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Tooling up FOR GROWTH

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Diamond cluster forming tools

make exterior panels shine

Transbay Transit Center wraparound showcases punched crystalline pattern

The San Francisco Transbay Transit Center is a massive $2 billion project comprising a ground-floor arcade, second-level bus terminal, and rooftop park. Designed by Pelli Clarke Pelli Architects, its quarter-mile-long, wraparound exterior features a vast crystalline screen that acts as an aluminum awning with the appearance of an original sculpture. The 132,000-square-foot screen—fabricated of 4,486 conjoined panels, each averaging 65 by 72 inches—encircles the entire 4-city-block building (see **Figure 1**).

To achieve an inviting, light-emitting finish throughout this exterior panel structure, Architectural Systems Inc. fabricated a geometric pattern, punched into the aluminum panels using forming tools supplied by Mate Precision Tooling. With 37 percent of the panels open, the hole design allows natural light and air to penetrate the building interior.

The Science of Pattern

"The exterior panel hole pattern has serious academic credentials," said Michael Graves of Architectural Systems Inc. "Known as 'Penrose tiling,' the hole pattern is based on an algorithm discovered by Dr. Roger Penrose, an Oxford mathematician, physicist, and British knight. The pattern is a fivefold aperiodic tiling or quasi-crystalline arrangement previously thought to be impossible.

"Dr. Penrose was able to show that it was in fact mathematically possible," Graves continued. "His pattern gives the illusion of symmetry while deviating from exact symmetry by an arbitrarily small amount. The resulting pattern is unique in that it never repeats, regardless of the surface area over which it is extended" (see **Figure 2**).

Architectural Systems was equipped to handle such a large task because of its past work with panel and curtain wall projects on buildings such as Millennium Tower in New York; Mandarin Oriental Hotel in Boston; and Winnie Palmer Hospital, Orlando, Fla. The fabricator's equipment lineup includes turret punch machines, CNC machining centers, CNC routers (with cutting surfaces up to 96 in. by 372 in.), finishing lines (able to handle up to 36-ft.-long material), curving operations (both roll and stretch forming), folders, and press brakes.

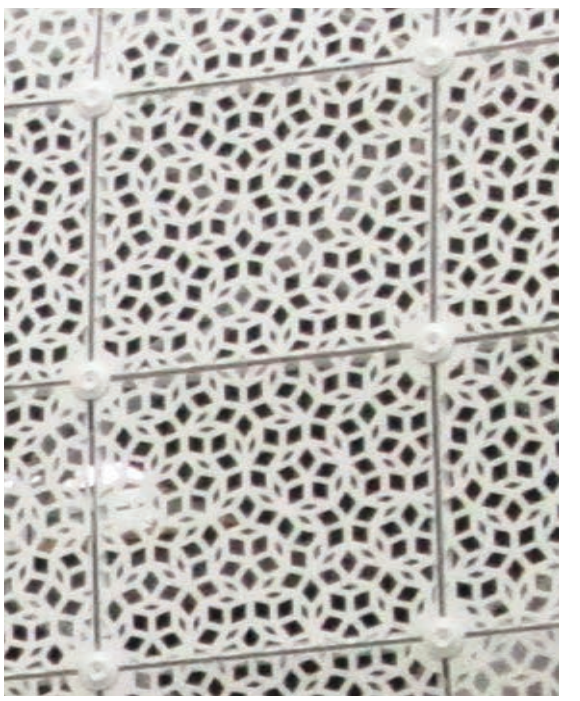

Figure 1
Transbay Transit Center in San Francisco features a light-emitting exterior panel structure punched into aluminum panels using special forming tools. The hole pattern required angular orientation for visual symmetry, with each hole having smooth, burr-free edges.

The Role of Tooling

"Our four Murata Wiedemann 4560 turret presses, using Mate's diamond cluster tools in particular, are uniquely suited for fabricating the Penrose tiling pattern," Graves explained. "This is true because the presses are robust yet simple in design. They have the speed and accuracy so that an individual rhombus can be located and oriented both in the punch programming and in the punching of the hole pattern itself."

Figure 2
Michael Graves (right) and Craig Stephens (left) managed the massive fabricating project for Architectural Systems Inc. Pictured in the foreground is one of the forming tools used to punch the panel hole patterns shown beneath the tools.

The tooling was critical, because any deviation in the angular orientation of the rhombus perforations would cause the pattern to become visually asymmetrical.

"After punching, the entire panel surface [was] coated in an ultrahigh-metallic Kynar® paint coating to achieve a burr-free punched edge so the paint [dried] smoothly," said Graves. "It was critical that the shear edge inside each punch was free from any defects throughout the punching cycle. We needed the punched edges to allow the metallic paint flake to lay as smoothly and uniformly as possible over the entire face of the panels. The Mate tools achieved that.

"One of the key features of the diamond cluster forming tooling is the tool's extreme degree of orientation accuracy," Graves continued. "The precision of the machined punch and die's cutting edges, along with Mate's engineering expertise in the design of the rooftop shear face of the punch, allowed us to meet the required angular orientation of the panel perforations while maintaining their visual symmetry. That allowed us to meet both of those challenges and exceed design expectations on the project."

Figure 3
Finished panels were positioned using large cranes. Each panel measures 65 by 72 in.

Panel Production Parameters

Each of the 4,486 panels was punched from ¼-in. aluminum plate on presses with 36-toolstation capacity (see **Figure 3**).

Each panel rhombus punchout required four hits per second, with each punch press producing five completed panels per hour. Minor secondary machining operations followed punching, along with finishing, folding return legs, pretreating, painting, and packaging. Total production time per panel was about two hours.

"Edge quality after punching was burr-free and required no cleanup," explained Graves. "The design of the tools and the staggered punch order dictated by our programmers resulted in finished panels with no measurable deviation in flatness from the original raw aluminum plate. That was important both from an appearance standpoint and for easy panel assembly at the Transbay site.

"When installed, the overall crystalline screen façade really is breathtakingly different," Graves concluded. "The entire project went forward very smoothly without downtime or scrap." **FAB**

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Mate Precision Tooling, 800-328-4492, www.mate.com