

Stamatina Th. Rassia  
Panos M. Pardalos *Editors*

# Future City Architecture for Optimal Living

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 Springer

### *Editors*

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# Preface

*Future City Architecture for Optimal Living* presents a unique interdisciplinary combination of architecture, engineering, physics, and related fields in strategic planning, thinking, and designing future cities as livable urbanized environments.

Cities in the words of Geoffrey West are “the crucible of civilization.” In our belief, cities and their development can provide an impact on future ways of living as they can transform our lifestyles through a wide network of attributes. By combining together a variety of disciplines, this book presents new ideas and research practices on a variety of topics related to architecture and interdisciplinary mathematical thinking, network design, smart city development, as well as related theories for the future.

The chapters composing this book are written by eminent researchers and practitioners who offer expert opinions and hands-on international approaches to shaping future cities. Together, experts from the United Kingdom, Portugal, France, Italy, Switzerland, Netherlands, Greece, USA, Canada, Singapore, and Hong Kong present their work, experience, and new ideas. New questions are presented, such as whether cities can really be livable and how one can build sustainable systems and resilient cities to climate changes. This book offers a forum of novel ideas that are presented in a unified manner.

We would like to express our special thanks to all the authors of the chapters contributed in this book. Last but not least, we wish to acknowledge the superb assistance that the staff of Springer has provided during the preparation of this publication.

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# If Robots Conquer Airspace: The Architecture of *The Vertical City*

Jan Willmann, Fabio Gramazio, and Matthias Kohler

**Abstract** Today, more people than ever live in the metropolises of our world. The tension between the explosively growing metropolises and their satellite cities, and between these interconnected regions and the diminishing rural communities, present immense social and economic challenges that require entirely new ways of thinking about and materialising architecture if the twenty-first century's urban adventure is to succeed. And this is expressed in the most radical way in *Flight Assembled Architecture*.

**Keywords** Computational design • Digital fabrication • Airborne construction • Urban diversity • Mass-customised modularity • Architectural utopia

In *Flight Assembled Architecture* a group of quadcopters cooperatively assemble over 1,500 elements to form a complex building structure [1]. Their flight behaviour is generated by an algorithmic translation of digital design data: the quadcopters land on a platform where they pick up foam elements and then set them down precisely on top of one another (Fig. 1). An overall undulating figure emerges, whose individual layers are offset from each other, creating a geometrically differentiated outer envelope. *Flight Assembled Architecture* not only represents the world's first installation built by flying robots but simultaneously embodies a vision.

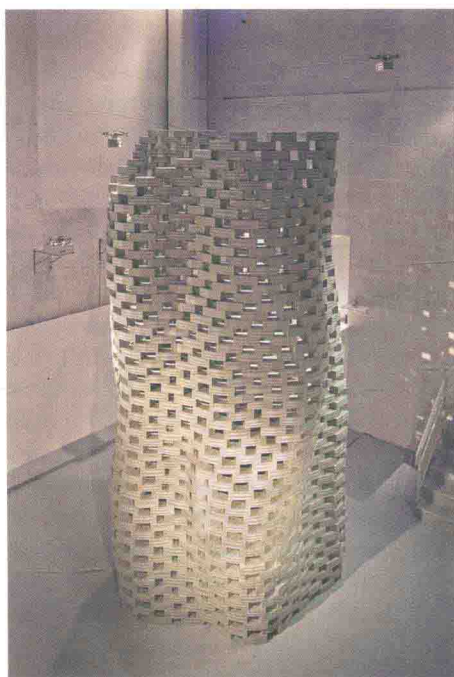
Presented at the *Regional Fund for Contemporary Art* (FRAC Centre) in Orléans, the installation is a 1:100 model of a 600 metre tall urban structure, which, with its 180 floors, possesses a total useable floor area of 1.3 million square metres—a kind of “vertical” utopia [2]. Comprised of vertical core structures and horizontal module chains, the structure is notable on two counts: its porous arrangement not only creates living space for over 30,000 inhabitants with a great variety of programmatic and urban potential but also enables a large degree of freedom for the spatial arrangement of the modules and their space-enclosing, self-stabilising formation. Here it is not the absolute height that is decisive, but rather the spatial order resulting from the structural composition (Fig. 2).

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**Fig. 1** The complex structure of the 1:100 installation has been assembled by autonomously flying “quadcopters” which land on a platform to pick up building elements and then set them down precisely on top of one another (Image by François Lauginie)



**Fig. 2** *Flight Assembled Architecture* represents the first architectural installation assembled by flying robots and was demonstrated in 2011 at the FRAC Centre, Orléans, France (Image by François Lauginie)

Overall, *Flight Assembled Architecture*, with its rationalised acquisition and treatment of data, unifies all stages of the architectural process—from the original digital design needed to the final built structure [3]. At the same time, the threshold between robotics and architecture increasingly begins to disappear, and the architectural installation becomes an expression of an architectural future utopia—a *Vertical Village*.

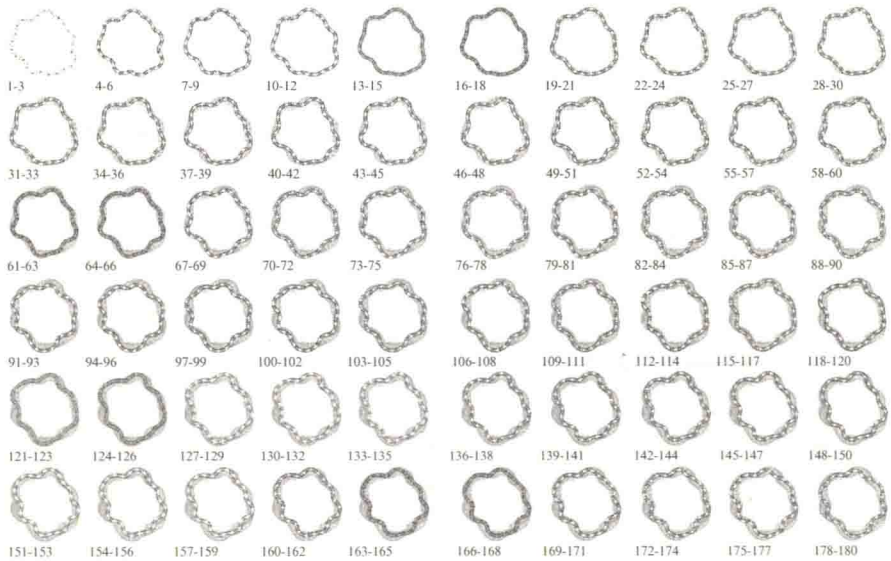
At a scale one hundred times smaller than the vision, this certainly appears to be an abstraction, but its physical significance is both real and tangible. It is this perception and the interaction of many different disciplines and potentials, which allow the project to hover between utopia and a built architectural installation, in order to design new kinds of dynamic structures for a future urbanity and to transform technological, architectural and urban design analogies into built reality [4].

## 1 How to Tilt the Grid?

*The Vertical Village* makes use of a grid-like organisation. This however does not run horizontally, as in an ideal city or a usual city grid, but is turned vertically and closed to form a circular entity. A geometric assemblage is generated that not only is the basis for the particular constructional features of the whole structure but also enables a varied urban programme: the individually positioned modules communicate with each other; the spaces in between grow and shrink and change their position and size (Fig. 3), and yet nevertheless form a unified whole.

Indeed, according to Peter Sloterdijk, for a city to be able to function and to survive in the future, a consideration of the structural form of the contemporary city is essential. He argues that urban spaces must be connected vertically as well as horizontally, in order to ultimately form multi-directional spatial relationships and with them, urban “Wohnschäume” [5]. With its network of interrelated modules, in-between spaces, and connections, *The Vertical Village* enables a decentralisation that avoids not only the point-like restriction of older settlement planning and the orthogonal and therefore laborious pathways of the modern city but also the confusing chaos that characterises almost all unregulated urban expansion today [6].

Consequently, circulation in *The Vertical Village* can remain constrained to solely pedestrian access. Inhabitants have quick and direct access to all important functions such as schools, shops, public services and leisure activities. As such, *The Vertical Village* offers a healthy and communicative urbanity of short distances and a mixture of work and living; everything remains decentralised and freely accessible. Furthermore, the high-density architecture of *The Vertical Village* offers not only a high amenity value and capacity for adaptation but an enormous economic and ecological potential as well. Simultaneously, the complete “transcendence of the grid” enables a spatial occupation and linking of new uses, functions and programmes, from which ultimately emerges a wholly new urban ontology (Fig. 4). This integrates the entire constructional morphology through to its detailed architectural articulation. In this sense, *The Vertical Village* negotiates the transition from an ideal order of a city to a



**Fig. 3** *The Vertical Village* generates a geometric assemblage that not only is the basis for the particular constructional features of the whole structure but also enables a varied urban programme on 60 individual building layers (Image by Gramazio Kohler Architects, Zurich)

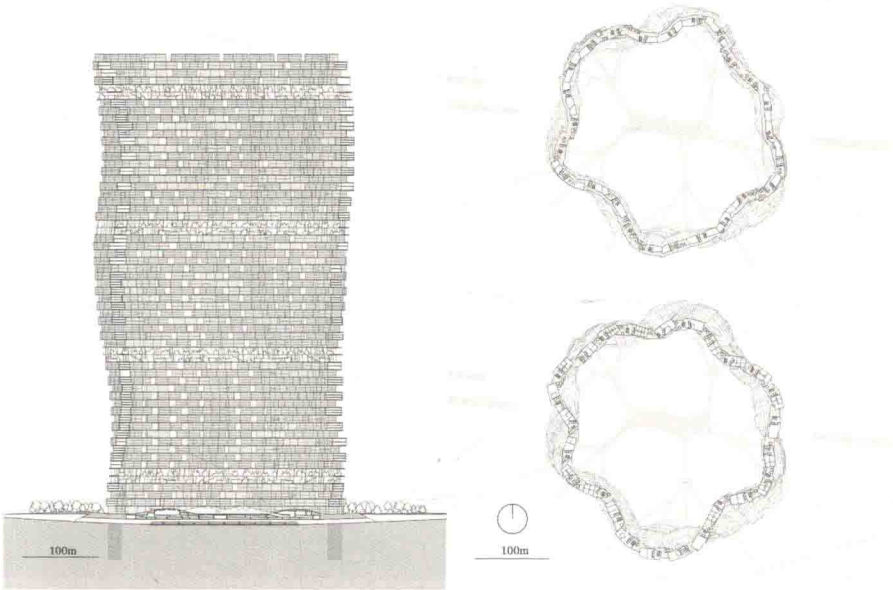
spatial differentiation—no less than a complete revision of the city’s organisational nature: the monotonous, often unbearable density of earlier eras thus becomes the engine of a newly discovered urbanity.

## 2 Understanding a Vertical Urban Landscape

The sustainable development of the twenty-first century city has long been a topic of discussion. On the one hand, in the coming decades it will be developing countries, with their rapidly growing cities, that will absorb much of the overall urban growth. On the other hand, and no less important, more than half of the world’s population will live in cities of less than 250,000 inhabitants [7]. There is no doubt that the European city faces exciting and important challenges. These tasks can no longer be tackled with old design and planning processes, or with simplified strategies of densification or of social housing [8]. It is these phenomena that form a fundamental basis for *The Vertical Village* since its adaptable size enables a shift in the form of development from a traditional city grid and rigid block structure towards a “village-like” densification of urban landscapes.

Thus the priority of this concept is in the design and practical usability of such urban landscapes, and their characteristics. Here, there are fewer collective or prestigious aims in mind, instead: liveliness and balanced social composition [9]. An “image of the city” arises, principally emerging from the individual activities of





**Fig. 4** The high-density architecture of *The Vertical Village* offers a healthy and communicative urbanity of short distances and a mixture of work and living—everything remains decentralised and freely accessible (Image by Gramazio Kohler Architects, Zurich)

its inhabitants [10]. This is possible in *The Vertical Village* because of its “porous” outer envelope, which remains recognisable as a whole despite its adaptability, and its scenic depth, which is achieved through the seamless integration of its outer surface, its construction and its contents. While traditional systems for towers, multifunctional building-types and networked towers require a defined order, in *The Vertical Village* a cohesive urbanity arises, which is formed by an intricate layering of private, semi-private and public space (Fig. 5). Within this high level of density, the various bifurcations and intricate structure allow an increased amount of diversity and “publicness” [11].

The question of the variety and accessibility of urban spaces and their contents becomes one of the central themes of *The Vertical Village*; this inasmuch as the four giant continuous public double-rings with a combined length of one kilometre, which are located not—as usual—on the lowest level, but rather spread out through the entire height of the structure, creating heterogeneous city structures [12]. The public space thus extends over the entire height. Together with the enclosed space, which with a diameter of over 300 metres is quite comparable with a river valley, this creates the possibility of an urban generosity and permeability, which treats public life, with everything it offers, less as something unified, horizontal and insular, and far more as an essential feature. For because of the sheer size and structure of *The Vertical Village*, the inhabitants and their activities are only vaguely discernable,



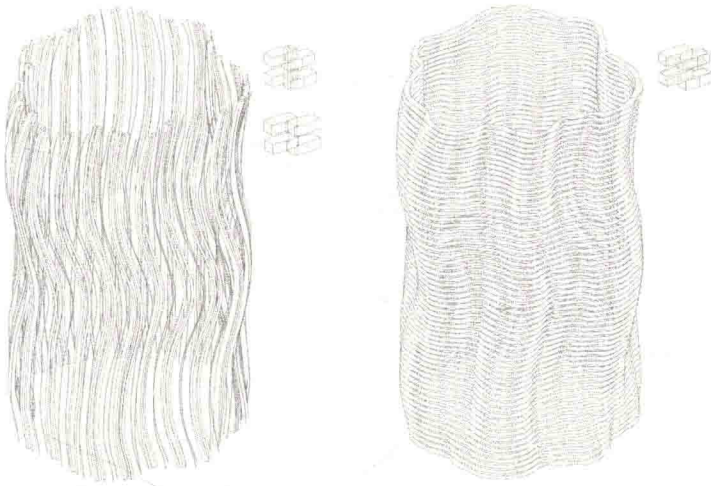
**Fig. 5** Computer rendering of the self-stabilising, porous arrangement of *The Vertical Village*, creating living space for over 30,000 inhabitants (Image by Gramazio Kohler Architects, Zurich)

whilst still maintaining a presence that enables the life and intimacy within *The Vertical Village*.

### 3 What Is the Architecture of the Supersized Modularity?

Seen against the background of the radically changing production conditions in the digital age [13], it becomes clear that the acceptance of industrialisation's serial repetition and the romantic notion of the uniqueness of handcraft are both no longer tenable in the context of this project. What is more conceivable than to transpose this new architectural framework to the scale of the city? For many places a new language of variation is already being created, whose formation allows processes instead of final forms to be designed. In these processes, different elements are assembled to form a continuous, differentiated, yet coherent whole. As *The Vertical Village* demonstrates, such processes need not be limited by their application to individual objects or prototypical building elements, but could allow a new approach to architectural criteria, relationships and degrees of freedom within an urban scale.

Prerequisite for this is a generic modularity of the individual elements (Fig. 6). In *The Vertical Village* there are up to 25 modules on each horizontal layer. They rest upon on another only near their ends: odd and even floors are offset from one another, creating an intermediate space underneath the middle of each module.



**Fig. 6** *The Vertical Village* makes use of a grid-like organisation. This however does not run horizontally, as in an ideal city or a usual city grid, but is turned vertically and closed to form a circular entity (Image by Gramazio Kohler Architects, Zurich)

Additionally, all even and odd floors are displaced in relation to each other, so that the structure gains a geometrically differentiated figure as a whole. The modules are then differentiated only internally, where they contain between one and three floors. The outer dimensions of the modules are, in contrast, unified. They are 30 metres long, 12–15 metres wide and 10 metres high. Whereas a module is traditionally defined in its function essentially as a building component or a spatial unit, something else is apparent here: the module acquires a particular variability, freed internally from any specific functionality, and is thus versatile in its actual form whilst externally remaining unified and generically deployable. The consequence for the geometry of the overall structure is a “seriality”, which externally and internally is never monotonous or repetitive, but rather differentiated and adaptable. To make this possible to construct, a special assembly process was chosen for the load-bearing structure of the module. This comprises an inner core of concrete, steel and reinforced concrete columns, and a steel framework for the floors and ceilings. A shell of complex curved glass panels—membranous, flexible and adjustable—forms the outer layer of the module. Simultaneously the modules establish their own relationships to the outside space, through which the terraces and semi-private areas can be individually adjusted and embedded within the undulating structure. From an apparently unified modulation, a principle is produced that is robust, comprehensive and versatile all at once [14]. This also shows how important insights from the construction of elements and floors can be transferred to the capacity for configuration at an urban scale [15].



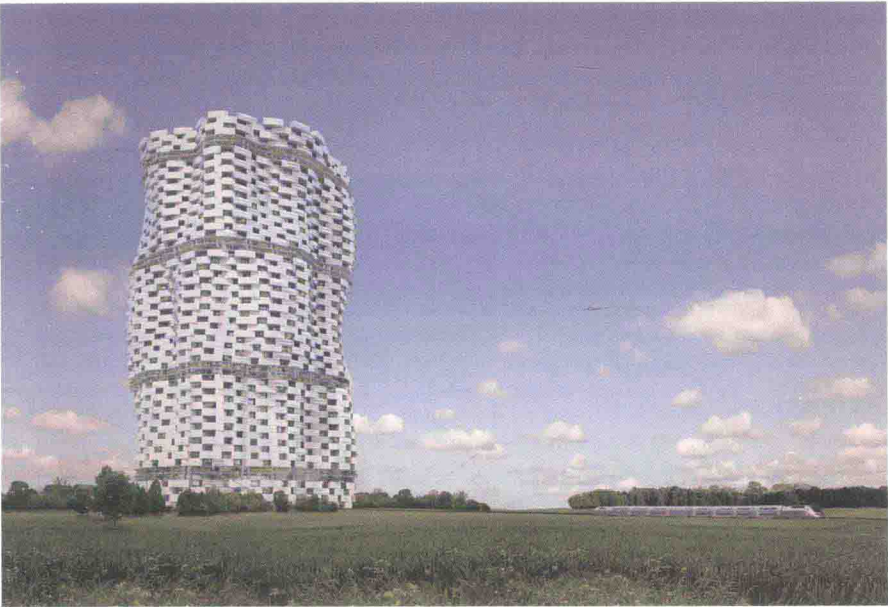
## 4 The Village as Object

Planned nature, the intermediate state of the suburbs and the resulting loss of the clarity of the city—all this today appears normal; at the same time the classic distinction between city and landscape disappears, and everything becomes blurred. What emerges instead is a suburban idea in which established and preferred cultural products, gestures and artefacts lie “somewhere in between” and simultaneously create the desire to make hybrid forms and interventions. This was the main reason to set *The Vertical Village* in the French Département of Meuse—a region that, like many other European regions, is already characterised by an exodus of the local population and should be considerably improved through politically determined structural measures. An existing TGV station that was built within the “diagonale du vide” [16], has a largely unused yet direct connection to Paris and other important destinations throughout Europe. The goal of *The Vertical Village* is therefore to activate hitherto unused potentials of the structurally weak region, and to bestow the place a new significance. It is no coincidence that *The Vertical Village* appears radical in this context, for in this the principle of independent place-making is at work: in the surreal surroundings of the region, *The Vertical Village* alone creates the potential for a new identity for the region itself.

It is surely fitting to embed the structure in the surrounding cultural landscape: the half derelict, half open landscape is both artificial and natural, and in its vastness forms a suitable setting for *The Vertical Village*. Seen in the context of its landscape—the most common view of the structure—*The Vertical Village* assumes the appearance of a large-scale sculpture that blurs and dissolves into smaller entities as one approaches. The somewhat surreal and transparent corporeality of *The Vertical Village* is therefore a kind of architectural apostrophe—an orientation within the scenic nothingness, mirrored simultaneously in higher realms of dissolved order. It is that visual unsharpness, that *Digital Materiality*, which is now being unfolded and translated at a completely different scale [17].

The bodily presence of the design is thus characterised by a distinct “aesthetic robustness”. Despite the large number of intricately organised modules, the building volume remains integrated as an object in the landscape: it is easily recognised and reveals its inherent order depending on the point from which it is viewed. Seen from the outside, the first impression of a completely vertically stacked city is suddenly graspable and reveals itself in its true scale (Fig. 7). But a great variety of impressions and perceptions are also formed from inside *The Vertical Village*. At no time does the “porous” city structure appear deterministic or monotonous. Instead, it enables the inhabitant to be “in the city”, with all its varied relationships—for wherever one is located in *The Vertical Village*, new insights and visual connections to the surroundings are continually being formed. This can be recognised not just in the texture or the outer surface of the structure, but equally in its entire sculptural depth and transparency. In this way it becomes possible to allow digital and material order to enter into a phenomenological correlation, in which they enrich one another and reflect many different layers of perception.





**Fig. 7** *The Vertical Village* contains four giant continuous public double-rings with a combined length of one kilometre, which are located not—as usual—on the lowest level, but rather spread out through the entire height of the structure, creating heterogeneous city structures (Image by Gramazio Kohler Architects, Zurich)

## 5 Utopia Reloaded?

From a contemporary standpoint, the project represents a form of utopia. Flying robots of the size and ability required to realise the project do not yet exist. Yet this captivating approach merits further material study, such as with the experiments made in *Flight Assembled Architecture*, in the hope of one day translating these ideas into built reality [18]. With this deliberately confrontational and radical city design and sculptural installation, we seek not only to develop an architectural utopia but also to generate entirely new modes of perception and comprehension. History has shown us that we often repress the new, and as such prevent the realisation of innovative, but risky ideas. Hence the urban utopia—from antiquated visions of ideal states and cities, biblical approaches and Vitruvius’ theory, and the idealised mediaeval representations of ideal cities to revolutionary architecture up until the early socialist, modernist or post-modern subversions—has a secure place in the history of the built and planned environment [19]. This surely holds true for *Flight Assembled Architecture*, for here the utopia becomes tangible, can be experienced, and expresses the transformations of an era. For when the great urban designs and models have fallen out of use, and when, through complex social and global conflicts, ideal or monolithic solutions have become obsolete, then, as