

The Rigors of Sensation

By David Ruy

The unexpected sight of a simple stainless steel chain standing upright from the floor is your introduction to the structural magic performed regularly by ARUP's Advanced Geometry Unit. Aluminum leaves float in this labyrinth—enigmatic modules aligned in an inscrutable suspension. As you move through the trench and pause in the cave, you will be tempted to touch the chain when no one is looking—you will be curious how it works. You may sense that the tension in the chain might be the key to understanding its perplexing rigidity. The poise of that sensation is the beginning. Soon you will feel compelled to move on and let more of the fuzzy order unfold in this curious metallic hedge maze.

Since the AGU was founded in 2000 by Cecil Balmond, one of the great structural engineers of our time, this remarkable group of engineers, architects, mathematicians, and scientists has been conducting an astonishing series of experiments studying some of the most advanced topics today in mathematics and science, probing their applications and consequences for building. This installation at Artists Space is their latest experiment, and it raises provocative questions for architecture, art, and engineering. As the idealities of Euclidean Space and the instruments of Newtonian Mechanics finally unravel (the death knell has tolled throughout the twentieth century), what idealities and instrumentalities will emerge in its place? From art installations to bridges, and from buildings to urban plans, the experimentation is far reaching and examines some of the most difficult and inspiring insights of contemporary mathematics and science. Though it may seem at first a technical inquiry into design technologies, the AGU's project is more dangerous. The relevance of the project is realized when notice is given that mathematics and science is not a grab bag of miscellaneous technological powers but ultimately propositions about the world we are in. The world that is delivered and reinforced through what we build is the high stakes

game at the heart of the inquiry. It is an inquiry into the deep structures of material formation and the degree to which we can participate in them as designers.

Collaborating with the AGU on this exhibition is the promising young architect Jenny Sabin as well as students of the University of Pennsylvania School of Design (PennDesign). Their interaction is a vital subtext to this exhibition. The AGU's link to PennDesign is a unique partnership in this context, and sets an interesting precedent for the future of architectural design research. Included in the exhibition is Jenny Sabin's *Fourier Carpet*. Using the Fourier series as an unexpected calculus of affects, Sabin's research transforms the technical instruments of harmonic analysis into a surprisingly alluring ornamentation engine. It is particularly interesting that the weave is executed on a Jacquard loom—one of the first machines to incorporate the concept of stored memory and an important precursor to the modern computer. Together, *H_edge* and *Fourier Carpet* probe the potentials of new geometries, new models of material formation, and most importantly, the possibilities of new sensations in our time.

More Than a Surface, Less Than a Volume

H_edge was configured using a Menger Sponge as a model. This is worth a closer look. The Menger Sponge is one of the most enigmatic constructions in mathematics, and reveals some important aspects of the AGU's way of working. The Menger Sponge is a fractal. A quick Google search on fractals will yield a perplexing but provocative harvest of proofs and conjectures about this concept. Everything from broccoli to coastlines to the structure of space-time itself has been conjectured as a fractal-like phenomenon, but how it is being used by the designer is the topic we're interested in here. But first, how do you construct a Menger Sponge?

Let's start with Cantor Dust, discovered and named after the mathematician Georg Cantor in the late nineteenth century. Take a metal wire of any length. Cut the wire into three equal parts then remove the middle third. You have two wires now. Cut each of them into

three equal parts and again, remove the middle thirds. You now have four wires. Let's suppose you have an infinitely small knife and that you repeat this process infinitely many times—what you'll have left in the end is the Cantor Dust. You will have an infinite number of Cantor Dust particles since we have cut it an infinite number of times. However, you have also removed by the end, a length equal to the original length of wire! Technically speaking, the Cantor Dust is more than a point but less than a line—it has a fractional dimensionality, approximately 0.6309 if you're curious (a point having a dimension of 0 and a line having a dimension of 1).

Now imagine a similar operation, starting with a metal sheet. Similar to what you did before with the wire, cut the sheet into an equal 9 square grid, and remove the middle square. Do the same with each of the remaining squares, and repeat. After you do this infinitely many times, you have made the Sierpinski Carpet—more than a line but less than a plane with a dimension of approximately 1.8928. Finally, the Menger Sponge. Start with a metal cube. Cut it into 27 equal cubes (imagine a Rubik's cube). Remove the center cubes from each of the six faces and the center cube of the whole. And again, repeat infinitely many times with each of the remaining cubes. You'll have left at the end the Menger Sponge—more than a plane but less than a volume with a dimension of approximately 2.726833. The Cantor Dust has no countable length; the Sierpinski Carpet has no countable area; the Menger Sponge has no countable volume. If you investigate further, you will discover that the Cantor Dust, the Sierpinski Carpet, and the Menger Sponge, have startling associations with the modeling of complex physical phenomena (Brownian motion for example). This strange foamy construction that hovers between dimensions, yielding unexpected associations with the life of matter, is the geometric model for the construction of *H_{edge}*.

Do we use this strange foamy construction with a fractional dimension like a new architectural material? Is it a device for organizing space? Do we deploy it as a representation of a mathematical ideal, like a new Platonic form? For instead of the idealities of the perfect square and the perfect cube, we have the Sierpinski Carpet and Menger Sponge? These are some of the interesting questions raised by *H_{edge}*.

Despite the enigmatic properties of the Menger Sponge, the designers of *H_edge* speak of design considerations very practically. They emphasize considerations such as movement through the gallery space, the occupation of this given space, the dissolution of the object, the pragmatics of cutting with a laser 5200 aluminum patterns, and the pre-tensioning of the chain. It is also striking that this practical mindset applies to assessing the potentials of the Menger Sponge. AGU pointed out that other models could have been used, but that the Menger Sponge was particularly useful to the given problems of this installation. This practical outlook engages the rigors of the research in order to cultivate sensations in the work. In *H_edge*, the mathematical concept of the Menger Sponge is not interesting in and of itself, and there is little interest in merely building a mathematical object. The enigma of this fractional foam only becomes interesting for its unique affects. We can return to the Menger Sponge and ask, "How does a construction of 2.726833 dimensions make you feel?"

The *H_edge* Maze

In some of the great Gothic cathedrals, you will find labyrinths inscribed on the floor. A curiosity today, in its time these labyrinths were significant features of the cathedrals and were meant to be walked and experienced. As you meander through the circuitous path and your attention slowly focuses on the journey to the rosetta at the center, your mind is freed from distraction and is primed for the disclosures of the cathedral. The famous labyrinth at Chartres is organized in four quadrants and inscribed in a perfect circle. Though there are many interpretations of the symbolism in this geometric pattern, nothing is recorded as to exactly what the pattern represents. However, it is fascinating that these labyrinths are meant to be experienced. They are instruments for bundling and delivering sensations. The Chartres labyrinth is drawn through an ingeniously simple algorithm that packs and circumscribes a continuous line about a center—it is a geometry engine that generates a pattern and operates with an impersonal precision. Like most mathematical constructions, the pattern holds no content, no meaning. Still, the fecundity of the pattern allows a projection of multiple narratives, some intended, some not, but all narratives are

somehow immanent to the pattern. The consistency and precision of the engine's operation allows spatial order and structure to emerge, but these are the side effects. It is the afterglow that is of greatest value.

The unusual descriptions of this metallic hedge maze direct attention to its afterglow. The leaves are grown; the sponge is eroded; a path is drawn, a trench is cut, a cave is formed. The load paths bundle sensations and deliver it through movement. The designers of *H_edge* process numbers, pretension steel chains, and cut aluminum with a concentrated beam of light. They draw outputs from a feral geometry engine, and cultivate moments of poise in the impersonal flow of data.