

## **IN DEPTH: Shattered glass: what causes panes to fall off buildings**

Two engineers explain what could be behind recent incidents in Toronto, Montreal, Austin

*Kazi Stastna, CBC News*

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Two instances of glass falling off highrise buildings in Toronto this week have people wondering whether it's pure coincidence or a sign of some pervasive construction flaw.

Similar incidents have occurred at a highrise hotel and residence complex in Austin, Texas, and at the Quebec provincial library in Montreal.

On Monday and Tuesday of this week, panes of balcony glass fell from two separate condominium towers in downtown Toronto, scattering shards on sidewalks and structures below but not injuring anyone.



*A missing pane of glass can be seen about halfway up the Festival Tower at King and John streets in Toronto. The piece of glass fell from a 27th-floor balcony on Tuesday night. Andrew Lupton/CBC*

The incidents happened at the Festival Tower above the TIFF Bell Lightbox, the new headquarters of the Toronto International Film Festival that opened only last year; and at one of two highrises that make up the Murano complex on Grosvenor Street near Bay Street.

In both cases, it was not the first time that balcony glass had broken free of the structures.

At the Murano tower, the glass that fell was part of balcony partitions installed in 2009, at least eight of which have shattered since December 2010. They were made by a company that has since gone out of business, according to the developer, Lanterra Developments.

After two panes fell in late July, the city ordered Lanterra to remove the balcony glass from the building because the situation was deemed unsafe for people in and around the structure, the Toronto Star reported.

At the W hotel and residences in Austin, several glass balcony panels fell off the 37-storey building in two separate incidents this June. In Montreal at the provincial library, decorative glass panels have been falling off the facade since soon after the building opened in 2005.

We asked two engineers familiar with the phenomenon to explain what could be causing the glass to shatter in such a spontaneous and spectacular way.

#### **Flaw likely in glass**

One of the first things engineers do when trying to identifying the cause of such failures is to look at the frequency with which they are happening, said Doug Perovic, a professor in the materials science and engineering department of the University of Toronto. He has been a consultant for people involved in litigation over similar incidents.

"When we have a number of these sorts of things happening in close succession, that usually rules out any kind of external influence — impact, user neglect or something of that sort," Perovic said. "It points back to a problem with either manufacturing design or installation."

Given the scorching temperatures in Toronto this summer, many people's immediate reaction was to blame the shattering on the heat — or more specifically, on the expansion that happens when glass heats up and on the temperature gradients that arise as glass gets hotter in the middle and cooler at the edges.

But Perovic says the problem likely lies with the glass itself rather than with any external stress placed on it by heat or wind.

"The amount of stresses generated simply from hot versus cool is not enough, I don't think, to induce the kind of fractures we're seeing.



*A screen shot of some of the balconies under repair at the Murano condominium complex on Grosvenor Street in Toronto, where several panes of glass have fallen from the structure.*

"I think it's more likely this glass has impurities, and the most likely culprit is something called an inclusion that [is] the result of the glass manufacturing."

The most common type of impurity found in glass is nickel sulfide, which is responsible for about 90 per cent of impurity-related fractures, Perovic said.

There's no way to completely eliminate inclusions, but there are ways to "prevent them from rearing their ugly head," he says. The main way is by tempering the glass.

"That's a process that involves heat treatment and needs to be done properly to essentially build stress into the glass to help strengthen [it]," Perovic said.

If the glass is not treated properly, the internal, or residual, stress of the glass will be too high and, coupled with the unavoidable imperfections, will result in spontaneous, also known as delayed, fractures that grow over time.

#### **Must account for temperature variations**

The panes that fell from the Toronto buildings were tempered glass, as are the panes that have been falling off the Bibliothèque et Archives nationales du Québec in Montreal. The library has had 15 of the 6,200 decorative, frosted-glass panels that cover its façade shatter to date, the most recent one in August 2010.

An independent assessment of the glass problem commissioned by the library found that 30 per cent of the panes on the building do not meet Canadian standards for glass treatment. It suggested the library have the glass re-treated.



*The Bibliothèque et Archives nationales du Québec on Montreal's Berri Street has been shedding its frosted glass panels almost since it opened in 2005. (Paul Chiasson/Canadian Press)*

The engineering consultants who carried out the assessment concluded that shattering could occur because of a combination of faulty treatment, fractures within the glass and too tight mounting of the glass onto the façade, which didn't allow for temperature-related expansion and contraction.

Accounting for temperature variations when installing glass on buildings is especially important in places like Montreal and Toronto that experience extreme weather at both ends of the thermometer.

"If the temperature rises, the glass will expand, and if it expands, of course, there has to be room within the grooves for it to move," said Saeed Mirza, professor emeritus of civil engineering at McGill University.

"Otherwise, what'll happen will be the whole thing will be in compression — that means it'll be bearing against the ends, and the glass will buckle and fail.

"If it cools down very much, then it is possible it could move out of the groove, in which case it could sort of just come out and fall."

The phenomenon of temperature fluctuations and the effect they have on mounted glass is well known in the building industry and should not pose a problem anymore, Mirza said.

"It is just a question of accommodating that movement within the framework around the glass piece," Mirza said.

Each type of glass has its own particular physical characteristics that determine how much it will expand or contract and what kind of "loads" or stresses it can take.

Loads like wind act perpendicular to the glass pane while pressure exerted from the edges, by a too tightly installed frame or mount, for example, act in the direction of the plane itself.

Accounting for the effects of those loads on the glass doesn't add much onto the cost of a building, Mirza said. And, normally, the glass used in construction can withstand considerable forces, so if it doesn't, it's likely a question of lack of experience on the part of those who handled the glass or a lack of quality control.

"These are simple things, but we don't do them simply," Mirza said.

#### **Montreal library put up buffer, kept glass**

In the case of the Montreal library, the building contractor, Pomerleau Inc., contested the findings of the library's consultants and, in the end, the library chose to simply replace the 15 broken panes with the same type of glass, not do a new treatment.

It also installed a permanent buffer zone around the building made up of shrubs, bushes, plants and 1.8-metre-wide aluminum and galvanized-steel awnings.

"[The panes] don't fall; they shatter," said library spokesperson Geneviève Dubuc. "They break into small pieces that aren't really dangerous. The aim is to, if necessary, collect the debris caused by the shattering. In the event that glass does shatter, it falls into the bushes, not on people."

The buffer zone cost \$750,000, split evenly between Pomerleau and the library, and the library was criticized at the time for choosing a Band-Aid solution rather than fixing the problem.

**'You could take the glass out, heat treat it, relieve some of the stress and put it back into service.'**—

*Doug Perovic, engineering professor*

What caused glass to break at the two Toronto buildings is still being investigated. The repetitive nature of the incidents and the fact that at the Murano complex, the glass on an adjacent tower, which came from a different manufacturer, has not shattered suggests it might be a problem with the material rather than how it was installed, Perovic said. But he does not rule out the latter and said it could even be a combination of both.

"The first thing is to get to the root of the problem to see whether this glass has been improperly tempered and is carrying too high an internal stress," Perovic said. "If that were the case, you could take the glass out, heat treat it, relieve some of the stress and put it back into service."

He said modern techniques allow technicians to measure the stresses in the glass on site in order to determine whether other panes are of a similar nature as the damaged ones.

Lanterra Developments doesn't have the option of waiting for that kind of assessment. It has already begun replacing the glass balconies at its Grosvenor tower and said the process will likely take until October and cost millions of dollars.

The W hotel in Austin is also replacing all of its 1,000 glass balcony panels, the Austin-American Statesman newspaper reported.

The developer of the Festival Tower, the Daniels Corporation, said Wednesday the company did not yet know what caused the glass to break and would be erecting scaffolding on the sidewalk below while it investigated further. Daniels did say the glass that fell from the same building last month did so because of pressure exerted on it by the expansion of a metal balcony railing in the heat.