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Building with water: innovative approaches for sustainable architecture

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ABSTRACT

Water is not only essential to life in every form, but throughout history it has been a fundamental means of production for populations, used for trade, defence, transportation, industry and recreation, hence determining the topographical character of urban areas. In the post-industrial society, though, the use of water for aesthetic pleasure in urban planning and architectural design has increasingly prevailed on other functions since the origin and development of the leisure and tourism industry and, finally, leading to the transformation of the meanwhile abandoned urban industrial waterfronts.

However, many contemporary experimental urban and architectural projects are addressing water from different perspectives and introducing new modes of thinking and practices that will radically change our relationship with this natural resource. The aim of this work is to pinpoint and to analyse these developing approaches, which unveil possible paths of design innovation: using existing urban water as building ground to relieve space for a new density, in order to respond flexibly to the growing urbanization prospects and to the effects of the ongoing climate change; employing water as a material for passive sustainable design strategies and as a resource to preserve, conserve and reuse in integrated solutions for water sensitive urban design. Selected case studies are disclosed to present these new forms of building with water, at the different scales, showing how environmental concerns are combined with the perceptual, symbolic and metaphorical values of this elemental material.

KEYWORDS: water, architecture, sustainable design strategy , density , climate change , water sensitive urban design , urban design.

1 INTRODUCTION

Since ancient times any building, as a shelter for man's dwelling, has to respond to water threats posed by rainfalls, soil humidity, weathering and condensation; still, we make an abundant use of water through installations for domestic purposes and to control the indoor climate. The relationship with this element is clear and explicit in the diverse functional and symbolical interpretations (Moore, 1994) unfolded by the earliest human transformations of the natural environment and resulting in landscape construction and change, until the last centuries irreversible impacts of human activities on the ecosystem.

The loss of the ecological balance, in which water is a primary factor, and the urge for its conservation as a resource, lead to a general rethinking of the way water is nowadays conceived in architecture, in order to overcome the too often sectorial approaches. In post-industrial, global, contemporary society, in fact, water is no more a fundamental means of production to determine the location of factories and the construction of new infrastructures and transport hubs as in the XIX century, but its aesthetic enjoyment has been so exacerbated as to become itself a commodity.

Since the 1980s the deindustrialisation of the port enterprises and changes in the predominant trade routes have triggered massive transformations of the waterfronts' urban and spatial conditions which have focused on water as the determining design element. These redevelopments, which still occur in cities all over the world, attract major investments and yield structural and spatial improvements to provide for ecological restoration and social and economic rehabilitation. "The popularity of living, playing and working by the waterfront is evident through a creative interface between waterfront redevelopment and architectural place making" (Grau et al., 2010).

The presence of neighbouring water just for views or for accessibility is certainly a key to success for real estate developments, not only to rehabilitate degraded city districts, but also for holiday resorts, and for the expansion of existing settlements, as the Dubai experience clearly points out. Land reclamation, the digging of new artificial canals and ponds have acquired a fundamental role (Daglio, 2008) in drawing the unrestrained growth of the Emirates metropolis before the last economic crises.

At the same time, contemporary landscape architecture and urban design are making a wide use of water features in the design of parks and public spaces (Lohrer, 2008), combining a baroque sense for wonder with the potential to provide a strong identity to the place and the diverse possible functions for children's play and grown-ups' leisure.

The growing ecological awareness, has bestowed new significance to the concept of water as a resource to preserve in its quality and overall cycle and as a metaphor of the lost balance of the environment, when its scarcity or unexpected abundance appears as the threatening, often deathly, consequences of climate change. Moreover, as an early mode of ecological thinking, the low tech vernacular approach, focusing on passive solutions and the properties of materials, rediscovered the use of water within these techniques in order to condition both the building behaviour and the microclimate of open spaces as in ancient Middle East and Islamic architecture (Petruccioli, 1985).

Hence, contemporary architecture generally shows univocal and sectorial approaches towards water as a theme for design, exploiting this material because of its instrumental value, or enhancing its aesthetical features or focusing on water as an environmental resource to manage at different scales.

The aim of this article, however, is to highlight the importance of a systemic and holistic approach to water architecture, such as emerging in some selected case studies, in order to outline a possible path towards a change of perspective to interpret water as a construction material in virtue, and simultaneously, of its ornamental and functional potentials within sustainable design strategies at the building and urban scale.

2 METHODOLOGY

As a basic methodological step, a definition of water architecture is necessary in order to correctly focus the topic. Because of the diversity of approaches and the variety of the potentials of this material, the research embraces "architecture associated with the water element, either in the utilitarian, symbolic, therapeutic, leisure or visual context" (Wylson, 1986). This concept, therefore, includes both buildings which are related to water as a feature of the context, adjacent or standing on top of it, and edifices using water as a construction material, these different declinations not being important for the purpose of the present work. The aim of the research, in fact, is to understand whether and how the use of this element in architecture can be not only ornamental or enjoyable but effectively contributing to face the current issues of inhabiting our planet, thus benefiting from its multifunctional potentials. With this goal, a large number of contemporary case studies have been collected and analysed in order to select the projects with a holistic and multiscalar approach illustrating how water is considered as a natural resource to manage and preserve but also as a possible instrument for sustainable design at the different scales and, furthermore, as an aesthetical fundamental feature of design.

These projects show sustainable and balanced solutions to integrate the natural and the artificial, where water is used as a construction material, to reduce energy consumptions during the operational phase of the building, but it is also conserved as an environmental resource and where, at the same time, water is not only respected as an urban and natural landscape feature but also offers opportunities to enhance the landscape and to manage and control the impact of human settlements on the environment.

Thanks to this multifunctional and integrated relationship with water, the case studies analysed are able to respond to the diverse environmental issues of the present society, thus highlighting possible strategies and methodologies for the future, showcasing the multifaceted potentials of water architecture when conceived as a multifunctional integrated solution.

3 WATER ARCHITECTURE FOR SUSTAINABLE DESIGN

This section of the paper illustrates, through the aid of case studies selected among a wider collection, which sustainability challenges water architecture can respond to in contemporary emerging urban and building design, offering answers and possible model strategies with a multiscalar approach.

3.1 Responding to climate change

As a significant and lasting consequence of global warming, mostly due to certain human activities, climate change poses both long term and short term threats to human settlements. “The rate of sea level rise since the mid-19th century has been larger than the mean rate during the previous two millennia. Over the period 1901 to 2010, global mean sea level rose by 0.19 [0.17 to 0.21] m.” (IPCC, 2013). Moreover the occurrence of floods, which is the most frequent among all natural disasters, has been increasing significantly in the past twenty years (Jha et al., 2012). Urban flooding is a serious and growing development challenge, especially when considered together with demographic growth and urbanization trends, therefore the scientific community is increasingly driving policy makers to better understand and more effectively manage existing and future risks.

Two of the three possible measures (Peel Ed., 2010) to face up rising sea levels and flooding disasters on waterfronts entail the design of water architecture. Whilst “retreat”, in fact, as a first strategy, means stepping back from the problem and avoiding a potentially catastrophic blow through the relocation of critical infrastructure and housing to safer ground, “defend” and “attack” are intended as possible strategies to build in coexistence with water.

“Defend” involves the construction of engineered defence infrastructures to stop water entering the existing built environment, which could host also other functions, public or commercial, benefiting from the water proximity and leaving the protected zones behind for public recreational spaces. The Eiland Veur Lent project in Nijmegen, The Netherlands (Web-1), currently under construction, includes a major dyke relocation and new flood-relief channel to reduce flood-risk and support urban growth in Lent. Baca Architects were invited to draw-up plans for an integrated solution which proposes on the artificial island water recreation, river ecology, flood-resilient development and sustainable infrastructure to create a self-sufficient ‘eco-leisure’ destination in continuity with the landscaped surroundings.

Figure 1: Baca Architects, Eiland Veur Lent, Nijmegen, The Netherlands, ongoing

A final strategy, “attack”, includes building onto the water thanks to means which have been practiced for centuries, like stilts, floating structures or land reclamation techniques.

The IBA DOCK, the exemplary exhibition and office building of the Internationale Bauausstellung (IBA) Hamburg 2010 (Web-2), focusing among the many themes also on “Cities and Climate Change”, faces the issue of the elevating water levels in historical city centres and monuments inundated by rising waterways, through the proposal of a floating structure on the river in the Müggenburg customs port. In addition, the building, which has a gross floor area of about 2000 sqm and was designed by Slawik Architekten, makes use of the sun and the river water to generate energy. The ambient heat required by the brine/ water heat pump is either taken from the river water by a heat exchanger or generated by solar thermal collectors.

Figure 2: Slawik Arkitekten, IBA Dock, Hamburg, 2010

3.2 Managing environmental impact

Water architecture can also be experimented in regeneration programmes or in new developments as means to re-establish a lost balance in existing environments or to reduce the impacts of new settlements.

A significant case study of landscape rehabilitation through water is the Internationale Bauausstellung (IBA) Fürst-Pückler-Land held in Germany in 2000-2010 (Web-3), which had the aim of providing new economical, creative and ecological impulses for the required structural change of this mining region. The mighty craters left behind, where huge diggers once lifted lignite out of the earth, have been flooded in order to create a water world of thirty lakes, ten of which are connected by navigable canals, the largest artificial lake landscape in Europe. The transformation of a previous degraded industrial landscape in a large water park with touristic resorts has encompassed the construction of new housings for leisure, floating on the new lakes. The light, dry assembly, easy to dismantle and recycle construction systems, used for these new settlements onto water, also suggest the use of such reversible technological solutions to build floating architecture, as a possible approach to reduce the environmental impact of new resorts in existing natural landscapes, thus matching landscape conservation issues with the economic and social benefits deriving from touristic industry.

Figure 3: IBA Fürst-Pückler-Land, Germany 2000-10. Project 27: Floating Homes On Gräbendorfer See

3.3 Densifying and intensifying urban landscape

Water architecture in urban design can present interesting twofold opportunities to face the increasing issues of urban population growth. The concept of using water as building ground for new urban expansions dates back to the 1960s Utopias - such as Yona Friedman's Gibraltar Bridge (1963) or Buckminster Fuller's tetrahedronal floating city for Tokyo bay - but in contemporary cities it can relieve space both for a new density, providing worldwide opportunities for cities to respond flexibly to climate change and urbanization, and for adding new public functions, such as cultural and sport facilities, to existing dull or mono-functional environments in order to trigger the revitalisation of the area.

The work and research of Koen Olthuis of Waterstudio.NL (Web-4), focuses on these themes proposing a large number of concepts for floating apartment buildings, to increase the density of existing communities, and floating "urban components" that add a particular function to the existing static grid of a city. These additional functions can be stationary, on stilts or moored to the shores, otherwise they can be moved in different areas of the city to provide a dynamic multi-functionality to the varied demands of the neighbourhoods.

The Makoko Floating School in Lagos, Nigeria (Web-5), completed in 2013, is a movable floating prototype structure, conceived by NLE Architects, that addresses physical and social needs of the aquatic community of Makoko, in view of the growing challenges of climate change in an urbanizing African context. Though primarily serving as a school, it can be customized and adaptable for other uses, such as a community hub, health clinic, market, entertainment centre or housing. The special construction, able to safely support a hundred adults, even in extreme weather conditions, is also designed to use renewable energy, to recycle organic waste and to harvest rainwater.

Figure 4: NLE Architects, Makoko Floating School, Lagos, 2012-2013

Whereas the case study of Waterwoningen IJburg (Web-6) in Amsterdam (2001-2011), by Architectenbureau Marlies Rohmer, explores the restraints and the potentials of a high density community (100 housing units per hectare) built onto water, on stilts and on floating pontoons with the aim of producing a pronounced urban character with an integrally planned urban design and architecture. The design of the 75 dwellings was conceived as an experimental process to provide experience to future similar projects. Therefore it explores not only constructional and technological aspects to provide homes with different price classes, facing the urban design challenge to give the water its due prominence as a distinctive feature of the neighbourhood, but it confronts also with procedural and property legal issues tackling with the technical distinction between floating houses and houseboats.

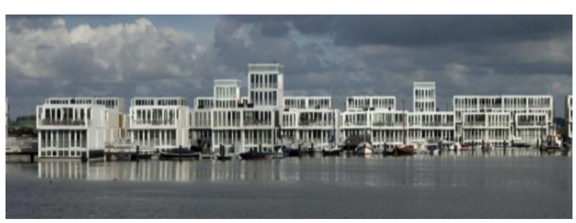

Figure 5: Architectenbureau Marlies Rohmer, Waterwoningen IJburg, Amsterdam, 2001-2011

3.4 Managing environmental resources

Water architecture can play different basic roles in the quest to resource conservation. Water can be exploited in passive cooling strategies both for indoor and outdoor climate, thanks to the phenomena of evaporative cooling, resulting from the evaporation of water, which removes latent heat from the air. Albeit evaporative cooling occurred since ancient times, it was only starting in the Nineties that these techniques where again applied for passive design, though in few outstanding and unique projects. The Expo 1992 in Seville, Spain, was the field of the first experimentations for open spaces and buildings, such as in the Nicholas Grimshaw & Partners British Pavillion, which east façade supports a 65m x 18m water wall to cool the glass surface.

The evolution of the work of the German architectural firm Atelier Dreiseitl, can be taken as an example to illustrate, how through the following decades, this use of water has been developed and encompassed in a larger multi-scale and systemic concept of sustainable design, which also considers this element as an environmental resource to preserve and to manage in urban contexts (Dreiseitl et al., 2009). The McLaren Technology Centre in Woking (UK), designed by Foster + Partner (Web-7) with Atelier Dreiseitl (consultant), faces an artificial lake which is perfectly integrated in the architectural design of the building, and which collects storm water run-off from the roof and parking lots, to be used for cooling. Water is in fact pumped via a natural filtration system of reed beds and a cleansing biotope through to the building's heat exchangers and back out through a stunning 200 m long cascade. The landscape character of the site is protected both from the perceptive and from the ecological point of view, because, thanks to this natural cooling system the need for massive cooling towers was eliminated and, in addition, the adjacent stream is fed with clean water from the lake, preventing its running dry.

Figure 6: Foster + partners, McLaren Technology Centre, Woking, UK, 1998-2004

Therefore, water for passive cooling purposes allows for the reduction of energy consumption but is itself preserved as a resource also in order to come up against urbanization problems such as increased flash flooding after sudden rain occurring in urbanized contexts. Accordingly, it can be included into “water sensitive urban design” solutions (Hoyer et al., 2011), to reduce the potential impact of new and existing developments with respect to surface water drainage discharges, to integrate the urban water cycle into urban design to minimise environmental degradation and improve aesthetic and recreational appeal.

Another potential of water for passive conditioning relies on its thermal mass. Roof ponds, a passive application of this property, use a store of water above the roof to mediate internal temperatures, usually in hot desert environments or to provide heating when the water is used to absorb solar radiation during the day. In the Water-Cooled House, built in Singapore in 2009, the architects of Wallflower Architecture + Design (Web-8) design a shallow pond on the second level of the villa, to thermally insulate the dining, bedrooms and family spaces underneath, from solar heat gain. In the same way, the water body above also helps to regulate temperature swings within the house.

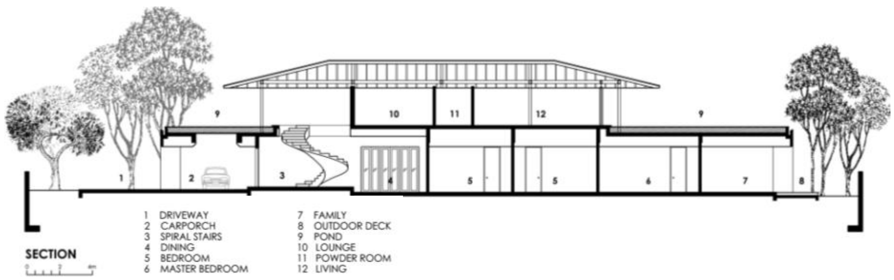

Figure 7: Wallflower Architecture + Design, Water-Cooled House, Singapore, 2009

Another interesting opportunity for water architecture, exploiting the thermal mass property in an active way, is deep water source cooling and heating which use water as a heat source in winter and a heat sink in summer, with the aid of a heat pump to transfer thermal energy from and to the adjacent water mass. In the studio apartment and boathouse for a photographer, Lake Ontario, Toronto, Canada (Web-9), the architectural firm Studio gh3 take advantage of the lakefront site not only for the panoramic views of the setting but also for the deep-water exchange to heat and cool the building year–round through radiant slabs and recessed perimeter louvers at the floor and ceiling.

Figure 8: Studio gh3, Studio Apartment for a photographer, Lake Ontario, Toronto, Canada, 2012

4 CONCLUSION

Albeit the extremely concise selection of case studies here presented, a larger list of projects illustrate an ongoing trend towards a holistic concept of water architecture. The use of water in buildings as a material and as a meaningful stimulating feature of the geographical context, allows for the application of integrated strategies, at the urban and architecture scale, to approach environmental sustainability issues against resources depletion, to re-establish a balance with nature and to rehabilitate and enhance the quality of existing environments. The success of these projects as model strategies depends on their relationship with larger redevelopment efforts that go beyond singular acts of architecture and include a commitment to environmental, ecological but also cultural and social matters. It also simultaneously relies on the metaphorical, symbolical and aesthetical aspects of water and how they can be interpreted and declined in compelling designs which introduce new ways of living, working and playing with water.

REFERENCES

Daglio, L. 2008. Planning in “New Frontiers in Architecture: Dubai Between Vision and Reality”, Bellini O. E., Daglio, L., Whitestar, Vercelli.

Dreiseitl, H. et al., Eds. 2009. Recent waterscapes: planning, building and designing with water, Birkhauser, Basel.

Grau, D., Zeljka, C. K. 2010. Where water meets the land: The Rediscovery of the waterfront in “Building with water: concepts, typology, design”, Ryan, Z., Birkhäuser, Basel.

Hoyer, J. et al. 2011. Water sensitive urban design: principles and inspirations for sustainable stormwater management in the city of the future, Jovis, Berlin.

IPCC 2013, “Climate Change 2013: The Physical Science Basis”, Cambridge University Press, Cambridge, USA.

Jha, A. K., Bloch, R., Lamond, J. 2012, Cities and Flooding. A Guide to Integrated Urban Flood Risk Management for the 21st Century, The World Bank, Washington, USA.

Lechner, N. 2009. Heating, cooling, lighting: sustainable design methods for architects, Wiley, Hoboken.

Lohrer, A. 2008. Basics designing with water, Birkhäuser, Basel.

Moore, C. W. 1994. Water and architecture, Thames and Hudson, London.

Peel, C., Ed. 2010. Facing up to Rising Sea-Levels: retreat? defend? attack?, Building Futures, Institution of Civil Engineers, RIBA.

Petruccioli, A., Ed. 1985. Water and architecture, Environmental Design: Journal of the Islamic Environmental Design Research Centre, Carucci Editore, Roma.

Wylson, A. 1986. Aquatecture: architecture and water, The Architectural Press, London.

Web-1: http://bacablog01.wordpress.com/2014/02/07/baca-wins-top-mipim-masterplanning-award/

Web-2: http://www.iba-hamburg.de/fileadmin/Mediathek/S20_ibadock/Projectflyer_IBA_Dock_en.pdf

Web-3: http://www.iba-see2010.de/en/index.html

Web-4: http://www.waterstudio.nl/vision

Web-5: http://www.nleworks.com/case/makoko-floating-school/

Web-6: http://www.archdaily.com/120238/floating-houses-in-ijburg-architectenbureau-marlies-rohmer/

Web-7: http://www.fosterandpartners.com/projects/mclaren-technology-centre/

Web-8: http://www.archdaily.com/58294/water-cooled-house-wallflower-architecture-design/

Web-9: http://www.dezeen.com/2012/03/13/photographers-studio-over-a-boat-house-on-stoney-lake-by-gh3/