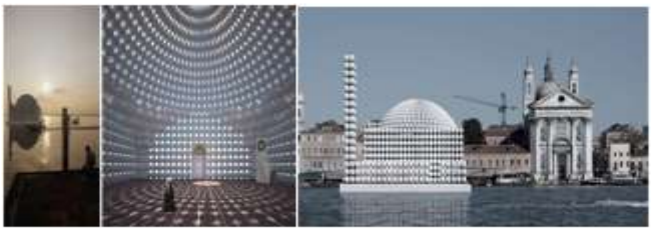


Figure 95. Floating Mosque (Venice), Venice Biennale 2010 (architects: Inter.National.Design - IND)
Source: https://www.internationaldesign.nl/filter/concept/Venice-Floating-Mosque, Accessed: July 12, 2023.
Source: http://mosque-moschea.blogspot.com/, Accessed: July 12, 2023.

After two years of work, the artists Christo Vladimirov Javacheff (1935–2020) and Jeanne-Claude Denat de Guillebon (1935–2009) opened their project The Floating Piers to the general public in the period from June 18 to July 3, 2016. (Figure 96). Although the project was temporary, as often happens with contemporary works, it is the last major episode according to time and media coverage of the attention Lake Iseo is paying to contemporary art. Visitors could follow the installation, which was on the way between Sulzano, Monte Isola and the island of San Paolo. This direct use is accompanied by a new opportunity to observe the landscape from a vantage point on the surrounding hills. The idea of the project was formulated and proposed by Christo and his wife Jeanne-Claude in 2000. A 2,000-meter coiled, inflatable pier, which was to be built in Rio de la Plata in 1970, and in the Daiba project, a project for Odaiba Park, intended for Tokyo Bay in 1996 These large and highly urbanized locations did not allow the implementation of the project due to technical, bureaucratic or economic complications. Christo therefore moved on to a new dimension, intimately connected with the attraction of lake landscapes, certainly under the influence of the climatic and morphological conditions of this landscape, which fully meet the technical needs of the project. The project consists of a series of floating high-density polyethylene pontoons anchored to the bottom of the lake, covered with an iridescent and wavy orange fabric. Thanks to these features, the installation surface captures and reflects light in its various shades

*Corresponding author: **Ahmet Hadrovic**

and variations of shades that range from the metaphysical feeling of zenithal light to the atmosphere of dusk, to the night lit by the moon and artificial lights. The lake, too, plays an active role in touching the perceptual senses of those who take the orange road with its sloping edges, which are designed for a gentle immersion in the water. Operation Floating Columns enriches the gallery of water projects that Christo and Jeanne-Claude have developed in different places around the world over the last forty years. About 92,903 m2, a project on Little Bay in Sydney in 1969 or a surrounded island, an installation opened in 1983 in California's Biscayne Bay, The Floating Piers proposes a new dialogue with water, an element that has always been a challenge for man and his attempt to urbanize. With floating piers, Christo proposes a new architectural solution that achieves an urban utopia of a new reading of the landscape, views and habits of its inhabitants. This utopia was set up with the most modern engineering means and its own poetics, which, separating itself from the narcissistic mechanisms of individualism, is able to interpret certain requirements of contemporary art. At the same time, emphasizing primarily the tactile and sensory dimensions of the project, the artist helps the viewer to abandon his passive role imposed by the elitist system of exploiting a part of contemporary art, making it an active part of the work [71].

Figure 96. The Floating Piers 43, Sulzano-Monte Isola-San Paolo Island, Italy, 2016 (design: Christo Vladimirov Javacheff and Jeanne-Claude Denat de Guillebon)
Source: https://www.galeriebreckner.de/shop/christo-und-jeanneclaude-wolfgang-volz-the-floatingpiers-lago-diseo-wv-40-2016/
Accessed: July 12, 2023.
Source: https://visitlakeiseo.info/en/arts-andculure/the-floating-piers/, Accessed: July 12, 2023.

The Powerhouse Company has unveiled a new design for the Floating Office Rotterdam (FOR), the headquarters of the Global Adaptation Center (GCA), (Figure 97). According to the team, construction will begin in the spring of 2020, and the project envisages a building built entirely of wood that will be energy neutral and self-sustaining. GCA will be located in Rijnhaven in Rotterdam for a period of 5 to 10 years. The Powerhouse Company explains that the GCA launched a mandate to encourage the development of measures to manage the effects of climate change through technology, planning and investment. The commission is led by former UN chairman Ban Ki-moon, Microsoft founder Bill Gates and the director general of the International Monetary Fund (IMF), Kristalina Georgieva. “As the world's climates change, extreme weather events and sea level rise present new challenges for architects. Incorporating resilient features into design before disaster strikes not only makes economic sense, but can also help us mitigate climate change. I am delighted that GCA will be housed in a building that represents pioneering climate-resilient office design and I hope it will inspire others to preserve their infrastructure in the future“ (Prof. Dr. Patrick Verkooijen, CEO of GCA) [72]. As for the team, Powerhouse Company is responsible for the entire project, from sketch to construction. DVP is involved as a project manager of the development company RED Company. The construction was designed by Bartels & Vedder in combination with solid wood. DWA is a consultant for installations, fire safety and architectural physics. The FOR Building will be built by a combination of Valleibouw and Osnabrugge constructors. „Designing a sustainable, floating office building was a very challenging commission and we approached it in an integrated way. By using water from Rijnhaven to cool the building, and by using the roof of the office as a large source of energy, the building is truly autarkic. The building structure is made of wood, it can be easily dismantled and reused. The building is ready for the circular economy“ (Nanne de Ru, founder and architect of Powerhouse) [72]. In the spring of 2020, the construction of the FOR will take place at the Van Leeuwen grounds in Maashaven from where it will be shipped to Rijnhaven.

Figure 97. Floating Office Rotterdam (FOR), Rotterdam, 2020 (architects: Powerhouse Company)
Source: https://www.designboom.com/architecture/powerhouse-company-worldslargest-floating-office-rotterdam-09-01-2020/
Accessed: July 12, 2023.
Source: https://www.avontuura.com/floatingoffice-by-powerhouse-company/, Accessed: July 12, 2023.

Conceived as a 'floating island', this hotel is located 500 meters off the coast of China's southern Fujian province (Figure 98). Called the 'hi sea floating hotel', the project offers guests an unsurpassed view of the water, as well as spectacular sunrises and sunsets. the hotel's remote location meant that the project's architects, balance design, a company led by Dong Xinmeng, had to take environmental factors such as ocean currents and monsoons into account. The roof is made of the same corrosion-resistant materials found on airport terminals and yachts, and the outer deck is made of weather-resistant floors. This material has a texture comparable to solid wood and is environmentally friendly and protects against fire. electricity is provided from the land, by submerged cables. The internal accommodation, which has a total of 500 m², consists of a common living space, a kitchen and three guest rooms. The interiors have been created as simply as possible, with wood used throughout and large openings offering panoramic views of the water. The seating and dining areas offer plenty of space for dining alone or in company. Guests can catch fish from the deck or relax in the pool that is integrated into the outdoor deck [73].

*Corresponding author: **Ahmet Hadrovic**

Figure 98. Hi sea floating hotel (Hi sea floating hotel), Dongshan Island, Zhangzhou city, Fujian province, China, 2020 (architect: Dong Xinmeng)
Source: https://www.designboom.com/architecture/hi-sea-floating-hotel-chinadongshan-island-balance-design-02-08-2021/
Accessed: July 12, 2023.

Little Island is a public park that houses three new performance venues on the Hudson River (Figure 99). Designed as a haven for people and wildlife, it's a green oasis, held above the water by sculptural girders, just a short walk across Manhattan's Lower West Side. Philanthropist Barry Diller and the Hudson River Trust invited Heatherwick Studio to create a pavilion for a new pier along the southwest tip of Manhattan. Instead of designing a decorative object to sit in a Hudson River park, the design team saw an opportunity to think about what a pier could be. The starting point was not a structure, but a new experience for visitors: the excitement of water, the feeling of leaving the city behind and immersion in greenery - inspired by Central Park, where it is possible to forget that you are in the middle of the most densely populated city in the USA. Unlike the flat streets of Manhattan, the design team wanted to create a new topography of the city that could rise to form different spaces. The first iteration was a curled leaf shape that floated on the water, its veins rising like ribs at the edges to shield the space from the wind. The idea of building the park on its foundations came from the existing wooden piles in the water, the remains of many piers that once stretched from the Manhattan coast. Beneath the visible peaks, the wooden piles have become an important habitat for marine life and are a protected fish breeding ground. Heatherwick Studio envisioned the pier as a complete experience; a single, cohesive object, instead of disjointed elements glued together. Instead of sticks holding up the deck, the piles become the deck—extending into planters that join together to create a park surface. The height of the piles varies to create the contours of the park: the angle of the pier is raised to allow sunlight to reach the marine habitat, and the edge falls to define hills, vantage points and create a natural amphitheater for performances. In this way, the pillar and its supporting structure are one. The planters or 'pots' are filled with more than a hundred different species of native trees and plants, which encourage biodiversity and can thrive in the New York climate (each corner of the island represents a different microclimate). To determine the shape of the pots, the design team looked at nature and the mosaic of ice that forms around the wooden piles when the river freezes. The studio has reinterpreted this in a creative pattern that looks organic but uses repeated elements that could be standardized to make. Care was taken to change the angle and repeat the vessels on the rim, where they were most visible. To give the structural concrete a smooth, tactile quality, Heatherwick Studio worked closely with a local manufacturer. Prefabricated components were transported by boat and assembled on site, thus minimizing disruption to the city [74].

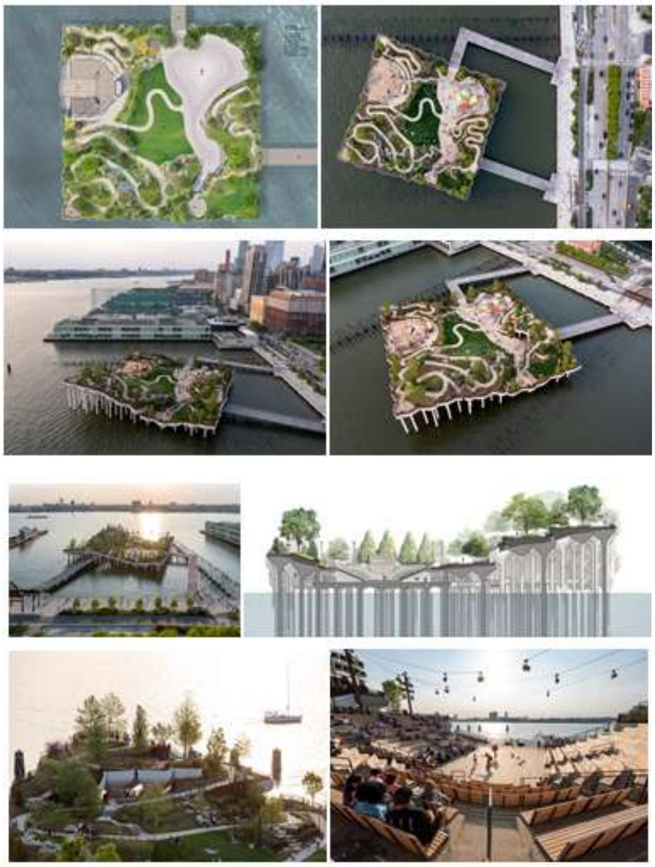


Figure 99. Little Island/Public Space, New York, 2021 (architects: Heatherwick Studio)
Source: https://www.archdaily.com/962374/little-island-park-heatherwick-studio, Accessed: July 12, 2023.

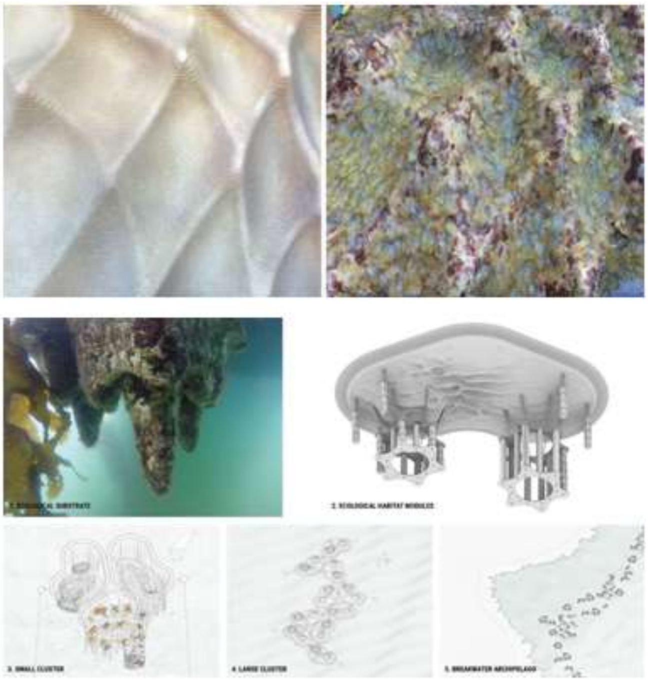
5. Conclusion (Perspectives)

Perspectives of EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER) can be seen in the light of perspectives of architecture in general [1,23,75]. „However, perspectives in architecture, regardless of which historical period it is, have their constant as well as a number of more or less variable dimensions appropriate to the specific time and space, that is, to the natural and social environment. The constant perspective in architecture is related to man, that is, confirmation of his true values. At the same time, some requirements of architecture according to human needs are universal and timeless and, as such, are prescribed by standards at the world, regional or national level. It is about the so-called definition area of human comfort in the field of thermodynamics, acoustics and lighting“ [23]. When it comes to the perspectives of EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER), several facts should be kept in mind: 1. the growth of the world population and the reduction of construction areas on land, 2. a large number of natural disasters (tornadoes, floods, earthquakes, war conflicts - problems with refugees...), 3. climate change (where the rise in the level of the World Sea is one of the consequences - flooding of cities with low altitude), 4. the need for new sources of food, near the places where people live... Water bodies occupy 71% of the Earth's surface, and by volume, the ocean provides about 90% of the living space on planet Earth. When these facts are put in relation to the problems of humanity as a whole, the ideas for its 'saving' are necessarily directed towards water, that is, water surfaces as a new natural environment for human habitation

*Corresponding author: **Ahmet Hadrovic**

and a number of economic activities. This paper presents some contemporary architectural realizations that float on water. It seems that even without official 'declarations' and 'strategic plans', building on water, 'in a natural way', becomes a social-architectural practice as the best and most economical way of building in concrete relationships of Environment-Man-Borders-Perspectives. This is confirmed by the examples presented below.

The Buoyant Ecologies project (the brainchild of Adam Marcus, Margaret Ikeda and Evan Jones from the Architectural Ecologies Lab) combines scientific research with visionary aspirations for floating architecture based on mutually beneficial coexistence between humans and other beings [74] (Figure 100). Building on five years of proof-of-concept prototypes for ecologically optimized substrates that provide diverse habitats for marine invertebrates, the project seeks to use computational and digital fabrication techniques to drive new models for the overall concept of human habitation, other biota habitats, and ecological resilience in anticipation of the impacts of sea level rise. must [76]. The research challenges conventional notions of 'biofouling' - the unwanted build-up of marine life on the underside of floating structures - and instead proposes controlled upside-down habitats for animals as an ecological resource. This helps to promote ecological diversity and supports biological growth which can greatly help in reducing wave action. Since 2014, nearly twenty prototypes of full-scale ecological substrates have been produced to test and monitor different surface geometries, slopes and dimensional parameters for 'hills' and 'valleys' adjacent to the substrate. These prototypes confirmed that the substrates work remarkably well as upside-down habitats for a variety of invertebrate species, including bryozoans, sponges, crustaceans, gobies, mantled crustaceans, crustaceans, molluscs, and urchins. The project imagines a coastal ecology where people and animals are connected to each other. Unlike anthropocentric 'resilience' technologies motivated primarily by self-preservation, the Buoyant Ecologies project offers an alternative strategy for human adaptation to environmental change: one that depends on and supports the health and diversity of marine species.



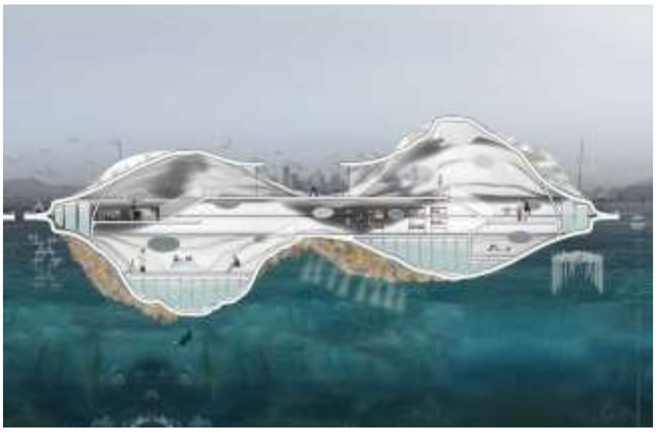


Figure 100. Buoyant Ecologies, project, 2014 (architects: Adam Marcus, Margaret Ikeda and Evan Jones, Architectural Ecologies Lab)
Source: https://futurearchitectureplatform.org/projects/677d4667-d51d-4de3-b538-e8d90cda6d17/, Accessed: July 12, 2023.

A comparison of a prototype ecological substrate before underwater installation (left) with the same prototype after 12 weeks installed underwater in Monterey Bay (right) reveals that variable topographies can yield variable settlement patterns of marine invertebrates. These drawings envision the use of large-scale floating breakwaters as a means of reducing coastal erosion and the impact of sea level rise on coastlines. A necklace of floating wave-dampening structures offers an adaptable and reconfigurable alternative to the more conventional fixed and permanent typologies of seawalls and barriers that many cities currently look to as models of coastal resilience. Although based on empirical, scientific research, the project also encompasses visionary aspirations for a floating architecture of the future based on mutually beneficial coexistence between humans and non-humans. This speculative section begins to envision how the Float Lab can be scaled to habitable, multifunctional, self-sufficient floating structures that provide habitats for humans and animals.

The water building resort is conceptually and architecturally shaped in the form of a drop of water and intends to be the first building in the world that can turn air into water using solar energy (Figure 101). Technique is a combination of technology and nature. Photovoltaic glass made towards the southern facade will use the necessary solar energy and let the light through. In contrast, the north facade includes lattice ventilation and uses Teex Micron equipment to convert humid air into clean drinking water through condensation. Moreover, the lower floor of this resort complex will have a water treatment zone to treat rainwater and salt water and a technology research center to control and verify water quality [77].

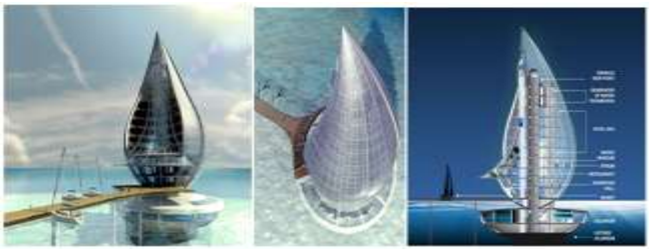


Figure 101. The water building resort, project, 2012 (architect: Orlando De Urrutia)
Source: https://lifestyleamour.wordpress.com/2012/06/19/water-building-resort/, Accessed: July 12, 2023.

*Corresponding author: **Ahmet Hadrovic**

Floating cities have long seemed like a utopian idea based on little more than fantasy. UN-Habitat, which works on sustainable urban development, will partner with the private company Oceanix, the Massachusetts Institute of Technology (MIT) and The Explorers Club, a professional society that promotes scientific research around the world, to advance the idea. As climate change progresses at an alarming rate and huge numbers of people are crammed into urban slums, 'floating cities are one possible solution', says UN-Habitat Executive Director Maimunah Mohd Sharif [78]. Oceanix City, or the world's first sustainable floating city, would basically be groups of hexagonal platforms - anchored to the seabed - that could accommodate around 300 people, effectively creating a community of 10,000 inhabitants (Figure 102). Cages under the city can harvest shellfish, algae or other forms of seafood. Marc Collins Chen, CEO of Oceanix, said the technology to build large-scale floating infrastructure or housing already exists. Concerns have been raised that floating cities could be seen as a quick fix to address the dangers of climate change and sea level rise. The caveat with this project is that people sometimes promote these futuristic ideas as a way to say that climate change isn't so bad, because if it happens, a way around it will be found. However, Oceanix works with a 'solid team' of experts in waste management, water engineering, marine regeneration and energy efficiency, so the project seems completely realistic. Cities could also be a defense against natural disasters. Floating cities will be located specifically in places where they will have sufficient water depth to be unaffected by tsunamis. The main obstacles at the moment are psychological and not technological, said Richard Biese, president of The Explorers Club [78]. People become psychologically nervous about the term 'floating city', since through the term they have the perception that it is a structure that 'can disappear'. To begin the realization of this project, it would be good to create small extensions of existing cities, choosing Hong Kong, New York or Boston, for example, as potential testing grounds. In addition to housing solutions, floating hospitals that are towed on the surface of the water to disaster areas are being considered.

Figure 102. Oceanix City (project), 2019.
Source: https://www.bbc.com/news/world-47827136, Accessed: July 12, 2023.

References

1. Hadrovic, A. (2011). Architectura in Context, Sarajevo, Acta Architectonica et Urbanistica, Faculty of Architecture, University of Sarajevo, Sarajevo, pp. 189, 191, 192, 219, 225
2. Bajau Villages of Togeans http://www.kadidiriparadise.com/bajau-villages/, Accessed: July 8, 2023.
3. Ganvie, the Village on a Lake https://www.amusingplanet.com/2013/12/ganvie-village-on-lake.html Accessed: July 10, 2023.
4. Hadrovic, A. (2021), EARTH WATER AIR ARCHITECTURE (ARCHITECTURE ON THE WATER), Faculty of Architecture, University of Sarajevo, Sarajevo (in Bosnian)
5. THE WORLD'S FIRST FLOATING TIMBER TOWER https://materialdistrict.com/article/worlds-first-floating-timber-tower/ Accessed: July 10, 2023.
6. Hadrovic, A. (2021). Architecture in extreme climatic conditions, Faculty of Architecture, University of Sarajevo, Sarajevo, pp. 7 (in Bosnian)
7. New Clues Reveal the True Origin of Earth's Water https://www.bbvaopenmind.com/en/science/scientific-insights/clues-true-origin-of-earths-water/, Accessed: July 10, 2023.
8. Hidenori, G. (2016), Origin of Earth's oceans: An assessment of the total amount, history and supply of water, Geochemical Journal. 50 (1), str. 27–42.
9. Origin of water on Earth https://courses.seas.harvard.edu/climate/eli/Courses/EPS281r/Sources/Origin-of-oceans/1-Wikipedia-Origin-of-water-on-Earth.pdf, Accessed: July 10, 2023.
10. Archimedes' principle https://www.britannica.com/science/Archimedes-principle, Accessed: July 10, 2023.
11. Surface Tension and Water https://www.usgs.gov/special-topic/water-science-school/science/surface-tension-and-water?qt-science_center_objects=0#qt-science_center_objects, Accessed: July 10, 2023.
12. Hall, M.R. and Allinson, D. (2010). Capillarity, Materials for Energy Efficiency and Thermal Comfort in Buildings. A volume in Woodhead Publishing Series in Energy
13. Marriam Webster Dictionary https://www.merriam-webster.com/dictionary/hydrodynamics, Accessed: July 10, 2023.
14. Jiang, T. (1998). Investigation of Waves Generated by Ships in Shallow Water, Mercator University, Germany, pp. 601-1025
15. Compressible Fluid https://www.sciencedirect.com/topics/earth-and-planetary-sciences/compressible-fluid Accessed: July 10, 2023.
16. Wang,Y., Kaur, A.P., ttanayake, N.H.A., Yu, Z., Suduwella, T.M., Cheng, L., Odom, S.A., Ewoldt, R.H., Viscous flow properties and hydrodynamic diameter of phenothiazine-based redox-active molecules in different supporting salt environments, Phys. Fluids 32, 083108 (2020); doi: 10.1063/5.0010168
17. Boundary Layer Separation http://farside.ph.utexas.edu/teaching/336L/Fluidhtml/node116.html Accessed: July 11, 2023.
18. Quimby, T.B. (2007), Hydrodynamic Loads https://www.bgstructuralengineering.com/BGASCE7/BGASCE7006/BGASCE70604.htm Accessed: July 11, 2023.
19. 13.021 – Marine Hydrodynamics. Lecture 24A – Lifting Surfaces http://web.mit.edu/13.021/13021_2003/Lifting%20surfaces/lectureA.pdf Accessed: July 11, 2023.
20. Falkovich, G., Sreenivasan, K. (2006), Lessons from hydrodynamic turbulence

*Corresponding author: **Ahmet Hadrovic**

https://physicstoday.scitation.org/doi/10.1063/1.2207037, Accessed: July 11, 2023.
21. Ohtsuki, T., Ohsawa, T. (2003), Hydrodynamics for Convection in Vibrating Beds of Cohesionless Granular Materials, Journal of the Physical Society of Japan 72(8):1963-1967, DOI:10.1143/JPSJ.72.1963
22. LAND AND SEA BREEZES https://www.weather.gov/source/zhu/ZHU_Training_Page/winds/Wx_Terms/Flight_Environment.htm, Accessed: July 11, 2023.
23. Hadrovic, A. (2020). PERSPECTIVES OF ARCHITECTURE, Faculty of Architecture, University of Sarajevo, Sarajevo, pp. 2, 3 (in Bosnian)
24. Prehistoric Pile Dwellings around the Alps https://whc.unesco.org/en/list/1363/, Accessed: July 11, 2023.
25. Sato, K. (1991), 'Menghuni Lumbung: Beberapa Pertimbangan mengenai Asal-Usul Konstruksi Rumah Panggung di Kepulauan Pasifik' "Antropologi Indonesia" no.49, pp.31-47, Jurusan Antropologi FISIP Universitas Indonesia
26. United Nations Convention on the Law of the Sea of 10 December 1982. Overview and full text https://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm Accessed: July 11, 2023.
27. PLACES FOR PLACEMENT OF VESSELS ON PART OF THE COAST AND WATER AREA IN THE TERRITORY OF THE CITY OF BELGRADE (PHASE I), („Official Gazette of the City of Belgrade“, no. 9/2013, 16/2013 - corr. I 62/2014), (in Serbian)
28. Hadrovic, A. (2019). Man, something or nothing, Faculty of Architecture, University of Sarajevo, Sarajevo, pp. 5. (in Bosnian)
29. Hadrovic, A. (2010). Architectural physics (Second updated edition), Sarajevo, Acta Architectonica et Urbanistica, Faculty of Architecture, University of Sarajevo, Sarajevo
30. Hadrovic, A. (2016). New approach to the conceptualization and materialization of architectural defined space, Faculty of Architecture, University of Sarajevo, Sarajevo (in Bosnian), pp. 63 (in Bosnian)
31. Prehistoric Pile Dwellings around the Alps https://whc.unesco.org/en/list/1363/, Accessed: July 11, 2023
32. Lake Dwellings. Pile houses https://www.britannica.com/topic/Lake-Dwellings, Accessed: July 11, 2023.
33. Duncan, G. (2012). Don't be blind to this Venetian charm https://www.thenationalnews.com/business/don-t-be-blind-to-this-venetian-charm-1.399221 Accessed: July 11, 2023.
34. UNESCO World Heritage List https://whc.unesco.org/en/list/ , Accessed: July 11, 2023.
35. The best cities in the world for, environment and infrastructure. A report by Mercer Consulting http://www.citymayors.com/features/quality_survey.html, Accessed: July 11, 2023.
36. 2thinknow Innovation Cities Global 256 Index https://web.archive.org/web/20100911231656/http://www.innovation-cities.com/2thinknow-innovation-cities-global-256-index/, Accessed: July 11, 2023.
37. De geschiedenis van Amsterdam https://web.archive.org/web/20080518134246/http://amsterdam.nl/stad_in_beeld/geschiedenis/de_geschiedenis_van#Navigatie, Accessed: July 11, 2023.
38. Nieuws op het gebied van de Tachtigjarige Oorlog of De Bello Belgico https://dutchrevolt.leiden.edu/Pages/start.aspx, Accessed: July 11, 2023.
39. Award of Excellence for Albert Cuyp underwater parking garage Amsterdam https://www.zja.nl/en/Award-of-Excellence-for-Albert-Cuyp-underwater-parking-garage-Amsterdam, Accessed: July 11, 2023.
40. HOUSES ON STILTS, PALAFITO, IN CASTRO, CHILOE, CHILE https://www.mostphotos.com/en-us/11244162/houses-on-stilts-palafito-in-castro-chiloe-chile Accessed: July 11, 2023.
41. Hadrovic, A. (2021). EARTH WATER ARCHITECTURE (UNDERWATER ARCHITECTURE), Faculty of Architecture, University of Sarajevo, Sarajevo (in Bosnian)
42. Aluminium Forest Building https://en.wikiarquitectura.com/building/aluminium-forest-building/, Accessed: July 11, 2023.
43. Water architecture: the fluid boundaries of building https://www.re-thinkingthefuture.com/designing-for-typologies/a4566-water-architecture-how-architects-construct-around-water/, Accessed: July 11, 2023.
44. Boat https://hmong.in.th/wiki/J/Boats, Accessed: July 11, 2023.
45. Page 2. Ancient voyaging in Near Oceania https://teara.govt.nz/en/pacific-migrations/page-2, Accessed: July 11, 2023.
46. Plakias Survey Finds Mesolithic and Palaeolithic Artifacts on Crete https://www.ascsa.edu.gr/index.php/news/newsDetails/plakias-survey-finds-stone-age-tools-on-crete/, Accessed: July 11, 2023.
47. Ship model in Kuwaiti site H3 https://www.researchgate.net/figure/The-Neolithic-site-of-H3-showing-chambers-within-one-of-the-stone-built-structures_fig1_269835647, Accessed: July 11, 2023.
48. Ancient and Modern Ships - Part I. Wooden Sailing-Ships https://books.google.ba/books?id=y_C1CwAAQBAJ&q=The+ancient+Arabs+and+Greeks+used+such+boats+as+trading+vessels.&pg=PT9&redir_esc=y, Accessed: July 11, 2023.]
49. Review of Maritime Transport, United Nations https://unctad.org/system/files/official-document/rmt2016_en.pdf, Accessed: July 11, 2023.
50. Meacham, S. (2008), Austronesians were first to sail the seas https://www.smh.com.au/entertainment/austronesians-were-first-to-sail-the-seas-20081211-gdt65p.html, Accessed: July 11, 2023.
51. Cemal, P. (1998), (1998). The Uluburun shipwreck: an overview, International Journal of Nautical Archaeology. 27 (3), pp. 188.
52. Review of Maritime Transport 2019 https://unctad.org/webflyer/review-maritime-transport-2019, Accessed: July 11, 2023.
53. Lakshmanan, A., Wharton, J.J.S.,Wharton's concise dictionary, str. 1091

*Corresponding author: **Ahmet Hadrovic**

https://books.google.ba/books?id=wLT0Vfh0TQsC&pg=PA1091&redir_esc=y#v=onepage&q&f=false, Accessed: July 11, 2023.
54. Floating Vietnam nightspot languishes in North Korean port http://www.thanhniennews.com/travel/floating-vietnam-nightspot-languishes-in-north-korean-port-31765.html, Accessed: July 11, 2023.
55. Knight, N. (2016), The mighty log rafts of the old new world – tough work – tough men https://www.thevintagenews.com/2016/01/14/46093/, Accessed: July 11, 2023.
56. Iraq's First National Park: A Story of Destruction and Restoration in the Mesopotamian Marshlands https://www.circleofblue.org/2013/world/iraqs-first-national-park-a-story-of-destruction-and-restoration-in-the-mesopotamian-marshlands/, Accessed: July 11
57. Vu, T.H.H. & Viet Duong, V. (2018), Morphology of water-based housing in Mekong delta, Vietnam https://www.matecconferences.org/articles/matecconf/pdf/2018/52/matecconf_esci2018_04005.pdf, Accessed: July 11, 2023.
58. Ko Panyi: A Floating Village in Thailand https://www.archdaily.com/tag/floating-architecture, Accessed: July 11, 2023.
59. De Simone, L. (2017), Floating Architecture is Making Waves https://www.architecturaldigest.com/gallery/floating-architecture-around-the-world-slideshow Accessed: July 11, 2023.
60. Scheeren, O. (2012). Archipelago Cinema Thailand https://buro-os.com/projects/archipelago-cinema-thailand, Accessed: July 11, 2023.
61. Drijf in Lelystad / Attika Architekten https://www.archdaily.com/564243/drif-in-lelystad-attika-architekten Accessed: July 11, 2023.
62. World's First Solar-Powered Floating Island Opens in Seoul! https://inhabitat.com/worlds-first-solar-powered-floating-island-opens-in-seoul/ Accessed: July 11, 2023.
63. A copy is (not a simple) copy: Role of urban landmarks in branding Seoul as a global city https://www.sciencedirect.com/science/article/pii/S2095263519300019 Accessed: July 11, 2023.
64. Nigeria's Makoko Floating School – Everything you need to know https://publicdelivery.org/makoko-floating-school/, Accessed: July 11, 2023.
65. Arctia Headquarters / K2S Architects https://www.archdaily.com/431501/arctia-headquarters-k2s-architects Accessed: July 11, 2023.
66. Stephen Turner, 2014. http://exburyeggtour.com/about.html, Accessed: July 11, 2023.] Waterwoningen //
67. Architectenbureau Marlies Rohmer https://architizer.com/blog/inspiration/industry/waterwoningen/, Accessed: July 11, 2023.
68. Floating Office for Waternet / Attika Architekten https://www.archdaily.com/585536/floating-office-for-waternet-attika-architekten Accessed: July 11, 2023.
69. Floating Pavilion, an experiment in sustainable architecture https://ilcroatia.com/floating-pavilion-rotterdam/, Accessed: July 11, 2023.
70. Floating House / MOS Architects https://www.archdaily.com/10842/floating-house-mos, Accessed: July 11, 2023.
71. Capponi, S. (2016). The Floating Piers https://visitlakeiseo.info/en/arts-and-culure/the-floating-piers/, Accessed: July 11, 2023.
72. Baldwin, E. (2020), Powerhouse Company Designs Floating Timber Office for Rotterdam https://www.archdaily.com/932278/powerhouse-company-designs-floating-timber-office-for-rotterdam, Accessed: July 11, 2023.
73. the 'hi sea floating hotel' offers remote residences off the coast of china https://www.designboom.com/architecture/hi-sea-floating-hotel-china-dongshan-island-balance-design-02-08-2021/, Accessed: July 11, 2023.
74. Little Island Park / Heatherwick Studio https://www.archdaily.com/962374/little-island-park-heatherwick-studio, Pristup; 31.08.2021.
75. Hadrovic, A. (2007). Defining Architecrural Space on the Model of the Oriental Style City House in Bosnia and Herzegovina, Serbia, Montenegro, Kosovo and Macedonia, Booksurge, LLC, North Charleston, SC, USA, pp. 8-14
76. Buoyant Ecologies. Interspecies Cooperation for Sea Level Rise Adaptation https://futurearchitectureplatform.org/projects/677d4667-d51d-4de3-b538-e8d90cda6d17/ Accessed: July 11, 2023.
77. WATER BUILDING RESORT https://lifestyleamour.wordpress.com/2012/06/19/water-building-resort/ Accessed: July 11, 2023.
78. Wright, G. (2019). Floating cities - fantasy or the future? https://www.bbc.com/news/world-47827136, Accessed: July 11, 2023.

*Corresponding author: **Ahmet Hadrovic**