

# HAVE FORMWORKS, WILL TRAVEL

To understand the design power of KnitCandela, start with a pair of suitcases.



It's not often you can carry the formworks for a 5-ton, 19-foot-tall hyperbolic paraboloid (hypars) concrete shell in a pair of suitcases.

But that's exactly what Dr. Mariana Popescu and her colleague from Switzerland's Block Research Group (BRG) carried onboard a flight from Zurich to Mexico City.

The contents of their suitcases formed the basis for an award-winning tribute to renowned Mexican-Spanish architect Felix Candela (1910–1997) called KnitCandela. The curvy, sinewy concrete shell was designed and built by BRG, Zaha Hadid Architects Code, and UK-based Architecture Extrapolated.

## WIDTH OF SWITZERLAND

"We packed 50 square meters of knitted drapes in two suitcases," explains Popescu. The fabric represents about 350 kilometers (roughly the width of Switzerland) of polyester yarn, describing a complex formwork mold the team used to build the shell over a two-week period in 2018. The Museo Universitario Arte Contemporaneo (MUAC) in Mexico City hosted the exhibit.

Popescu is an architect and Ph.D. doing post-doctoral research in the casting of double-curved geometries in concrete using 3D knitting.

Why knitting? Constructing extreme geometrical forms with concrete ordinarily requires casting molds built with timber or with milled foam supported by scaffolding. It's a time-consuming, one-off process that produces lots of waste.

## NEXT-GEN APPLICATION

"With textiles we move away from a rigid system to a flexible formwork system," says Popescu. "A flexible formwork system means there's some sort of membrane that's being tensioned to gain its 3D geometry. This can be done in various ways. It's not a new idea and has been tried throughout the last century but never gained traction because of the lack of computational design and fabrication tools."

BRG terms the next-gen, textile-based approach KnitCrete. "Knitted textiles can be made directly into 3D geometries, so it's more efficient. It minimizes the need for cutting patterns to create spatial surfacing. You can also add channels and openings without cutting, gluing, and stitching," observes Popescu. Compared to conventional weaving, knitting allows for more directional variation and better supports additional formwork elements, such as insulation, electrical components, and HVAC systems.

## BETTER CONSTRUCTION

To help turn the precisely fabricated knit into a rigid 3D shape, the fabric, the shuttering component, is supported by a load-bearing



Photo Credit: Lex Reiter



Photo Credit: Mariana Popescu



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cable net. The fabric is coated with a specially formulated cement paste.

In many respects, the precise off-site nature of the KnitCrete process resembles modular construction. The net result is a complex formworks mold that drastically reduces the need for field effort and uncertainty, which vastly simplifies logistics.

## HOLD YOUR BREATH

With so much of the formworks meticulously choreographed 9,677 miles away in Zurich, was there anything left to surprise or delight in the MUAC courtyard? After all, this was the first time BRG used knitted textiles at an architectural scale.

"We had no doubts about the science and computations behind the formworks," Popescu

says. "Even so, you're not quite sure how it will all work until you're standing there in front of it. You hold your breath. Wow, this is happening. There's no way this isn't happening," she smiles.

## HIGH PERFORMANCE OUTCOME

KnitCandela was an immediate sensation, earning a half-dozen notable awards and distinctions. How should architects understand the larger lessons of KnitCandela?

Consider a Formula 1 car race, Popescu advises. You won't find Formula 1 racers in city traffic. But the innovations used to create high-performance motor vehicles often find their way into mainstream design and manufacturing. Likewise with KnitCandela. The proven techniques used to realize sophisticated

geometries in concrete now have far broader possibilities in residential and commercial design.

And are simple enough to carry in a suitcase.

To learn more, visit [BuildwithStrength.com](https://www.buildwithstrength.com).

**Design:** ZHCODE: Filippo Nassetti, David Reeves, Marko Margeta, Shajay Bhooshan, Patrik Schumacher, BRG: Mariana Popescu, Matthias Rippmann, Tom Van Mele, Philippe Block

**KnitCrete Technology:** BRG: Mariana Popescu, Tom Van Mele, Philippe Block; Chair of Physical Chemistry of Building Materials, ETH Zurich: Lex Reiter, Robert Flatt

**Fabrication and Construction:** BRG: Mariana Popescu, Matthias Rippmann, Alessandro Dell'Endice, Cristian Calvo Barentin, Nora Ravanidou; R-Ex: Alicia Nahmad Vazquez, Horacio Bibiano Vargas, Jose Manuel Diaz Sanchez, Asunción Zúñiga, Agustín Lozano Álvarez, Miguel Juárez Antonio, Filiberto Juárez Antonio, Daniel Piña, Daniel Celin, Carlos Axel Pérez Cano, José Luis Naranjo Olivares, Everardo Hernández, Ramiro Tena



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