The Penrose Tiling at Miami University

by David Kullman

In September, 1976, Miami University held its Fourth Annual Mathematics and Statistics Conference. The theme that year was Recreational Mathematics and among the featured speakers were John Conway, Elwyn Berlekamp, David Klarner, Doris Schattschneider, Leon Bankoff, and Wolfgang Haken. Conway had just published his book, *On Numbers and Games*, and Haken had announced a computer-assisted proof of the Four Color Theorem only a month earlier. On the spur of the moment, to fill in for a speaker who had cancelled at the last minute, Conway offered to give a talk about "Penrose's Puzzle Pieces." (He just happened to have some transparencies with him.)

This was the first time that most of us in the audience had heard about this intriguing set of two tiles, kites and darts, that tile the plane only *nonperiodically*. That is, no region of the tiling will tile by means of translations alone. The following January, Martin Gardner, in his "Mathematical Games" column in *Scientific American* presented "for the first time" a description of the Penrose tiles, including many of Conway's results concerning them.

Meanwhile Bachelor Hall, which would become the new home of Miami's Department of Mathematics and Statistics, was still on the drawing board. Although we would share the facility with the departments of English and Communication, some of the mathematics faculty hoped that the design would include something uniquely mathematical. Milton Cox (who would become Chairman of the MAA Ohio Section ten years later) proposed to the University administration that a Penrose tiling would be a fitting decoration for the Bachelor Hall courtyard. After seeing the article in *Scientific American*, the vice president who oversaw the building projects and the architect agreed. Milt was appointed to come up with a specific design. (Perhaps it is more than coincidence that Milt's middle name is Dart and that he had an aunt whose last name was Kite.)

The way Milt tells the story, he took the magazine article, some outlines of Penrose tilings, and his daughter's colored pencils with him on a trip to Boston, where he examined the tilings in the Massachusetts Statehouse. He decided that Penrose's cartwheel design was the most interesting, and he chose the colors of wedgewood blue, cream, red, and white to complement the red brick exterior of the building.

The architect selected terrazzo, which is made by embedding small chips of marble or granite in mortar and then polishing the surface after it has dried, as the tiling medium. A brass framework was fabricated in the outline of the tiling, and the colored tiles were poured individually.

Work on the terrazzo began in the summer of 1979, while both Milt and our department chair, Elwood Bohn, were on vacation. When they returned, it was discovered that the brass frame had been rotated 90° so that the tiling's axis of symmetry did not coincide with the axis of symmetry of the building.

Work was immediately stopped while the powers that be scratched their heads. One idea that was rejected was to rotate the building 90 degrees. Fortunately, only about 25% of the tiles had actually been poured, so it was decided to chisel them out and start over, with the frame properly oriented. Only a couple of days' work were lost in the process.

Another minor flaw developed when a drain had to be installed in the very center of the tiling, to help carry rain water out of the courtyard. Here is an example of the beauty of pure mathematics having to be tempered by constraints of the real world.

Bachelor hall was dedicated in the fall of 1979, and the Penrose tiling has been a focal point ever since. Its overall diameter is approximately 22 feet, with individual tiles measuring 10.5 by 17 inches. Every semester students can be seen measuring the tiles or sketching the design as part of some class assignment in mathematics, art, or architecture. We believe that this was the first Penrose tiling to be incorporated in the design of a public building and it may still be the only one

executed in terrazzo. (In 1993 another cartwheel Penrose tiling, 15 feet in diameter, was constructed of ceramic tiles at Carleton college in Northfield, MN.)

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