By Lisa Gregoire

Breaking The Mould

Fusing architecture with physics and drawing inspiration from the natural world, Arielle Blonder reimagines how we build things

Architect Arielle Blonder has a radical vision for the future of architecture — not about how we design buildings but how we fabricate the materials we build them with. And it begins with smashing the mould.

Fibreglass, a lightweight, resilient and durable composite that resists fire, water, corrosion and insects, is popular in the aerospace, automotive and construction industries. But before components can be made, money and energy must first be sunk into building a mould and shaping the product, which amounts to an estimated forty per cent of the total cost. But what if we could eliminate the one-time need for a mould and all that throwaway material and labour?

Blonder, who holds postdoctoral research positions at the Racah Institute of Physics in Jerusalem and École nationale supérieure d'architecture Paris-Malaquais, believes we can and is working across disciplinary boundaries to prove it. "Composite materials represent the present and future of architecture, or at least they offer a lot of opportunities," she says. "But they have

PHOTOGRAPH BY DACIAN GROZA

limitations which, for a large part, lie in the moulding process that turns the raw materials into shape and into service."

When people talk about composites, they typically mean fibre-reinforced polymer, or FRP, a highly versatile material that's made of a polymer matrix, usually epoxy, vinyl or polyester, and reinforced with fibres such as glass, carbon or basalt. (Fibreglass is the most common form of FRP.) Yet, despite its proven attributes, the use of FRP in architecture has been limited, mainly due to stubborn building codes, opposition to plastic production and a profession that's generally slow to adapt.

PHOTOGRAPH BY HENRIK KAN, COURTESY SFMOMA

Inspired by the water and fog of San Francisco Bay, the expanded SFMOMA's façade showcases the architectural possibilities of FRP.

But change is afoot. The new 12-storey San Francisco Museum of Modern Art, adorned with an undulating white skin, has the tallest façade ever to be clad entirely in FRP. And although the building is groundbreaking, its FRP panels still had to undergo an expensive, multi-layered moulding process.

Blonder, the first architectural PhD student at the Technion – Israel Institute of Technology to focus on material research in a thesis, which she completed in 2019 as an Azrieli Graduate Studies Fellow, is exploring new ways of forming FRP without moulds. She is hoping to transform how we imagine small-to-medium structures and exterior façades by studying the fibre part of FRP, which is usually a woven textile.

As the former CEO of American Supply Paris, which creates and customizes materials for everything from haute couture to furniture, Blonder knows fabric can morph into any shape. She calls this "fabric materiality" or FM: "the essential material qualities, attributes and design paradigms of textiles with their associated techniques and technologies of fabrication and transformation." Based on its intrinsic materiality — and with help from computer simulators, mechanical manipulation, or both — fabric impregnated with resin polymers can assume any shape, if we let it.

"When we put FRP into a mould, we don't let any textile aspect of the material be expressed because we make it into a piece of plastic," says Blonder. "When you take a piece of fabric," she continues, pinching her shirt sleeve, "you can get an incredible shape. You see folds and curvature, things that we try to do in some of our building façades and envelopes."

As an Azrieli Graduate Studies Fellow, Blonder examined how fibreglass that is pre-impregnated with resin and then gathered through pleating can form a porous laminate. After being cured in an oven, the resulting stiff, rippled panels — a variety of which were produced through multiple gathering methods — underwent tensile, compression and bending tests, both singularly and stacked together. Further testing and scaling up are required but Blonder believes these are crucial first steps toward confirming the suitability of such FRP materials in architectural façades and cladding.

Blonder's FM research helped inspire Israel's 2016 contribution to the prestigious Venice Biennale of Architecture exhibition. This project manifested two other influential forces in her work: nature and interdisciplinarity. As one of the Israeli pavilion's curators, Blonder and her colleagues designed a structure inspired by a three-dimensional scan of a bird's nest. The unique, bio-architecture installation, "LifeObject," consisted of more than 1,500 free-formed, fibreglass tubes — or "twigs" — that were combined into a porous, resilient structure. Eventually, that is. In the weeks leading up to the Biennale, the structure kept failing, despite the team's valiant efforts. Panicked, Blonder consulted Oded Rabinovitch, a structural engineering professor who is now the Senior Executive Vice President at the Technion.

"He told me — and this was surprising, coming from an engineer — listen, it won't work," recalls Blonder. "You have to stop thinking like an engineer and start thinking like a bird." In other words: control what you can, accept limitations and embrace partial randomness, like a bird building a nest, piece by piece, from found objects. So,

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Arielle Blonder (top) transcends boundaries between architecture, physics and art in projects such as “LifeObject” (previous pages and bottom), Israel’s contribution to the 2016 Venice Biennale of Architecture.

PHOTOGRAPHS BY BOAZ PERLSTEIN (TOP) AND EYAL TAGAR

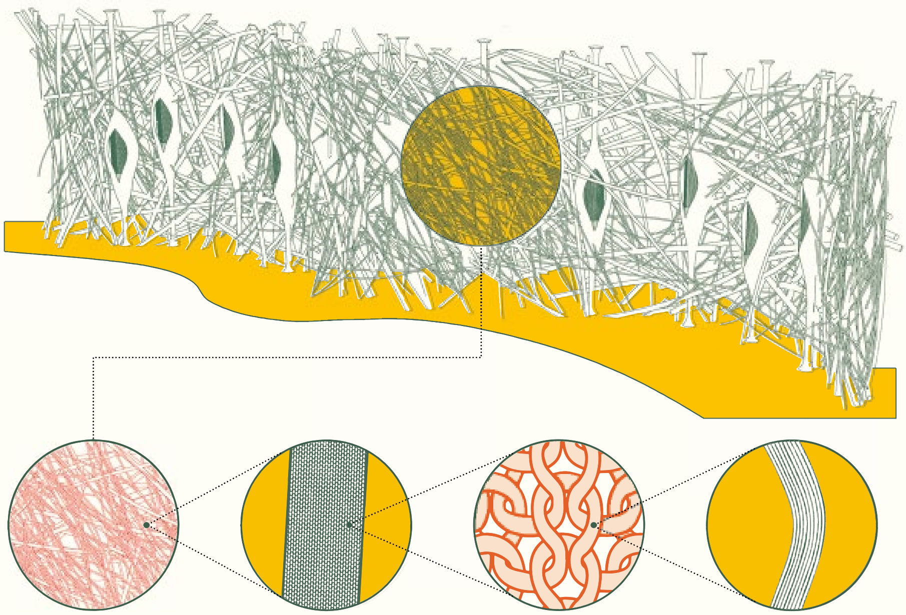

DIAGRAM BY DALBERT B. VILARINO;
SOURCE: ARIELLE BLONDER

Zooming in on one of the 1,500 fibreglass tubes used to build LifeObject, a simultaneously flexible yet solid structure.

after scanning the nest, analyzing it by algorithm and determining how many rods were needed per section to make the structure sound, Blonder's team of biologists and architects placed approximately ten per cent of the rods in fixed places and then randomly installed the rest to satisfy the density requirements. It worked.

"My biggest revelation, apart from the material, the structure and the proof of mechanics, was the understanding of the potential of partial control," she says. The bent twigs, with their inherent tension, need friction and contact points, she explains, but they are free to move, which makes the nest simultaneously flexible and solid. You couldn't live in the LifeObject, but the piece proved you could build an adaptive, resilient structure with a bunch of cheap, lightweight and randomly placed elements. LifeObject also proved that collaboration between architects and biologists was not just possible, but worthwhile. Continuing her commitment to teamwork, she's now moved on to physics.

Some people go into architecture for artistic, social or urban planning reasons. Blonder was drawn to numbers and angles, which is why, as a postdoctoral fellow, she feels comfortable in physicist Eran Sharon's lab at the Racah Institute.

Blonder first met Sharon at a design conference on the outskirts of Tel Aviv. His talk about how complex shapes form in natural elements, such as flowers, and the parallels with contemporary design prompted her to update some scientific elements of the Biennale installation when it came to Israel. Later, she met physicist Ido Levin, another Azrieli Graduate Studies Fellow, at an Azrieli Fellows Program event that brought together researchers from a range of disciplines; upon discovering that Levin had also been supervised and mentored by Sharon, she decided fate or coincidence was pushing her toward a formal partnership. Blonder brings architectural knowledge to their collaboration, building on the science of complex, self-shaping materials and applying them to her field, even if it is, at present, purely experimental and futuristic work with FRP, textiles and ceramics in her lab.

Together, they are diving deeper into FM and mould-free fabrication by exploring "frustrated materials," a term used to describe a material in which an incompatibility has been introduced. For example, if you stretch a latex membrane in opposite directions, it becomes "frustrated." Cut a V shape into it and the latex will release energy and the edges of the V will curl up to a relaxed state and create a complex shape. Blonder is examining how these principles, applied to specially designed and layered textiles and ceramics, can create unique and even predictable self-shaping morphologies. Being able to ship flat textiles or morph composites into shape on location has the potential to maximize and streamline the transportation of materials.

In a research article discussing their initial findings, Blonder and Sharon explained how traditional clay and FRP fabrication are strictly controlled to minimize shrinkage and avoid incompatibilities that could deform the

product. “Here, we harness the shrinking phenomenon and its subsequent internal stresses for the generation of complex morphologies,” they stated. A single layer of fibre composite, for instance, contracts in the direction perpendicular to fibre orientation. If you layer a composite with opposite fibre orientations, it will form a saddle-like shape when cured. Another experiment involved sandwiching a low-shrinkage ceramic between layers of higher shrinkage ceramic and cutting opposing grooves in the clay on the outer layers, which resulted in twisted ribbons after firing in an oven.

As part of their work, Blonder and Sharon are attempting to design exterior building panels using 3D software and its parametric design platform, incorporating “a simulation engine that allows the determination of the properties of a sheet in order to emulate its mechanical properties.” Digital panels are divided into smaller squares and, using surface pixelation, each square is given a particular fibre orientation. If you layer two sheets together with different fibre “maps,” the simulator predicts how the squares will contract and thus how the panel will shrink and warp once they do. This simulation can also be done in the inverse — conceiving a particular surface and then determining which fibre orientation map renders it.

Although Blonder’s research unfolds in the lab, her motivations are firmly rooted in the real world. By exploring the principles and physics of textiles and materials, she is part of a growing architectural movement pushing to transform how we design and build things. To those opposed to increasing plastic production, Blonder paints a bigger picture. FRP is efficient, resilient, durable and requires less framing and infrastructure because of its light weight — all of which could exponentially reduce costs, energy consumption and maintenance. Research into composites made from hemp and flax embedded in organic resins is also advancing and will likely proliferate as demand for FRP increases. All these things, Blonder says, will help integrate FRP into architecture in the future, both as exterior building covers and perhaps even small, lightweight, free-standing shelters.

Many of Blonder’s academic revelations have come through collaborations with colleagues in other fields — cross-pollination that picked up steam during her Azrieli fellowship, which is one of the goals of the program. She hasn’t been teaching much lately because of all her research, but if she could pass on one bit of advice to incoming architecture students, it would be to remain open and receptive to other fields of inquiry. “This is the future,” she says. “Points of convergence are where science becomes exciting and architecture becomes sensible. You have to use multiple languages and multiple approaches to be able to really suggest something valid. Not for today, for tomorrow.” ▲●■

PHOTOGRAPHS BY AMIT OFEK (TOP), COURTESY ARIELLE BLONDER (LEFT) AND SHAY BEN EPHRAIM (RIGHT)

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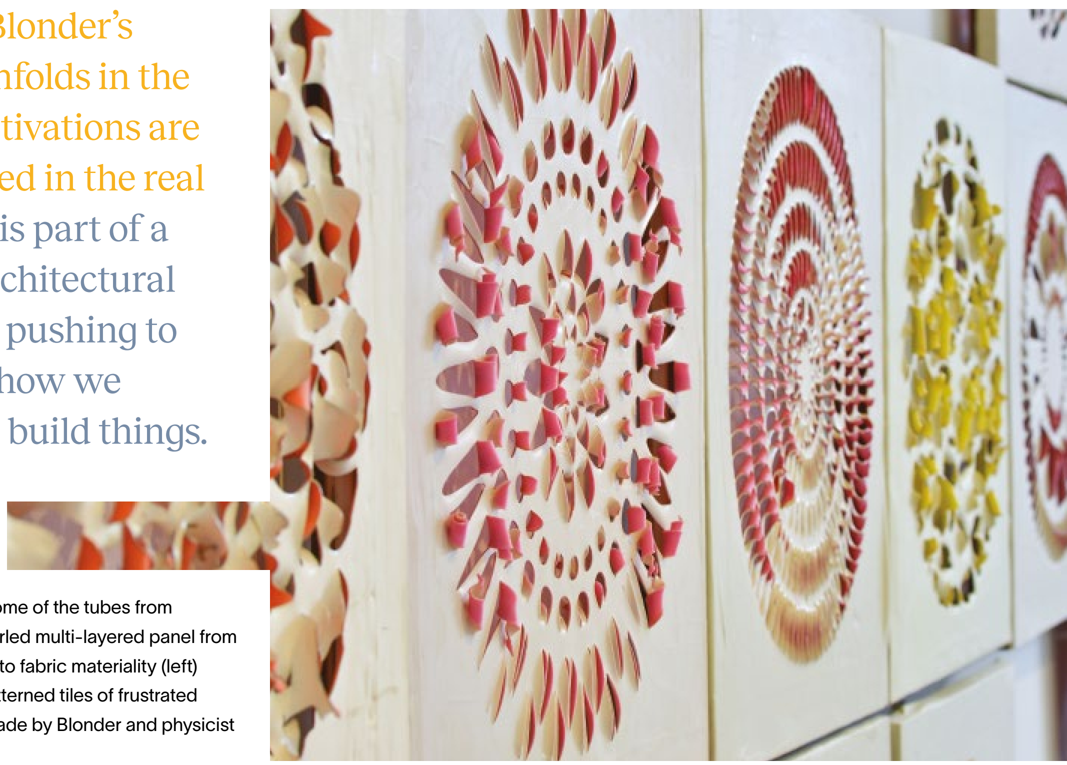

A close-up look at some of the tubes from LifeObject (top), a curled multi-layered panel from Blonder’s research into fabric materiality (left) and mandala-like patterned tiles of frustrated membranes (right) made by Blonder and physicist Eran Sharon.