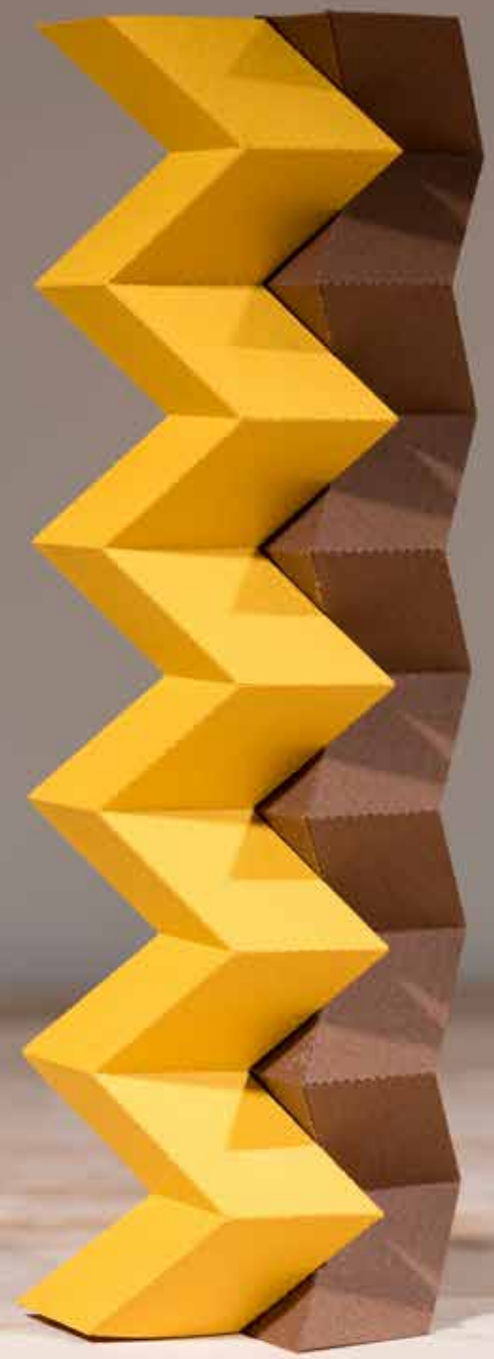


Two structures paired in the "zippered tube" configuration are stiff enough to hold weight, yet can return to their flat states for easy shipping or storage.

INTO THE FOLD

ORIGAMI ADDS A NEW WRINKLE TO THE CREATION OF STURDY STRUCTURES

4 The two tubes are put together so that they are both interlocking and deployable.

3 The tubes are individually folded out into three dimensions before they are paired into one structure.

2 Each tube is made of two zig-zag folded pieces of paper glued together to make a single tube.

1 The tubes start as flat structures, and can return to that state easily.

ROB FELT

From shipping and construction to outer space, origami could put a folded twist on structural engineering.

Researchers from Georgia Tech, the University of Illinois at Urbana-Champaign, and the University of Tokyo have developed a new "zippered tube" origami configuration that makes paper structures stiff enough to hold weight yet able to fold flat for easy shipping and storage. Their method could be applied to other thin materials, such as plastic or metal, to transform structures ranging from furniture and buildings to microscopic robots.

Origami structures would be useful in many engineering applications, such as robotic arms that could reach out, construction cranes able to fold to pick up or deliver a load, and pop-up furniture. Glaucio Paulino, a professor in Georgia Tech's School of Civil and Environmental Engineering, sees particular potential for quick-assembling emergency shelters, bridges, and other infrastructure in the wake of natural disasters.

"The geometry is what really plays a role," Paulino said. "We are putting two tubes together in a strange way. What we want is a structure that is flexible and stiff at the same time. This is just paper, but it has tremendous stiffness."

The researchers use a particular origami technique called Miura-ori folding. They make precise, zig-zag folded strips of paper, then glue two strips together to make a tube. While the single strip of paper is highly flexible, the tube is stiffer and does not fold in as many directions.

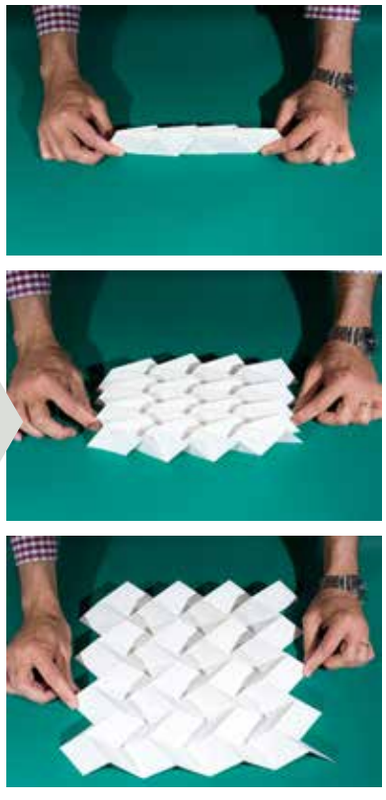
"Origami became more of an objective for engineering and a science just in the past five years or so," said Evgueni Filipov, a graduate student from the University of Illinois. "A lot of it was driven by space exploration, to be able to launch structures compactly and deploy them in space. But we're starting to see how it has potential for a lot of different fields of engineering. You could prefabricate something in a factory, ship it compactly, and deploy it on site."

MIURA-ORI

The "zippered tube" configuration is based on Miura-ori, a folding technique that allows flat, foldable surfaces to be expanded rapidly and easily. It was named for Japanese astrophysicist Koryo Miura, who was studying the configuration of solar panels for spaceflight, while working at NASA.

The researchers tried coupling tubes in different configurations to see if that added to the structural stiffness of the paper structures. They found that interlocking two tubes in zipper-like fashion made them much stiffer and harder to twist or bend. The structure folds up flat, yet rapidly and easily expands to the rigid tube configuration.

The work, supported by the National Science Foundation, was reported in the journal *Proceedings of the National Academy of Sciences*. — LIZ AHLBERG, UNIVERSITY OF ILLINOIS



A comparison between the second and third figures shows that the material exhibits a negative Poisson's ratio – meaning it dilates when stretched.