MASS–CUSTOMISED CITIES

Guest-Edited by TOM VEREBES
Automated fabrication techniques are currently largely confined to the production of discrete objects or building elements. To notch up the potential of robotics for architectural design, it is necessary to start pushing the limits and experiment at a larger urban scale.

**Fabio Gramazio and Matthias Kohler** are pioneers in this field. Here, with **Jan Willmann**, they describe the research that they are undertaking as part of the Future Cities Laboratory (FCL) located at the Singapore-ETH Centre for Global Environmental Sustainability (SECS), Singapore, 2012.

**On the left** In order to investigate and develop customised robotic processes, products and planning methods for architecture at the large scale, a unique robotic laboratory was installed at the Future Cities Laboratory in Singapore that allowed the fabrication of 1:50 scaled models of up to 50-storey high buildings.

**On the right** The design research studio was one of the first attempts to explore robotic fabrication in the context of large-scale residential tower development. In this experimental approach, through holistic digital materials methods the physical model — even in the age of computation — again gains central significance in investigations of novel building typologies in larger urban developments.
In the Second Digital Age, the employment of robotics in architecture is opening up the prospect of entirely new material capacities that will fundamentally alter architectural design and the culture of building. Architects, however, should not only focus on the technological investigation of robotic processes themselves, no matter how fascinating this might be, but also seek to establish an architectural vision through exploring the potential of robot-induced design and construction at a larger scale. Only then can the notions of the digital in architecture be significantly expanded, enabling new material dimensions to emerge, flourish and find expression.

The Robotic Foldings project, undertaken by Gramazio Kohler Research in the framework of the Future Cities Laboratory (FCL) at the Singapore-ETH Centre for Global Environmental Sustainability (SEC) and ETH Zurich, explores the architectural potential of robotic fabrication for residential tower developments. Building directly on the 2012-13 Design of Robotic Fabricated High Rises research project at FCL, Singapore, it proposes an experimental approach in which the robot directly links computational design to the automated fabrication of 1:50 physical models. Such hybrid digital-material explorations are central to overcoming not only the prevailing paradigm of repetition and mono-functionalism in larger urban developments, but also that of purely physical computational design.

As such, Robotic Foldings was conceived as a mixed-use high-rise structure created by a multitude of unique interior spatial configurations by computationally controlling the transformation and arrangements of a large number of generic elements. These were assembled through a custom robotic fabrication setup in which a multifunctional end-effector picks a paper stripe, cuts it at a predefined distance, folds it into the desired angle and then places it on the already built structure. Overall, 3,643 bespoke wall elements were amalgamated into two interwoven tectonic strata that branch and merge into a continuous overall shape in which the programmed design distributes predefined openings in sequences of shear walls to accommodate different apartment types. Each wall element specifically adjusts its folded geometry by negotiating between the required structural performance and the desired cut-out for the apartments.

The self-similarity of individual wall elements repeatedly assembled in different configurations dissolves not only the tectonic distinction between the whole and its single elements, but actually also what essentially characterises many conventional large-scale urban building typologies: the repetitive vertical addition of standard wall and floor elements. On the contrary, what remains in this project is a phenomenon that is no longer apparent in a pure object-character, but rather oscillates between the complex arrangement of elements and the resulting intermediate spaces. This ‘otherness’ takes on an
almost virtual character that stands in contrast to the scale and materiality of its constructive physi.

The Robotic Foldings project is not only exceptional in its tectonic differentiation, but also in terms of its overall development process, having been refined and physically 'versioned' over a number of design iterations. It thus turns away from the predominant representational mode of 3D-printed architecture, where the underlying constructive logic of the design is often not embedded. Programmed constructive principles are pivotal in guiding the robotic fabrication of the models. This is significant in that the architectural model has to function as a physically load-bearing artefact, and bring fabrication and structural logics into a concrete architectural aggregation.

Conversely, in this approach it is possible by means of computational design and robotic fabrication to anticipate the real-world building process through material experimentation, and thereby integrate its constructive nature into the programmed architectural design. The installation thus embodies, in an almost inevitable way, the knowledge of its own incremental building logic as well as that of its materiality.

Today, mass production at the urban scale has led to the global conformity of cities. The explorations at the SEC FCL, ETH Zurich, however, propose an alternative ontology where robotic fabrication catalyses a seminal change in the production conditions of the city, entering into a creative dialogue with industrial logics and paradigms, and thereby creating opportunities for automated diversity at new dimensions and intensities. Within such an approach, multiple mass-customised morphologies can evolve whereby robotic fabrication at an urban scale is no longer a magical thing that is going to fulfill a vision in the future, but rather a concrete approach with character and constraints and its own implications for the Jerzste, for the norm.5

Ultimately, in projects such as Robotic Foldings, the Design of Robotic Fabricated High Risers and Flight Assembled Architecture2 (which was presented in 2011 at the FRAC Centre in Orleans, France), the digitisation of architecture not only becomes physical and tangible, these explorations also take away the forced microscopic character of the digital and imbue it with a creative and critical vision for a novel material culture of the contemporary city.6

References