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After Machine-À-Habiter

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Abstract

The technological component in architecture has dramatically increased during the last 50 years. Buildings react automatically to various inputs and the machine-à-habiter—a main concept of Le Corbusier's thinking—is becoming actual one century after his Vers une Architecture. In the next 50 years, buildings (mostly tall buildings) will be completely artificial and fully digital—and dependent on a constant flow of electricity. Buildings will be energy voracious; networks will be overwhelmed by the demand and it will become essential for skyscrapers to produce the electricity they need. The Habitable Machines of tomorrow will be tailored to specific needs and locations, the design will parametrically accommodate market needs and construction will be more like today's car production than the construction industry we all know. Clusters of buildings will share a common DNA. Enabling all of this, new technologies in parametric architecture is becoming the incarnation of this new trend.

Keywords: Digital, Energy, Environment, Parametric Architecture

Introduction

All celebrations and commemorations are an encouragement to look back at where we come from, and what has been done in the past to better understand what we have today and how the future ahead could look.

The manifesto of Le Corbusier, and the actuality of the thoughts of that prolific essay cause us to reflect on how much climate change, the fast modifications of the human habitat and the evolution in the construction industry are affecting, and will affect, the design profession and the cities we live in. In the work of Zaha Hadid Architects some of those changes have already affected our design and clusters of towers—driven by parametrical tools—have now become the urban ingredient of many design proposals.

Longevity of the Le Corbusier Manifesto

It's almost a century since the publication of *Toward an Architecture*. With his book, Le Corbusier foresaw exactly the revolution that was going to happen. It took 50 years for his five points to become a common denominator of contemporary design worldwide. It's worth listing them again, as a tribute to one of the fathers of the revolution that followed:

- Buildings lifted on *pilotis*, creating open spaces at the ground plane
- Free-form interior designs, enabled by structural columns
- Free-form façade designs, liberated from load-bearing functions
- Horizontal windows to provide even daylight across rooms
- Rooftop gardens

These points have been widely adopted in countries, markets or functions, and though not all have been adopted for every project, it is inarguable argue that those points have underpinned some of the most widespread and successful movements in modern architecture. The triumph of the recipe is due to the solidity and simplicity

Figure 1. We are living in a world that is chronologically after Le Corbusier, but immersed in a world shaped by the essence of the world that he managed to envisage.
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of the ingredients, and because the ideas resonated with the revolutionary sentiment of this era.

In the following 50 years, bringing us to the cities we have today, entirely new neighborhoods, city expansions, and new city foundations were shaped along those simple principles. The "rules" have not always been respected in their original form; for developments with no design ambitions, the principles were simplified and reduced to a mere ghost of Le Corbusier's ideas. "Rooftop gardens" have been translated to "flat" (low-slope) technical roofs; "lifted-up buildings" often became covered parking lots; the "freedom offered by the new structural solutions" to optimize the plans, façades and windows, and to improve the spatial and architectural outcomes, has been minimally profitable.

However, the actuality of those principles is realized in much of today's best tall-building architecture. Buildings with common ground, where the private and public realms merge, are often mandatory requirements from authorities, or in the client's briefs, to increase the quality of the product. New city-center developments frequently provide public squares and gardens on top of private towers in the major cities of the world. Architects take full advantage of the new structural possibilities to grant the right amount of natural light, diaphanous facades and quality interior spaces to their compositions.

Therefore, the use of the word "after" in the title of this article, must be interpreted in both meanings: we are living in a world that is chronologically after Le Corbusier; and we are all immersed in a world shaped by the essence of his vision (see Figure 1).

Le Corbusier, in his book, explained another inspirational idea: he suggested that new architecture should be considered as "machines for living". This concept was not one of the main five points of his manifesto, but became more relevant in the 1970s with the inspirational work of Archigram, Buckminster Fuller, and others, and has become a reality in the contemporary condition of "smart", tech-enabled buildings.

In the last 10 years, with the fall of prices in electronics and the spread of smartphones, we have seen an incredible growth of informatics and automation in the architectural environment. Thanks to the Internet of Things (IoT), home automation has become a part of our everyday lives. In the next 50 years, the predictions of Le Corbusier will bear an even closer relationship to reality, and the last tile of his mosaic will have been placed.

The transformations occurring in cities—replacing of the traditional building with the future machine for living —will have dramatic impacts, both on city infrastructure and skylines. Some explanations are related to the change between the Industrial Revolution "3.0" to "4.0"—from electronic to informatic—others are related to the consequences of the urbanization process that proceeds at unprecedented pace.

Growth of Megacities

Around 77 million people are moving from rural to urban areas each year. The latest UN World Cities Report has found that the number of "megacities"—those with more than 10 million people—has more than doubled over the two decades 1995–2016, growing respectively from 14 to 29 (UN Habitat 2016).

Humans, as all animals, migrate to improve the quality of their lives. Cities can deliver a higher GDP per person—increasing the average production per capita—and reduce the percentage of poverty. Those two factors raise the megacity's attractiveness. The bigger such cities become, the denser the center of megacities will be. As a consequence, for the sake of efficiency, cities will grow in height.

The World's Richest People Emit the Most Carbon

Research supported by the NGO Oxfam in 2015 estimates that the world's richest 10 percent of people have carbon footprints that are 60 times higher as the poorest 10 percent (Colarossi 2015). Those who emit the most are those who use the most energy. This happens because of lifestyle (refrigerators, electronics, home automation, etc.), and because of the consumption intrinsic in tall buildings (air conditioning, elevator systems, surveillance, facade cleaning, security, safety, etc.)

The centers of megacities will be populated with the most energy-consuming people and buildings, and will demand a vast amount of electricity to be delivered through infrastructure to their doorsteps. As a matter of fact, cities alone emit between 50 and 60 percent of the world's total greenhouse gases, without taking into account the indirect contribution generated by urban inhabitants (in which case it rises to 80 percent).

New Stress for City Infrastructure and the Design Process

Buildings will become energy-voracious: the more energy they receive, the they will require. City centers will soon become energy "black holes". In the meantime, power plants have become centralized in a few efficient areas and the energy infrastructure network has become a large-scale power grid with little resilience.

Research by Umberger (2012) stated that:

America's outdated and vulnerable energy infrastructure is in desperate need of reform, one that can end our reliance on fossil fuels and enable American cities to become self-sustaining with localized, renewable energy distributed generation.

This could be applicable to all developed and fast-growing economies, not just America. For these reasons, it becomes essential for buildings in cities to produce the electricity they need.

All the green energy tools and innovations of the last 50 years (wind turbines, photo voltaic panels, plus the introduction of luminescent solar concentrators, bioactivated walls, etc.,) will become the new ingredients to play with in designing the buildings of the next 50 years.

Already architects must harmonize these new inputs into the overall design. This adds a further level of complexity to the usual aspects taken into account and coordinated by designers. A new, sophisticated chapter for energy production will soon be added to inputs already present in the design process. The architectural solutions will need to be specific to the environment, location and site; maximize efficiency and flexibility; control natural light and solar performance; plus develop a strategy to incorporate energy production and create the perfect balance between all factors.

Considering the speed of urban drift and the resulting fast-paced need for projects and construction, plus the new levels of complexity of project coordination, projects are probably going to expand their physical dimensions. What is happening in Asia today will become the global. In the cities of the third millennium, single-building projects will represent a rare opportunity. They will be often limited to historical centers, where the plot shape and dimension will still have a second-millennium "flavor."

In China, cities have already started to grow via unconventional strategies: large plots are developed at once, containing several buildings and different functions, and are partially self-sufficient, forming entire neighborhoods.

How Cities Will Grow

Clusters of buildings with the same language, designed by the same company and built by the same contractor, will probably become the standard procurement process of city expansions for the next 50 years. Projects will easily capitalize the scale of the investment, speed up the development of the design, and improve quality while reducing costs.

Regrettably, speculative investors will save on costs by replicating a single tower design several times within the same development. Hopefully, it will be understood that this unscrupulous and short-sighted approach will have a short future: indeed, the outcome of this approach is a dull, monotonous design that drastically reduces the value of the investment, and thus dramatically affects the investment return.

Buildings are Still Handcrafted

The method described above applies a principle of the first Industrial Revolution to a different industry, which is an important market misjudgement. At the beginning of the last century, the introduction of machined mass production drastically cut costs through the repetition of the same process: a well-designed object could be delivered to a large number of customers at a fraction of the cost of the hand-crafted equivalent.

The advantages of this principle have been incredible for both entrepreneurs and customers, and the change has significantly multiplied return on investment and quality of life for the entire population. It relies on the possibility to automate the construction process of the object.

Although the industrialization and automation of building sites has improved considerably in the last few years, construction processes are still heavily supported by manual labor, and the output per hour in the construction industry—even in the United Kingdom—has been stagnant for the last 25 years.

Buildings are still built one at a time. The construction process can be helped by technology; large and small machines can make labor less strenuous; coordination can be improved by scans, drones and BIM technologies, but the business model of building construction still has more similarities with hand-crafted object production, than with objects produced during the first Industrial Revolution.

Meanwhile, in Industrial Revolution 4.0, object production is drifting towards the customization of products. Smaller, user-friendly 3D plotters are becoming available; 3D models are shared online; and user-friendly software is available to allow customized and personalized objects to be produced by consumers. Although changes in the construction sector are traditionally slow, there are some witness some commonalities between the two industry models, especially in certain geographic areas.

Indeed, most of the projects the author's firm designs take full advantage of technological progression in the industry: prefabrication of structural components, computerized machining, computer-driven façade paneling, and automatic manufacturing of façade cellular components are only a few of the techniques used in contemporary projects. This new paradigm is being pioneered throughout Asia, and in Chinese megacities in particular, but it is rapidly spreading globally for the sake of quality and returns on investment.

Computer-based design, BIM-driven or not, dramatically helps this kind of change. In fact, such tools allow faster construction by creating a shortcut between the design and manufacturing processes. At the same time, these tools open a new chapter in the design method. The design can indeed be adjusted—by operation on specific parameters—to accommodate different needs, functions, orientations, roles of a single element in the building, as well as the building in context.

For the reasons above, clusters of parametrically-driven towers are becoming the obvious ingredient for many new developments. This method is an efficient way to increase the differentiation needed to meet different client segments within the same development, create the correct relation between different functions, and, at the same time, maximize the repetition of constructed elements and improve efficiency.

Clusters of Parametric Towers

In several projects demonstrated here, compositions of clusters of towers are erected by the same developer, builder, designer, and team.

All the parameters usually coordinated by the architect and team to produce a single building are incorporated in a generative algorithm that will create a consistent family of parametrically-controlled towers. Aspects like the brief inputs, code compliance, energy consumption and production, building systems performance, structural efficiency, construction process, design aspirations, and all other aspects usually coordinated in a design process and condensed in a single building, will become the shared DNA of the entire process.

Today the majority of architects tailor every single building to the specific needs of a single client and location, as a clothing tailor would have done in the 18th century. We could instead consider every single result as a prototype of a new breed that could generate entirely new types and families. In the next 50 years, we will design tools to generate projects as "bundles of buildings". Every prototype will generate the full potential embedded in its DNA.

The following case studies highlight how the trend of tower clustering started more than 10 years ago in Singapore, has developed in Asia, and has big global potential in the future.

Case Studies

D'Leedon Singapore

Zaha Hadid Architects has been always at the forefront of the design process evolution. Already 12 years ago CapitaLand chose ZHA to develop the first cluster of parametric residential towers to be built in Singapore (see Figure 2). D'Leedon

Figure 2. D'Leedon Singapore—the first cluster of parametric residential towers to be built in Singapore. © Hufton+Crow

Figure 3. D'Leedon Singapore—the towers share a common language and feeling. © Hufton+Crow

Figure 4. D'Leedon Singapore—the stacking of different unit types allows a variation in elevation that characterizes the overall image of the entire development. © Hufton+Crow

Figure 5. D'Leedon Singapore—the towers have a flower-shaped footprint, with different numbers of petals depending on the amount of units per floor. © Hufton+Crow

Figure 6. Wangjing SOHO, Beijing was designed as three interweaving "mountains" that fuse the buildings and landscape. © Virgile Simon Bertrand

development accommodates almost 1,000 apartments, penthouses and villas totaling more than 200,000 square meters. The towers share the same brief, rules, technical requirement, construction technologies and aesthetic ambition but each tower caters to a different market sector: some towers were tuned towards the high-end market, with bigger apartments and less units per floor, others were adjusted to be dense and complete the market offer. The outcome is an articulated, elegant composition of towers with a flower shaped foot print (see Figures 3, 4, and 5). The towers have different numbers of petals depending on the number of units per floor. The staking of different unit types allows a movement in elevation that characterizes the overall image of the entire development. All the towers share a common language and feeling, united by an effective precast concrete construction process. The views of the towers are never the same, and the variety of the skyline adds value to the proposal.

Wangjing SOHO, Beijing

The parametric cluster design process has been a successful tool in several other opportunities. The Wangjing SOHO project in Beijing is a mixed-use development consisting of three towers of 118, 127, and 200 meters in height, respectively (see Figures 6, 7, and 8). Designed as three interweaving "mountains" that fuse the buildings and landscape, the surrounding community is integrated with a new 60,000-square-meter public park. The design responds to the flows of the city and allows natural daylight into each building from all directions. The juxtaposition of the towers' fluid forms continuously changes when viewed from different directions—appearing as individual buildings in some views, or as a connected ensemble in others. The cohesive design of the project creates an anchor and identity for the growing Wangjing community.

As required by the client, dividing the total 560,000-square-meter built area into three smaller buildings reduced the scale of the project, compared to a single building placed on the 115,393-square-meter fan-shaped site. The parametric design of this cluster of towers has allowed for strong repetition in the coordination and overall robust identity of the office and retail development.

CBD Core Area of Beijing

A fascinating and fruitful design of a cluster of towers can be found in the Urban Design and Architectural Concept for Beijing. The Beijing CBD Core Area envisaged a design for an advanced, high-value business neighborhood. Providing a stimulating urban environment was a critical factor in fostering a vibrant business community. The provision of a critical mass and density of office accommodation was merely the necessary starting point for the development.

The planned disposition of the tower volumes creates a variegated urban massing and lively silhouette. The axis described by the main tower, together with the linear park,

Figure 7. Wangjing SOHO, Beijing—the surrounding community is integrated with a new 60,000 square meter public park. © Virgile Simon Bertrand

Figure 8. Wangjing SOHO, Beijing—the design responds to the flows of the city with the juxtaposition of the towers' fluid forms continuously changing when viewed from different directions. © Virgile Simon Bertrand

Figure 9. CBD Core Area Beijing—a cluster of towers fostering a vibrant business community. © Zaha Hadid Architects

Figure 10. The concept design works as a cohesive network of towers that is fully integrated at ground level and coherently develops as it grows in height. © Zaha Hadid Architects

gives clear order and orientation to the whole urban field. However, the design goes further in its effort to establish an organic order and elegance that is akin to the beauty found in nature.

The design breaks with the typical tower-and-podium typology by redefining the ground as a continuous landscape that seamlessly weaves between the towers. The proposed concept design doesn't work like a traditional array of adjacent buildings, but rather, as a cohesive network of towers that is fully integrated at ground level and coherently developed as it grows in height.

The proposed master plan design for the CBD Core Area aims at the creation of a new business and civic node for the city of Beijing that embodies values of functionality, elegance and innovation (see Figures 9, 10, 11, and 12). The towers belong to the same family, sharing most of the parametric DNA, generating different types and breeds. It creates a strong identity area, virtually a "man-made natural environment" in which business can thrive and prosper.

Conclusion

In the last 50 years, we have witnessed an impressive evolution in the way architects conceive projects to shape the world around us. Towers will become more sophisticated, not only in the way they use energy, but in the way they generate it. The towers we are developing today could become the prototypes of a new species; parametric design will drive their evolution.

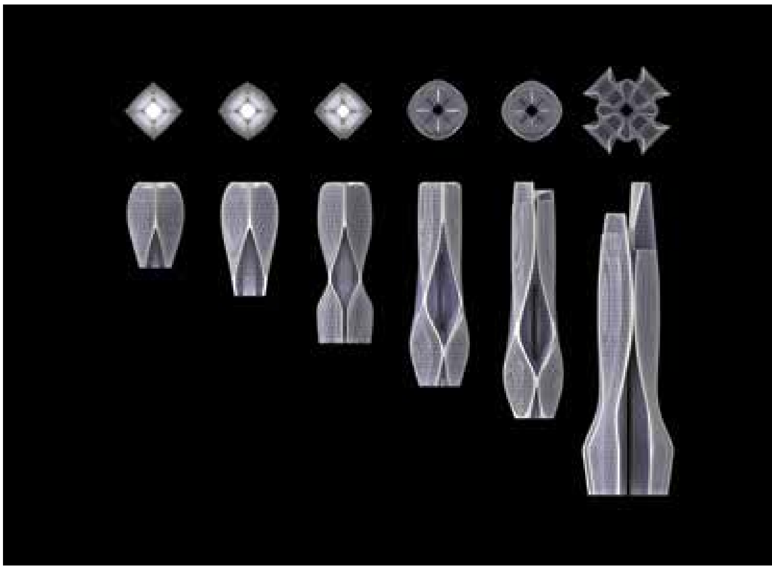

Figure 11. The towers belong to the same family, sharing most of the parametric DNA.
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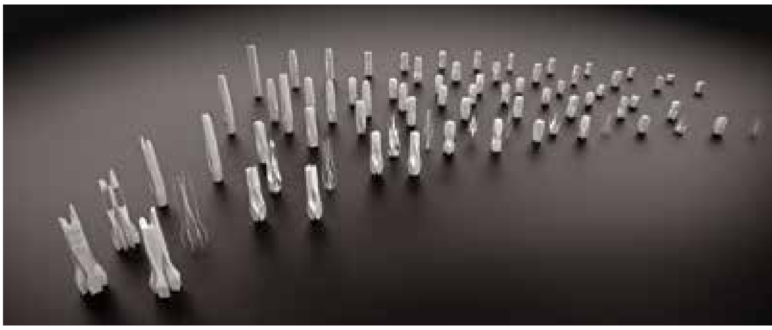

Figure 12. The parametric process generates different types and breeds.
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