Water in Architetture, Architecture of Water

From Knowledge to Wisdom

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Water in Architecture, Architecture of Water

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Abstract: Water is one of the fundamental resources for the survival of humanity and during the centuries in all the world it became integral part of building and garden architecture. For this reason, starting from general considerations of our countries of origin, we wanted to collect in this article some of the most representative examples of water treatment all over the world in three different fields: the outdoor spaces, the indoor spaces and the in-between spaces, both public and private, to mark the role of water in the designing of architectural process in the last 25 years and proposals for the future not so far.

Key words: Water, architecture, outdoor, indoor, in-between spaces.

1. Introduction

Water is one of the fundamental resources for the survival of humanity; it needs continuous protection by mankind, in the light of the climate changes we are experiencing, such as rising temperatures, desertification and floods.

Water has always had a close relationship with architecture, influencing buildings since ancient times. Thinking about the Roman world we can mention the *domus* which had in the centre of the main atrium the *impluvium*, the square or rectangular tank for collecting rainwater for domestic use but also to cool the hottest places in the house.

During the Roman Empire there were *thermae*, specialized structures, complemented by meeting and entertainment places such as gardens, sports facilities, theatres, museums, libraries for body care. Pliny the Elder in the *Naturalis Historia*, and Vitruvius in *Book V of De Architectura* left a precious testimony on the way of life of the ancients in these healing complexes, in which the motto "*mens sana in corpore sano*" was applied: the use of water as a medicine, the practice of massages, the correct use of the various environments (the *tepidarium*, the *calidarium* and the *frigidarium*) are at the same time evidence of technological innovations both for the production of heating and ventilation and the supply and disposal of water [1]. The Baths of Diocletian and Caracalla in Rome and of Trajan at Villa Adriana in Tivoli are considered to be among the most representative examples of the compositional and spatial articulation of the different environments in which water had a leading value (Fig. 1).

Water mirrors, fountains, waterfalls are an integral part of the garden design in noble and royal houses from Renaissance to Baroque, from Rococo to the 20th century all around Europe, as well as in the Persian gardens during Qajar era. Over the centuries, fountains have become landmarks of cities everywhere, also used as movie sets by film directors as Trevi Fountain in Rome (Figs. 2-4).

Crown Fountain by Jaume Plensa, within the Millenium Park in Chicago, consists of two 15-metre-high glass towers facing each other. Their location marks the boundary of a granite pool of about 70 metres inundated by water. The towers are screens on which video images appear; faces that change expression and from whose mouths water gushes out, attracting large and small crowds. When the faces disappear, the towers are transformed into glass walls from the top of which the water falls cascading down (Fig. 5).

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Fig. 1 The *thermae* complex in Villa Adriana, Tivoli, Italy.

Fig. 2 Villa d'Este garden in Tivoli, Italy.

Fig. 3 Fin Garden in Kashan, Iran.

Fig. 4 Trevi Fountain in Rome, Italy.

Fig. 5 Crown Fountain in Chicago, USA.

2. Fallingwater: Nature and Construction

We can say that Wright's genius invented a building where water is the protagonist of the project since its conception. The building stands in a place full of trees, rocks, waterfalls and streams and was the summer house of the owner of the department store in Pittsburg, Edgar Kauffmann, whose son knew Wight

well, since he had been a member of his school in Taliesin. The Kaufmann family was fascinated by a waterfall on a stream called Bear Run that runs through the wooded mountains of western Pennsylvania. Built between 1935 and 1939 the house was inserted parallel to the stream that gives its name to the entire area at the very point where it descends from the slope above a waterfall. The Kaufmanns hoped to have a view of the cascade, while Wright built the home above the property's naturally-occurring waterfall (Fig. 6).

The house is one of the best examples of a house that adapts to the land on which it stands and at the same time is shaped. Using all the resources of modern technology and its materials (concrete, iron, glass), Wright built one of the most daring works of engineering: a building consisting of cantilevered slabs hinged on a vertical supporting structure of exposed stone. But technical audacity is not an end in itself, it is the means that allows him to place the work of man in symbiosis with that of nature. The house lives in that environment as if it had been born there by spontaneous germination [2].

From the living room, a staircase leads to the base of the building, where shaped concrete supports and other load-bearing elements emerge from the water of the waterfall, formed of roughly shaped blocks of local stone arranged in horizontal lines (Fig. 7).

The privileged situation of the project gives life to the architecture, which is born in and adapts to the place, making natural elements, water, granite stones and trees the main theme of the project.

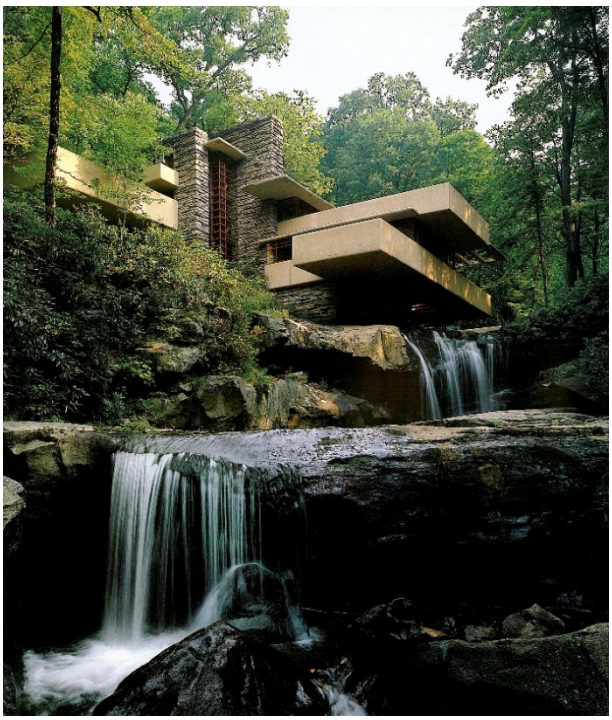

Fig. 6 Fallingwater in Bear Run.

Fig. 7 Bear Run: the staircase to the water.

3. Water in Outdoor Spaces

We want to start discussing the innovative use of water in architecture from the outdoor spaces that have played a very important role in the urban regeneration in which they are inserted, both permanent and temporary.

The Water Mirror in Bordeaux is the world's largest reflecting pool, covering more than 3.000 square metres. The reflecting pool is made of granite slabs covered by 2 cm of water, and a system allows it to create water and mist every half an hour in warm season. It is located along the river, just in front of one of the main square of the city with the palaces reflecting in: it became the new landmark of the urban regeneration of the city that has been taking place since the beginning of the 21st century. Created in 2006 by Jean-Max Llorca, Pierre Gangnet and Michael Corajoud, it reinterprets in a contemporary way the

Fig. 8 Water Mirror in Bordeaux, France.

Fig. 9 Water Mirror: mist effect.

ancient pools of water in French gardens. The place is very crowded, especially in summer when children, and not only, walk and play among the stunning water jets, becoming a place of social inclusion (Figs. 8 and 9).

Lake Arena is the name of the open-air space designed for Expo Milan 2015 event. It is a large mirror of water 90 meters in diameter, surrounded by steps that can accommodate up to 3,000 seated spectators; around it a square that can accommodate 20,000 people and about 100 trees arranged in three concentric rows. This place for 6 months was the scene of shows, concerts, art installations on floating platforms and stages, fireworks and sound and water effects (Fig. 10).

At the bottom of the basin a mantle of dark pebbles creates a mirror effect, while in the centre there is a system of fountains and the Tree of Life—35 metres high and a canopy with a diameter of about 42 metres—a structure made of lamellar larch wood with double curvature and steel that gave life to evocative water games, sounds and lights made with the most advanced entertainment technologies for the entire

Fig. 10 Lake Arena during Expo Milan 2015 event.

Source: http://www.expo2015.org.

duration of the event. The Lake Arena is powered by a canal, water being an element strongly linked to the theme of Expo Milano 2015, Feeding the Planet, Energy for Life.

The City of Arts and Sciences in Valencia is situated at the end of the former riverbed of the river Turia, which was drained and rerouted after a catastrophic flood in 1957. Designed by Santiago Calatrava and Felix Candela in 1996, the complex hosts buildings with different functions for the promotion of culture and art: the Hemisfèric, the Science Museum, the Palace of the Arts, the Oceanogràfic and the Humbracle, an open structure enveloping a landscaped walk with plant species indigenous to Valencia. All the structures are characterized by evocative shapes, an eye, a dinosaur's skeleton, a beetle shell, a water lily pad, and their exteriors are in white colour that has as background the turquoise of the big water mirror on which they seem to float. The pools of water reflect the shapes of buildings both during the day and at night, emphasizing their dimensions (Fig. 11).

KLCC Park and Esplanade Lake Symphony in Kuala Lumpur was created in the 1990s on the design by Brazil landscape architect Roberto Burle Marx. This public park has been designed to provide greenery for the Petronas Twin Towers and surrounding areas. It is one of the city's newest well sophisticated parks and is located in the center of the KLCC development which covers about 20.24 hectares area (Fig. 12).

Fig. 11 City of Arts and Sciences in Valencia, Spain.

Fig. 12 KLCC Park in Kuala Lumpur, Malaysia.
Source: https://www.timeout.com/kuala-lumpur/kids/12-free-things-to-do-in-kl-with-your-family.

This park is an oasis; the combination of trees and water fall and man-made lake. Fountain pool, two acre children's playground, wading pool, shelters and benches, patterned foot paths, sculptures and murals (Fig. 13), these features are contributing to reducing the urban heat island effect [3]. Two musical fountains display over 150 unique programmed animations in a magical performance of sound and water located in KLC Park. KLCC Lake Symphony Light and Sound Water Fountain show times are 8 p.m., 9 p.m. and 10 p.m. daily contributing to enhancing the KLCC Park as urban nodes that give live to the city day and night (Figs. 14 and 15).

Moving on to the private sphere of buildings, we can certainly speak of swimming pools that, especially in warm climate zones, use their ground floors or roofs to house them. Hotels all over the world pamper guests with swimming pools of all shapes and sizes located on

Fig. 13 KLCC Park: children pool and water mirrors.

Fig. 14 KLCC Park and Esplanade Lake Symphony.
Source: https://www.triip.me/kuala-lumpur/skip-the-linepetronas-twin-tower-ticket-16041#&gid=4&pid=5.

Fig. 15 Musical KLCC Lake Symphony Light and Sound Water Fountain.
Source: http://www.kuala-lumpur.ws/attractions/klcc-park.htm.

Fig. 16 Marina Bay Sands Hotel in Singapore.

the upper floors, offering relax areas with breathtaking 360 degree views. The most significant example is certainly the Infinity Pool of Marina Bay Sands hotel in Singapore designed by Safdie Architects and opened to the public in 2010 (Fig. 16).

It is the highest infinity pool in the world, located on a platform 200 meters high, supported by 3 towers, where guests can swim for a length of 150 meters or relax soaking, enjoying the skyline of the city. Here there is the feeling of being suspended from the void, it appears being borderless, almost blending in directly with the horizon. The water, in fact, pours over the edge into a basin below and then is pumped back into the pool. In addition to the swimming pool there is a bar, restaurant and wellness centre, a botanical garden with 250 species of trees and 650 plants and an observation deck (Fig. 17).

Very often due to the air pollution, people who live in the city centre try to find an accommodation in its green neighborhoods outside. In Turin, one of the Italian cities in which this problem is most felt-careful planning of the green-housing combination seems to be the most correct current answer and a challenge that many designers are facing by designing, where possible, urban villas on the top of existing buildings, where it is possible to combine the benefits of comfort of the city and at the same time those arising from the presence of nature [4].

Loft Cube in Turin is the name of the villa designed by the architect Fabio Fantolino on the top of a

Fig. 17 Infinity Pool looking to downtown Singapore.
Source: https://www.marinabaysands.com.

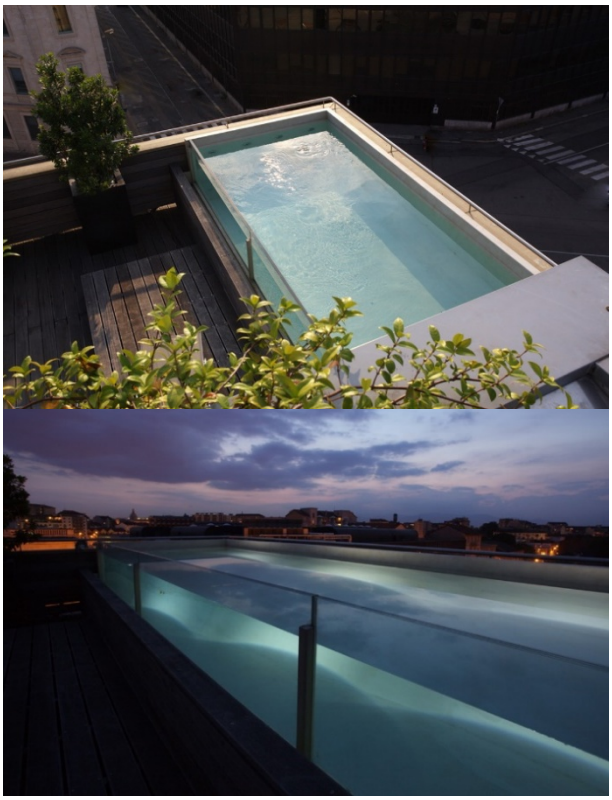

Fig. 18 Pool on the flat roof of urban villa in Turin.

recovered cable factory: it is surrounded by a terrace with stunning views of the mountains and the architectural emergencies of the city centre. The organization of the outdoor space includes evergreen essences in vases to ensure the presence of green all around the year and also an area in one of the corners with a swimming pool whose completely transparent profile towards the terrace, gives it charm both day and night (Fig. 18).

In warm climate pools on the ground floor are linked between tropical garden and the main living area, merging into a single environment made of natural and built elements.

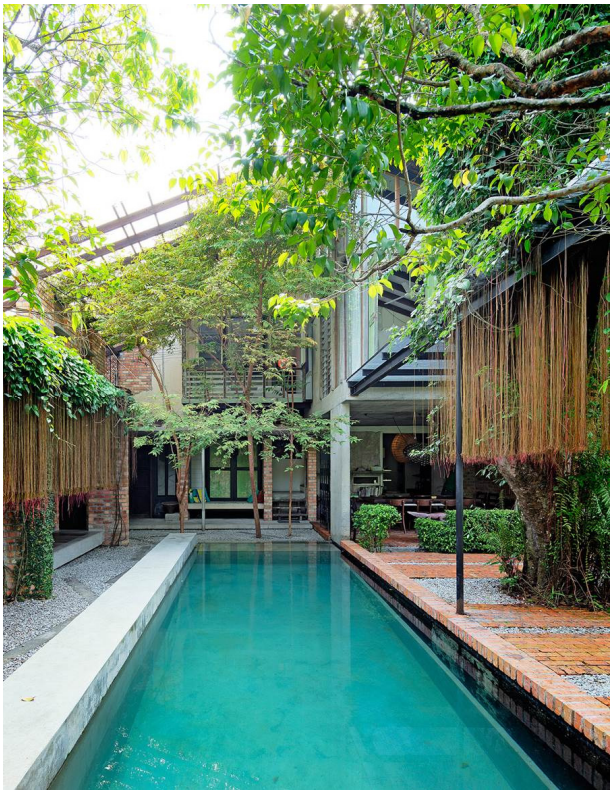

Fig. 19 Swimming pool in courtyard in Sekeping Tenggiri Retreat in Bangsar, Malaysia.
Source: http://ttnotes.com/sekeping-tenggiri.html.

Sekeping Tenggiri Retreat in Bangsar, Malaysia was designed by Seksan Design. Began as an intermediate and corner terrace houses were beautifully transformed by Seksan Design as an urban retreat within the city. These terrace houses were transformed into a private art gallery of its founder Ng Sek San as well as a 7 bedroom guest house which is open for rental to guest. The courtyard is designed as a private garden with decent sized lap pool situated to the side allowing one to take a dip while enjoying its more serene surroundings. The pool creates a cooling effect to all adjacent spaces at the same providing visual interaction within the compound (Fig. 19).

Hamdan [5] mentioned that the effective use of plants and water feature on the ground level will add to user comfort through natural shade and some evaporative cooling. The courtyard also contributes to natural lighting and ventilation in the building. Even if you do not feel up for a swim, the garden also incorporates sitting spaces for a more laid back enjoyment of the garden while seated on custom designed and built wireframe furniture.

4. Water and In-between Spaces

The in-between can be defined as "being in a space that is between one specified thing and another" [6]. In-between can also be known as a connection, transition, border, differentiation, threshold, where the design of space is neither internal nor external. Let us try to see in some examples how water becomes the protagonist of these spaces.

The Jewel in Singapore Changi airport designed by Safdie Architects and opened in 2019, with dome-shaped façade made of glass and steel offers a range of facilities for landside airport operations, leisure attractions, retail offerings and hotel facilities, all under one roof: so the structure is a connecting building among the airport terminals where people can have rest and fun, they can sleep, buy, eat and admire.

Admire what? A tropical garden hosts the world's tallest indoor waterfall, supplemented by a series of smaller cascading waterfalls and five terraced gardens (Figs. 20 and 21).

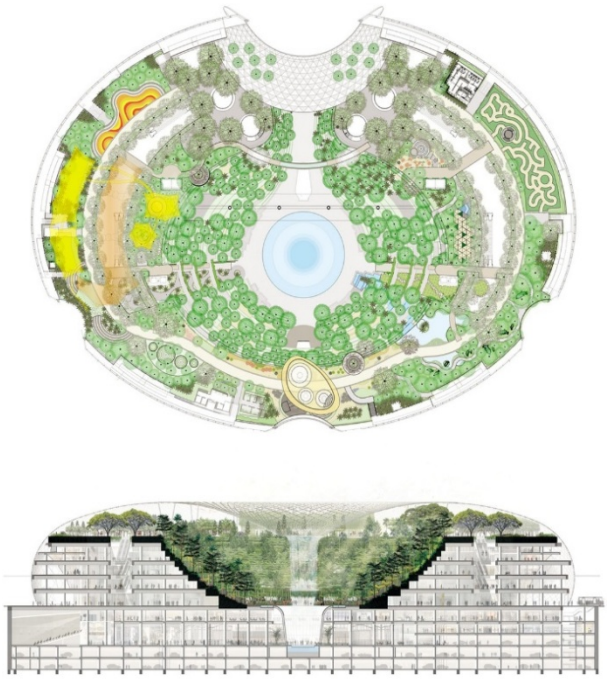

Fig. 20 Plan and section of the Jewel in Singapore Changi.
Source: https://www.safdiearchitects.com.

Fig. 21 The Jewel: general view of the waterfall from the balconies around.

Fig. 22 The Jewel: effects of light during evening.

At the heart of its glass roof oculus showers water down to the centre of the building for two levels below the ground where the restaurants are located. The water during evening and night the water movement is accompanied by light and sound shows (Figs. 22 and 23).

Water from the region's frequent thunderstorms is collected and circulated and helps to refresh the environment and irrigate the plants. The Canopy bridges, suspended 23 metres above ground, with its

Fig. 23 The Jewel: food court.

glass bottom at the centre portion, give users an immersive view of the greenery of the space. The Jewel is awarded as Building of the Year 2020 by ArchDaily Magazine.

We would like to include in this category of examples the Louvre Abu Dhabi designed by Jean Nouvel, even if we have not visited it personally and therefore we have to describe it through the images published on the websites [7]. The museum is located in the cultural district on Saadiyat Island and will be flanked by other important cultural institutions, Guggenheim Museum designed by Frank Ghery, Zayed National Museum of the United Arab Emirates designed by Norman Foster, the Maritime Museum designed by Tadao Ando and the Performing Arts Centre designed by Zaha Hadid. A labyrinth of 55 small and large rooms that house the galleries and facilities connected by glass passages and cavities are housed under a large, low dome, 180 metres high and a circumference of 565 metres, perforated to create an internal effect of "rain of light", as Nouvel describes the atmosphere. Inspired by the palm leaves of Bedouin huts, this structure is a steel and aluminium frame that rests on four supports, able to provide the open spaces below with the right shade (only 1.7% of daylight penetrates) and a temperature at least 5 degrees lower than outside. The museum is strongly linked to the context in which it is inserted made of desert, sky and sea (Fig. 24).

Fig. 24 Louvre Museum in Abu Dhabi, UAE.
Source: https://www.unsplash.com.

Fig. 25 Louvre Abu Dhabi: the water mirrors close to the galleries.
Source: https://www.unsplash.com.

Water is a fundamental element of the project, with the sea creeping under the dome, forming docks and swimming pools, bringing coolness and plays of light reflected on the candid exterior surfaces of the museum organized in a sort of kasbah. The buildings alternate with paved areas and pools of water, a reference to the traditional role of water in Arabic architecture but also an intelligent solution aimed at obtaining natural cooling and ventilation for people and works of art (Fig. 25).

Another interesting example of water used in transitional spaces is Penang Municipal Park in Malaysia. The park is known among the locals as Youth Park because it is mainly designed for youth, but the municipality decided to change the name after the park attracts more visitors from different age group of children, adolescent, youth, elderly, and

Fig. 26 Public swimming pool in Penang Municipal Park, Penang, Malaysia.

senior citizen. Researchers from the School of Housing, Building and Planning, USM in Penang [8] identified majority of the respondents agree that they feel comfort and relax in the park as it is a successful place making concept, it fulfills the public space design criteria which are: safe, comfortable, attractive and associated with the community. One of the main attraction is the outdoor swimming pool which is integrated with the landscape which brings the live to the park. The adults and children swimming pool was designed in organic shape blended well with the tropical landscape (Fig. 26). Trees shade the surroundings and create a social space in-between the water element. The combination of hardscape and soft scape gives an interesting character to this city public park.

5. Water in Indoor Spaces

The first example that comes to mind when we think about water indoors is certainly the aquarium. The aquariums of the latest generation are in fact structures in which the water surrounds the visitors' path making them live an immersive experience as if they were inside the sea among the fish which can be admired from all angles, such as in the Oceanographic of Valencia (Fig. 27).

Water enlivens the great malls, it becomes a playful element that accompanies and makes the shopping

Fig. 27 The Oceanographic of Valencia, Spain.

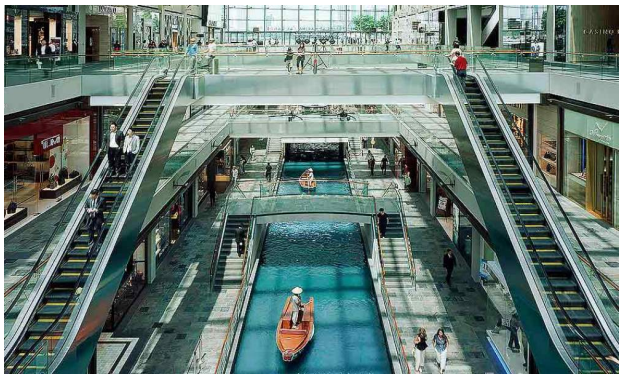

Fig. 28 The Shoppes at Marina Bay Sands in Singapore: general view from the upper level to the inner canal.

adventure even more exciting. This is the case of the luxury mall Shoppes at Marina Bay Sands in Singapore where is possible to take a leisurely ride along the canal in a crafted Chinese wooden boat (Fig. 28).

It is a place suitable for children too, because the effect of the water show fascinates them: the movement of the water can be experienced up close with the boats but at the same time admired from the terraces, the bridges that cross the inner canal and from the outdoor path. At the end of the tour there is an installation comprising a 22 metres wide acrylic bowl that collects the rainwater filling the canal and released it as a big waterfall, turning the ride into an even more funny experience (Fig. 29).

Certainly water in interior spaces finds its most varied declination in pools of spa and fitness centres, hotels, luxury residential complexes as well as in playful pools of individual villas. It is really difficult to

Fig. 29 The Shoppes at Marina Bay Sands in Singapore: the waterfall in the terminal pond.

Fig. 30 Spa Tschuggen Grand Hotel in Switzerland by Mario Botta.
Source: https://www.tschuggen.ch/it/spa.

choose the most significant examples in this area: we will try to do so with our experience in mind.

Peter Zumthor, Mario Botta, Matteo Thun have designed spa complexes in which water offers a unique experience in the setting of an architectural masterpiece, sometimes closed to the exterior with special light effects, sometimes made of a transparent envelope where people, immersed in the thermal water, can admire the surrounded mountain landscape (Fig. 30).

Sharifi-ha house is an excellent example of individual residential building not only for its feature in the main façade—wooden blocks on the front rotate changing its aspect during the season of the year—but also for the interior organization. The house, designed by Alireza Taghaboni, founder of Next Office firm, in one of the exclusive neighbourhoods of Tehran, is distributed over seven floors: the ground floor hosts parking and housekeeping rooms, public activities all happen on the first and second floors, the family's

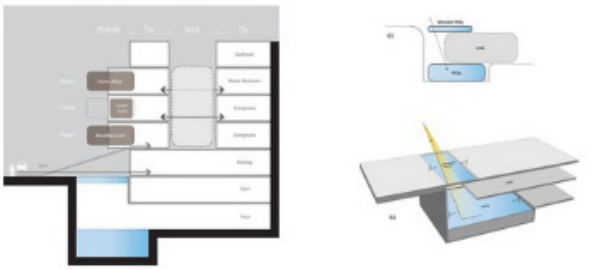

Fig. 31 Sharifi-ha house in Teheran, Iran: concept diagram.
Source: courtesy of Next Office.

Fig. 32 Sharifi-ha house: views of the pool in the lower level.
Source: courtesy of Next Office.

Fig. 33 Water wall for cooling strategy in the atrium of LEO Building in Putrajaya, Malaysia.

private life takes place on the third and fourth floors facing a central void, while the two basement floors are allocated to fitness facilities and wellness areas (Fig. 31).

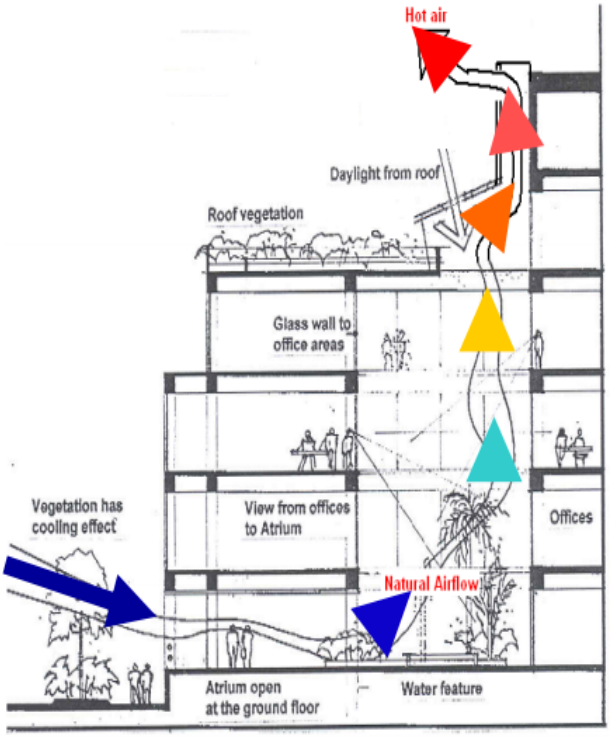

Fig. 34 Section shows passive and hybrid cooling strategies using water wall and roof chimney.

The pool environment is two-storey high with a glass roof, so the light can come inside during the day. The last flight of the staircase hangs from the ceiling on the ground floor and going down it seems to be suspended above the pool. Tri-dimensional mirrors are hanging on a wall of the pool evoking large drops (Fig. 32).

Low Energy Office (LEO) Building in Putrajaya is one of sustainable buildings in Malaysia. It is Ministry of Energy, Water and Communications (MEWC) headquarters (Fig. 33).

A study [9] reports the efficiency of different passive and hybrid cooling strategies using thermal stack flue, cross ventilation and water wall to minimize the overheating inside the atrium lobby of this building as shown in the diagram in Fig. 34. High water wall is located in the atrium towards the chimney outlet at the roof level as one of the cooling strategy. Monitoring was carried out at ten different points of the atrium lobby at the ground floor for 14 days in November of 2013. The recorded data represent the internal thermal conditions of the atrium lobby in seven different cases

by changing the opening composition, stack flue outlets, atrium lobby inlets, and water wall operating time. The study results highlight the importance of cross ventilation in improving the atrium indoor thermal conditions and enhancing the performance of other strategies. The atrium has the highest performance with the implementation of full cross ventilation via all inlet openings at the atrium lobby, together with the semi stacking flue outlet openings and water wall during the working time with high inlet to outlet opening area ratio (> 15).

In this case, the atrium benefits from two different airflow patterns during the working time to reduce both the indoor temperature and the humidity.

6. Conclusions

Which use of water in architecture and which architecture in or on water for the future? Let us try to analyze how architects and designers in collaboration with companies are imagining to link architecture and water in residential buildings, specially concerning the climate change.

Houseboats are a growing phenomenon in Europe, mainly in areas where rivers, canals and lagoons abound, especially in Amsterdam, where single-family houses and apartment buildings have been built since the beginning of this century in areas taken from the sea. The phenomenon of houseboats is not new: just think of the poor but fascinating examples of Bangkok, or the luxury examples offered to tourists in the resorts in Indonesia and in the islands of Pacific Ocean. Nicholas Grimshaw is developing designs for two-storey floating dwellings with the aim to provide a close connection to nature through their proximity to water, improving the users' wellbeing [10]. At the same time this is an answer of rising water levels due to climate change and lack of available land in urban centres (Fig. 35).

If the previous example is particularly suitable for those areas of the world that suffer from rising water levels, such as Netherland, in countries where the hurricane emergency is strong, such as Florida, Arkup firm proposes a floating house which behaves like a yacht [11]: it can navigate in the sea or stay close to the shore, thanks to four hydraulic poles that rest on the seabed, anchoring it firmly and lifting it from the water, to withstand storms or hurricanes (Fig. 36).

The floating villa has a surface area of 400 square meters distributed on two levels, with full-height windows that ensure natural light and a privileged view of the water, as well as large panoramic terraces protected by transparent railings.

We want to conclude this review of cases scattered here and there in the world with a really eccentric project that only in a city like Dubai will be able to find its realization: it is about the luxury house called Floating Seahorse that should be built on islands a few kilometres from the coast [12]. The villa will be developed on three levels, one under water that will house the bedrooms and bathrooms, one on the water level containing kitchen, dining and living room

Fig. 35 Grimshaw's floating houses proposal.
Source: https://www.grimshaw.global.

Fig. 36 Floating house by Arkup.
Source: https://www.arkup.com.

Fig. 37 Floating seahorse design for Dubai.
Source: http://www.archimadgroup.com.

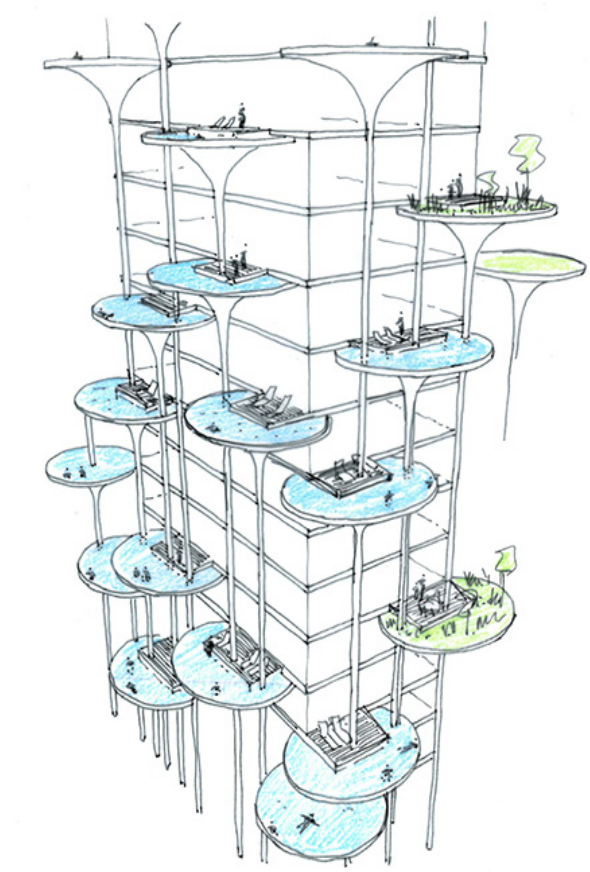

Fig. 38 Limassol Tower, Cyprus.
Source: https://www.hamonic-masson.com.

overlooking the outdoor patio and an upper level dedicated to relax with bar corner and Jacuzzi for a total of about 290 square metres (Fig. 37).

All levels are equipped with maximum transparency to allow a privileged relationship with the water that surrounds the villa: so the architecture will be really in and on water!

The visionary residential project proposed by the French firm Hamonic + Masson & Associés [13], winner of the second prize of the international competition for the Limassol Tower on the island of Cyprus, is configured as a set of flower petals, corolla-shaped platforms containing a swimming pool or planted greenery in direct relationship with the internal living room thanks to a large sliding glass door: inside and outside merge into the nature of water or greenery (Fig. 38).

The corolla system is also found on the ground floor green landscape where they become sunshades elements for the common spaces and on the rooftop where they become common swimming pools overlooking the void and the sea (Figs. 39 and 40).

The examples collected are to be considered only a first approach to the close relationship between water and architecture, a topic that has proved interesting in the course of its discussion and which we promise to take up and deepen on future issues.

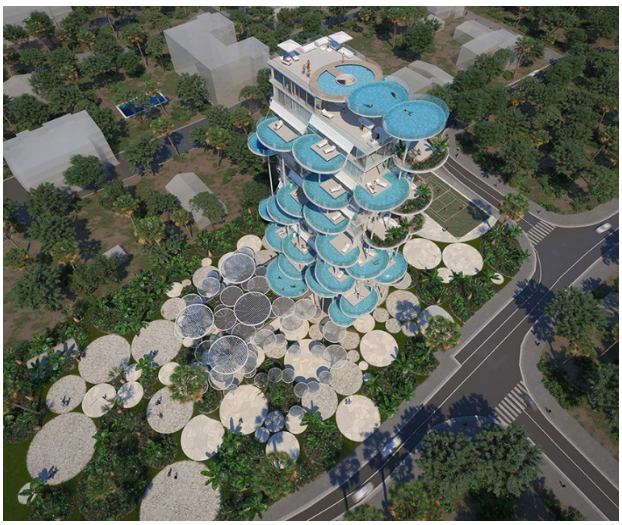

Fig. 39 Limassol Tower: general view of the complex.
Source: https://www.hamonic-masson.com.

Fig. 40 Limassol Tower: the rooftop atmosphere.
Source: https://www.hamonic-masson.com.

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