Built in 1980, the concrete building at 55 York Boulevard in downtown Hamilton was created to house both the city’s historic farmers market as well as its central library. However, after 30 years of hustle and bustle, it was ready for a facelift.

The focal point of an extensive redesign by David Premi Architects and Rounthwaite Dick and Hadley Architects (RDH) is a sweeping glass curtain wall that wraps around both the library and farmers market. However, Premi and the RDH design team desired more than just a glass wall—they wanted something striking that would add movement and depth to the façade while fostering a sense of connection between the street and the interiors.

After exploring various coatings and films, Scott Richards of Ferguson Neudorf Glass, the project’s glazing contractor, suggested a new twist on a popular glazing treatment—silkscreened ceramic frit on two surfaces of the curtain wall.

Silkscreening on glass is not a new technology; it has been used for decades as a means of applying a design to one surface of an insulating glass (IG) unit. However, new ways of thinking have created new design possibilities for this popular medium.

Recently, in projects such as the Hamilton Public Library and Farmers Market, architects have begun exploring placing silkscreen patterns on two surfaces of IG units. However, while this new way of thinking offers exciting visual and performance benefits, it must be thoughtfully used to prevent distracting esthetic issues.

**Back to basics**

Silkscreen printing on glass has been available in the architectural market for more than 20 years. To create a silkscreened pattern, ceramic-based paint—also known as frit—is applied to the glazing. This is done by pressing paint through a mesh fabric screen, which has been cut out to form the desired pattern. After application, the paint is fired to the glass by running the painted glass through a heat-treating furnace at approximately 590 C (1100 F). Once the firing is complete, the ceramic paint is essentially part of the glass.
An IG unit has two plies of glass, for a total of four surfaces (Figure 1). For solar control, the silkscreen pattern is typically placed on the second surface along with the low-emissivity (low-e) coating. The silkscreen pattern is applied first, and then the low-e coating over that. This combination offers optimal performance by placing both the silkscreen and coating on the surface closest to the sun. While it is possible to place the silkscreen pattern on the third surface with a low-e coating on the second surface, this configuration will block less heat than placing both on the second surface (Figure 2).

In addition to solar control, silkscreen patterns can be used as a means to reduce glare. Glare is any type of light interfering with visual perception. It can be direct, such as from the sun, or reflected from surfaces, such as computer screens. Exterior glazing controls light coming into a space and, therefore, is a component in glare control.

High light-transmitting glass is often specified to provide a view into a building from the exterior. While this can enhance the exterior façade, it can cause glare concerns for the building’s occupants. Whenever glazing allows 50 per cent or more of the visible portion of the spectrum into a building, the possibility for glare is increased. Adding a silkscreen pattern reduces visible light transmittance, reducing this potential.

As silkscreen patterns have increased in popularity for these functional purposes, their use as a design element has also increased. The esthetic options to be explored with silkscreening are nearly endless. Patterns can be customized using anything from repetitive designs over an entire piece of glass to a single element on just a portion of the glass.

Colours can also be chosen with most glass fabricators as they offer standard and custom ceramic frit colours. As architects seek ways to push design to the next level, playing with the silkscreen pattern has become increasingly frequent. When deciding whether to place the pattern on the second or third surface, it is becoming typical for the debate to question why both are not used.

**Dual surface design misconceptions**

Placing a pattern on the second and third surfaces can sound like an appealing means of enhancing esthetics. Designers often envision adding ‘depth’ to a building’s surface by playing with patterns on two separate planes in the glazing unit. As with any design element, appropriate dual design patterns can enhance overall building esthetics. However, when used improperly, dual surface designs can significantly decrease the façade’s visual appeal.

Moiré pattern

When a silkscreen pattern is applied to glass, there is a potential to see a moiré pattern. This is an optical phenomenon, appearing as a ‘wavy,’ ‘rippled,’ or ‘circular’ pattern. It is not a defect in the glass or the silkscreening, but rather an image formed by the eye; it may appear or disappear as lighting conditions change. A moiré pattern is produced when two regularly spaced patterns, one in front of the other, are slightly offset from each other, creating interference.

Moiré patterns may appear in various designs; however, there are specific configurations known to increase the potential of seeing them. Two patterns lining up with each other are almost always guaranteed to create a moiré pattern. For example, placing 3.2-mm (1⁄8-in.) dots on the second surface and 3.2-mm holes on the third surface increase the chance of moiré patterns. The possibility of seeing this is also

**Figure 1**

An insulating glass (IG) unit has two plies of glass with four total surfaces.

**Figure 2**

Changing the surface of the silkscreen pattern will impact its solar performance.

**Figure 3**

A moiré pattern may appear or disappear as lighting changes.
increased when the same colour of ceramic frit is specified for both designs, when closely spaced patterns are used, or when a high-light-transmitting glass and coating are employed.

As evidenced in Figure 3, moiré patterns are not consistent, and their appearance will change under varying light conditions. To avoid potential problems, it is critical to carefully review the patterns and colours selected, and the location of the patterns on the glass unit. Since the designs may appear under some lighting conditions and not others, it is extremely important to view a mockup of any dual surface pattern, preferably onsite under the same lighting conditions as will be seen on the completed project.

**Adding texture and solar control**

When used correctly, the outcome of a dual silkscreen pattern can be quite striking and highly functional. At the Hamilton Library (Figure 4) and Farmers Market (Figure 5), Premi and Robert Goyeche at RDH envisioned the glass curtain wall as a way to establish a visual connection between the building’s interior and exterior, but they wanted the glass to have a ‘veil effect.’

“By putting lines of different widths on both the second and third surfaces, we were able to vary the density, rhythm, and cadence from the street,” Premi said. “This creates the illusion of movement and depth.”

An opaque white line pattern was used on the second and third surfaces of the insulating glass units. The lines, varying in thickness from 6.4 to 19 mm (¼ to ¾ in.) were placed in a random pattern across the curtain wall façade.

“By adding frit to both surfaces, we were able to create a three-dimensional effect that you don’t usually see on buildings with just one surface,” said Goyeche. “The treatment gives the flat glass a great deal of texture and visual interest. The result is a curtain wall that gives these two venerable institutions a new contemporary face and raises their visual profile.”

Since most of the curtain wall faces north, solar heat gain was not a primary concern along this façade. A low-e coating, combined with the dual surface silkscreen pattern, provides ample solar protection for the north-facing segments. However, the south façade protects the library’s computer area so solar heat gain presented a greater challenge there. To combat the heat and potential glare concern, the design team widened the lines to increase the overall percentage of glass covered by the silkscreen pattern in that area, thus offering the same unique ‘veil’ esthetic with higher performance where needed.

One of the keys to this—and most successful dual-surface silkscreen projects—is the random pattern. When working with dual patterns, random is better than repetitive. If designers are thinking about how the design is going to ‘line up’ between the two panes, it is likely not the right one to be using on two surfaces. The silkscreen manufacturing process does not allow for exact alignment. If the pattern is off even 0.8 mm (¼ in.), it will no longer line up, the intended appearance will not be achieved, and the potential to see a moiré pattern is significant.

**Colour options**

Historically, most silkscreen patterns were dots or lines applied with a white or grey ceramic fit. This was because the ultimate goal of a silkscreen pattern was traditionally to improve solar control. As silkscreen has become more of a design element, it has become common to look at enhancing the design with coloured ceramic frit in addition to unique patterns. The standard colours available include both opaque and translucent ones such as green, blue, and yellow.
The Populous headquarters building in Kansas City, Mo., combines dual-surface silkscreen with two different ceramic frit colours with great success (Figure 6). The top and bottom of the building's floor-to-ceiling glazing features a random pattern of 'square doughnuts' on both the second and third surface of the insulating units. In addition to the random pattern, the architect selected two different translucent ceramic frit colours to add greater visual interest. One of the colours simulates a sandblasted pattern and the other simulates an acid-etched design.

**Custom possibilities**

While fabricators offer multiple standard silkscreen patterns, these are often limited to lines or dots. When standard patterns do not achieve the desired visual impact, custom patterns can be created. The silkscreening process allows for a great deal of flexibility in design, and virtually any shape can be created.

However, there are a few restrictions with the type of artwork and how the shape is created. The process is limited to a black-and-white format—no grey-scale or halftones. When designing a custom pattern, it is recommended all pixels, lines, dots, or spaces are at least 1.6 mm (1/16 in.) thick to ensure a quality print. Anything smaller does not provide a large enough hole in the screen for the ceramic paint to pass through repeatedly and consistently.

The design’s density should also be taken into consideration. The amount of glass with paint on it is typically referred to as the percentage of coverage. For example, a pattern with 3.2-mm lines and spaces between the lines provides 50 per cent coverage, while 3.2-mm lines with 4.7-mm (3/16-in.) spacing provides 40 per cent coverage. The maximum coverage recommended for a square foot is 60 per cent with darker colours and 80 per cent with a white or translucent colour. Increasing the pattern’s density beyond the recommendation increases the likelihood of pinholes or an inconsistent appearance.

When looking at custom patterns, another option is a graduated or gradated design. This starts with a heavier coverage and moves to a

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**Bird safety**

Silk-screened glass may also provide benefits when looking at bird safety as it relates to glass buildings. This is especially important for buildings located in the path of migratory patterns. It is known that birds do not see glass the same way humans do. This can cause collisions that may result in injury or death for the birds.

There are many groups involved in researching and reducing the number of bird/building collisions. Along with solutions such as lights-out policies, adding a silkscreen pattern on the glass surface is being reviewed. It is believed that adding a silkscreen pattern can help the birds recognize the glass as an obstruction, thus reducing the number of collisions. The specific reduction and details about which patterns and colours help the most are outlined in city guidelines, such as Toronto’s Bird-Friendly Development Guidelines.

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A custom graduated silkscreen pattern gives the illusion of greater glass size in Seattle’s Olive 8 building.

The Populous building uses square doughnuts in random patterns on two surfaces of the insulating glass unit to add visual interest and enhance solar performance of the glass.

The architect selected two different translucent ceramic frit colours to add greater visual interest to the Populous headquarters building in Kansas City, Mo.

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lesser one through decreasing spacing and dot or line sizes. A graduated pattern may be used to block sunlight at the window’s top or bottom while allowing a full view through the centre portion of the glass.

A graduated pattern could also be used as a way to mask the appearance of structural elements or create an illusion, as was done with the Olive 8 building in Seattle, Washington (Figure 7). The architects with Gluckman Mayner Architects wanted the glass sizes to be as large as possible, but were limited by the fabrication possibilities. The solution they developed was to add a graduated silkscreen pattern to create the illusion of larger glass sizes for the building’s centre portion. One glass unit in the centre did not have a silkscreen pattern, the units above and below the clear unit each had a white graduated band, and the four corner units each had a cross pattern. This created the illusion that nine pieces were actually one glass unit.

The bottom line

Even with high-performance coatings, the transparent appearance preferred by architects today often does not meet performance required by codes or requested by building owners. Vancouver, for example, uses American Society of Heating, Refrigerating, and Air-conditioning Engineers (ASHRAE) 90.1, Energy Standard for Buildings Except Low-rise Residential Buildings, as the basis for energy performance codes. ASHRAE 90.1-2007 is the latest version of this standard.

As a point of comparison, Toronto is in Climate Zone 6 and Calgary is in Zone 7. If a building using a vertical aluminum curtain wall has a window to wall ratio of 40 per cent, and is located in Climate Zone 7, the solar heat gain coefficient (SHGC) must not exceed 0.45. In Climate Zone 6, the SHGC must not exceed 0.4. A 25-mm (1-in.) insulating unit with a clear low-emissivity (low-e) coating has an SHGC of 0.54. To reduce this, a coating with slightly more colour or reflectivity could be used or a silkscreen pattern could be added to the clear low-e coated unit. Using a 40 per cent coverage, a white silkscreen pattern decreases the SHGC to 0.4.

Adding a silkscreen pattern has become a common method to significantly improve performance while adding interesting aesthetics. While dual-surface silkscreen designs and new frit colours and custom patterns provide several additional design options, caution must be exercised to ensure the design does not cause unintended visual shortcomings.

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