WINDOW RECEPTORS

Notes From the Field

By Don Kilpatrick

The popularity of condominium living in large metropolitan areas has engendered a well-established part of our cityscapes, with fierce competition to see who can deliver the best views, towering over adjacent buildings, boroughs, coastlines, and parks. Those with means can freely invest in housing with million-dollar views.

Developers and builders, however, often used economical receptor-set floor-to-ceiling glass to maximize the allure of already stunning panoramas. With increased frequency, our staff is approached by property managers representing condominium associations with reports of random and unpredictable leakage seemingly associated with the glazing systems. Unfortunately, a good number of these projects are fitted with lower-cost window systems, and in some instances, they fail to meet current-era established performance criteria for mid- and high-rise construction. Chronic leakage may be reported by some early in the performance history, while others may be challenged with reports of recurring leakage years into their respective service history.

There are hundreds of buildings across the United States with the signature characteristics of a steel-reinforced concrete frame with floor-to-ceiling windows (columns and floor slabs integrated with a window system). If the designer of record were so moved, the leading edge of the floor line might even be covered with sheet metal panning and some insulation. The nose of the floor slab breaks the plane of the exterior wall at regular intervals; one man's ceiling is another man's floor (*Figure 1*). Architecturally, it can be a rather bland look, but who cares? The otherwise breathtaking views more than make up for boring aesthetics on the building's exterior. The highly regarded element of curb appeal takes a back seat to the views.

It is at the projected floor slab and adjacent terraces where the assembly transitions to window parts, providing economical floor-to-ceiling closure of the conditioned space. Sill and head receptors, interfaced with accessory sheet metal closures, frame the opening, featuring fixed insulated glass (IG) units and operable hoppers with sliding doors onto the terraces. Generally, the fixed IG units and hoppers are nested in the sill receptors. Sill receptor stock comes in straight lengths and is field-cut to length based on the geometry of the floor slab and the architect's vision of the floor plan. Interruptions in continuity of the receptor are found at inside/outside corners, changes in plane, and the terrace doors.

Terrace door sill extrusions and frames are typically characterized as their own stand-alone "zones." The reference to zone places an emphasis on the notion that the terrace sliding glass door would be designed with a dedicated water management system (a weep path and ports) to manage and harmlessly discharge water that may enter the system. Windows routinely rely upon zone/end dams to prevent the lateral

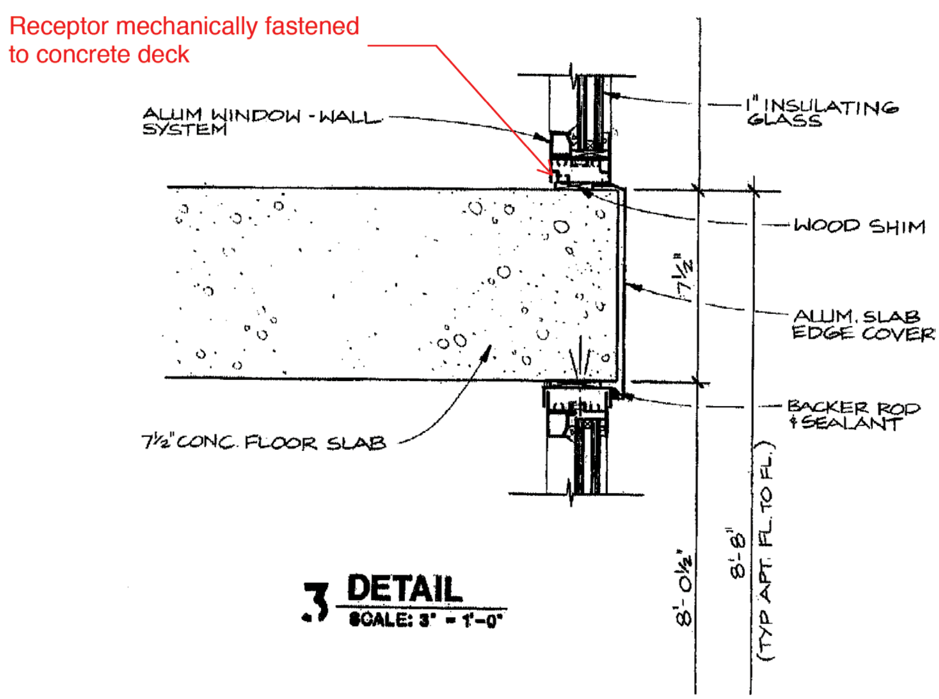

Figure 1 – Typical section at floor/ceiling line.

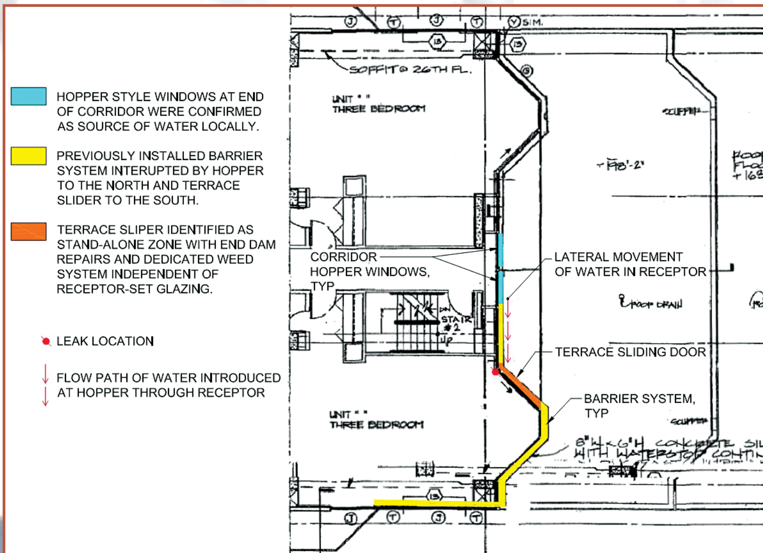

Figure 2 – Plan view.

Figure 3 – The more aggressive barrier system compromised the overall aesthetics and was not well-received by unit owners.

movement of water from one location or zone to another.

On a recent project, the facilities engineer and property manager reported patterns of recurring leakage to the building interior. Engineered wood, traditional hardwood, subfloors, and carpets were routinely subjected to water entry. The tenants with hardwood flooring took the worst of the damage, with cupping and curling of the individual boards and significant damage to the subfloors. In response to the leakage, others had previously installed work, but the leaks had persisted. The following observations were made as part of an ongoing investigation to locate source(s) for the recurring water entry in select units of this 28-story high-rise on the shores of Lake Michigan.

EXISTING CONDITIONS AND WATER TESTING

Owners of one unit reported significant water damage to the engineered hardwood floor of their living room. Most of the damage was associated with free moisture observed at the floor line just below the lower corner of an east-facing terrace door. The owner already had the sill portion of the sliding door completely taken apart with remedial repairs to end/zone dams. In the presence of these repairs, the leakage persisted.

A pair of hopper windows overlook a narrow terrace at the end of the corridor (*Figure 2*). Leakage to the building interior at the hopper was previously reported. Here again, the window system is set in sill receptors that run continually along the floor line through window mullions and parting walls. The sill receptor below the hopper window at this location continues south some 12 feet, through a series of fixed IG spandrels and mullions, ending at a change-in-plane or direction of the sill receptor at the jamb of the terrace sliding door.

Figure 5 – Free moisture pooling on the floor interior after "static" water test (came in at localized areas of bond failure between the sill extrusion [receptor frame] and sealant joint).

Figure 4 – The installation of vertical leg extensions needs to acknowledge the ever-present potential for lack of continuity at mullions and parting walls.

In response to leakage at the corridor hopper windows, workers had previously installed an extension on the vertical leg of the sill frame and sill receptor. Concurrently, an effort was made to convert the exterior of the spandrel glass to a barrier system via the introduction of cured silicone membrane (*Figure 3*). The work scope, however, may be described as overly aggressive, using far more material than required, which resulted in a compromised aesthetic. Installing reticulated foam in the weep ports of the terrace sliding glass doors that were to remain open was additionally recommended. All weeps at the sill conditions of fixed IG units had been previously closed as part of the conversion of the assembly to a barrier system. The weep ports at the sill of the hopper window remained open.

Although previous repairs were provided, leakage to the building interior persisted during periods of extended wind-driven rains. The remaining features in the glazing system that might be likely sources for water entry were the hopper windows.

WATER TESTING

The initial water test was performed by placing a uniform wash of water on the building exterior, with a spray bar centered over a hopper window in the closed position. To minimize cost, no chambers or negative air were used, as may be deployed in a more traditional forensic investigation or acceptance testing. During the water testing, free moisture was observed at the following locations on the building interior (intervals are approximate):

One-Minute Interval – Water was observed at the supplemental vertical leg extension at the sill/mullion interface (*Figure 4*). The water wasn't overtopping the increased vertical leg height, but rather observed as rolling out of the lower corner of the window frame from below the extender. Behind was the sealant bead that perhaps was once bonded to and provided closure/transition from the concrete deck to the sill receptor.

Two- to Three-Minute Interval – Water was observed at the floor line where the receptor was married to the concrete floor slab with a bead of sealant (*Figure 5*). Within two to three minutes, free moisture was observed trailing across the corridor floor. Complete bond failure was observed at the bead bridging the gap between the sill

Figure 6 – Free moisture pooling on the interior of the occupancy adjacent to terrace sliding door. The source was confirmed as water that was introduced to the sill receptor via the weep structure of the hopper window, some 12 feet removed from this location.

receptor and the concrete floor. Most of the failure was at the interface of the sill receptor and sealant, with free moisture flowing through unimpeded.

Four- to Five-Minute Interval – Water appeared at the floor line below the corner of the terrace sliding glass door (*Figure 6*). After four to five minutes, free moisture was observed pooling on the floor at the jamb of the terrace slider. Runoff from the water test across the terrace was ruled out as a source, as was the spandrel glass between the hopper and terrace doors. The spandrel glass portion of the glazing assembly had already been converted to a barrier system. The hopper window remained unchecked at this point. A second, more aggressive test was scheduled for the next week.

With the window open, the test was replicated, using a spray wand with a very small concentrated stream of water targeting one of the two weep ports on the skyward-facing portion of the sill frame. Within a couple of minutes, a pool of water was once again present on the floor adjacent to the terrace sliding door. Apparently, the "loading" of the condition with water of sufficient volume to result in leakage at the terrace door was a time-weighted cumulative event, compared to the more direct "injection" of water into the receptor at a weep port. The tests confirmed that free moisture that made its way into the receptor could be conveyed some distance from the source, where it presented as a leak.

REPAIR RECOMMENDATIONS

With a reasonable degree of certainty, it can be said that the above-described conditions would be receptive to being converted to a "barrier" system, which largely abandons or removes the need for any provisions for moisture control (weep path) within the hollows of the window frame and receptor. Through the introduction of strategically placed wet sealants and cured silicone membrane, the windows would be transitioned from a water-managed assembly, relying on weep ports and paths to manage free moisture that enters, to an assembly that puts the drainage plane on the exterior exclusively.

The weep system is typically closed at the most outboard portion of the frame, sash, and glazing. All remaining potential sources for water entry are sealed, including weep system(s), butt joints at joinery of extrusions, frame-to-glazing cap beads, slip/snap joints at mullions, etc. Sealant joints through the transitions from frame to concrete are additionally treated (*Figure 7*). Prior to fully executing this type of repair, it is recommended that an exhaustive process of due diligence

Figure 7 – Revised barrier system that places emphasis on a more targeted approach, resulting in a more aesthetically pleasing finished installation (cap beads, fillet beads, target patches).

be undertaken such that the mechanics of the failure are fully understood. Sealant compatibility must be confirmed, and adhesion tests are highly recommended prior to releasing the work for full production.

One tenant, having had enough of damage to hardwood flooring, chose to have his hopper windows sealed from the exterior—converted to a barrier system. The hopper windows present the biggest challenges in the conversion of the system to a barrier-type construction. The continuity of the existing assemblies (fixed floor-to-ceiling windows and spandrel glass accepting of a barrier conversion) is interrupted at regular intervals by operable sashes of the hoppers, known to be accepting of water. The water testing performed to date on the hopper windows demonstrates that in the absence of chambers and negative air, the hoppers leak in the presence of a uniform wash of water on the exterior.

The operable sashes tilt inward. The geometry of the sill extrusion is the opposite of what might be characterized as practical for the application. At the sill condition in section, the outboard vertical leg has the highest profile (a uniform 1-in. leg that additionally carries through the jambs and head), with the overall profile from there (at the sill section) essentially stair-stepping downward (beyond the ⅜-in. vertical leg), towards the building interior (*Figure 8*). Of all the seated joints in the hopper assembly in the closed position, the sill condition would be characterized as highly vulnerable to leakage during periods of sustained rain.

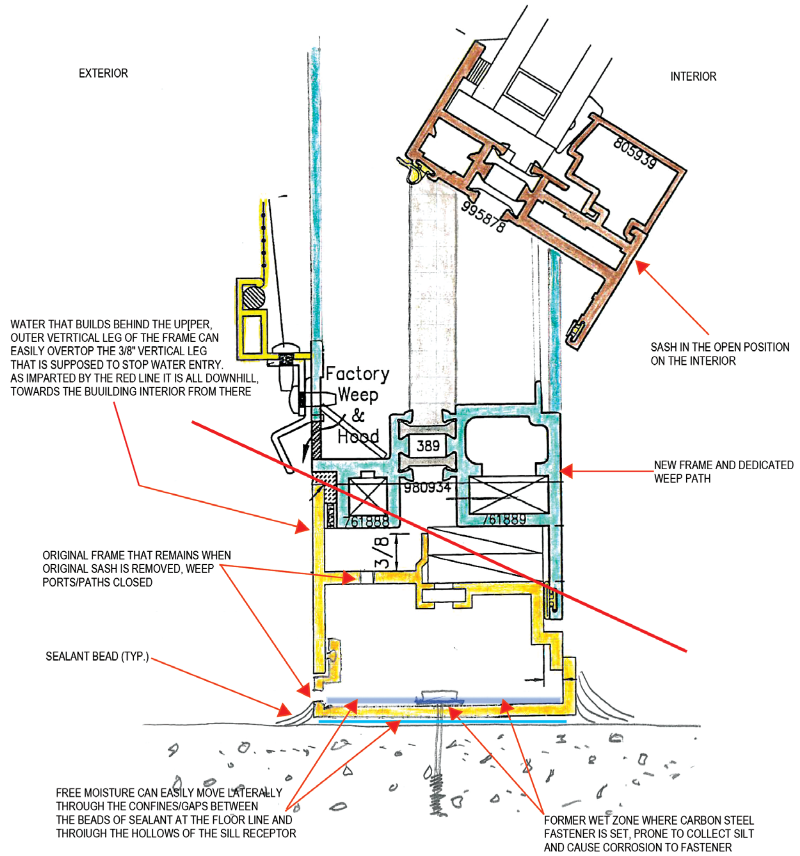

Figure 8 – Window section.

Figure 9 – During the dry fit process, shims in the sill are adjusted, and clips are installed in the jambs.

Figure 10 – New insert set in position being drawn down with clamps. The inner flange of the opening/existing frame is dressed with a bead of wet sealant prior to nesting the new window in place. The excess sealant on the exterior is struck with a knife, providing clean/crisp lines.

HOPPER WINDOW

As described above, the hopper windows would not be characterized as components of the assembly that would be receptive to the conversion to a barrier system. The following discussion summarizes observations made specific to the hopper condition that seem to validate the means and methods for the correction of a condition that would not be receptive to the barrier system.

The uniformity of the opening, or pocket of the frame that remains with the operable sash removed, lends itself to the introduction of a new window as an insert. The plug-and-play aspect of the installation is centered on the introduction of a new self-contained window frame and operable sash that would be independent of the frame surround that will remain. This new window would bring with it a compartmentalized zone for water management, with the existing window frame surround having been completely isolated and converted to a barrier system (with weeps in the sill completely sealed).

The team initially reached out to three window manufacturers, and the one that minimally chose to answer the phone and respond to e-mails was chosen to participate in the mock-up repairs. They dispatched sales and technical staff and enlisted the services of one of their preferred installers. Tooling charges for custom frame extrusions were built into the costs, and shop drawings were submitted and approved.

First the accessory hardware from the original hopper window was stripped from the opening, including fixed points for hinges and catches for latch mechanisms. Weep ports on the horizontal plane of the sill extrusion were plugged, and the joinery of the extrusions at the inside corners through the transition to the jamb were locally treated with an appropriate gun-grade sealant. The insert was dry-set, and adjustments were made to the shims at the sill condition. Heavy clips were mechanically fastened to the jamb and back side of the 1-in. reveal in the pocket, and dressed in a bead of silicone sealant (*Figure 9*). The insert was subsequently set in the opening and drawn down with clamps. The tolerances were such that when the clamps were drawn down, the previously installed wet sealant (setting bead) was observed extruding from the joint (*Figure 10*). With offsets measured and approved as consistent, and the window securely nested in the opening, fasteners were set at the jamb. The sealant bead on the exterior was struck smooth with a knife, and the installation was given a seven-day cure prior to testing.

PROOF TESTING HOPPER WINDOW RETROFIT

A test chamber was placed floor-to-ceiling on the interior of the assembly, fully engaging the lower replacement and the upper fixed IG unit that had previously been converted to a barrier system. The upper IG fixed unit was isolated using sheet plastic, and the spray rack was installed. The testing was performed in accordance with Method A of ASTM E1105, *Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors and Curtain Walls, by Uniform or Cyclic Static Air Pressure Difference*, at 15 psf (78-mph wind speed). During the test, no leakage was observed on the floor of the corridor below the replacement window, and no water was presented 12 ft. away at the floor line adjacent to the terrace door. The sheet plastic isolating the upper fixed IG unit was removed, and the spray rack was moved up, offering that location a uniform wash of water in the presence of negative air. The new window below was not isolated during the test of the upper fixed IG unit. At no time during the test was free moisture observed on the building interior sourced from either the barrier system on the fixed units or the new hopper window. Neither was any leakage observed at the floor line adjacent to the terrace slider.

OTHER CONSIDERATIONS

It is not unusual to see a robust sealant joint marrying the receptor extrusion to the floor on the interior with a similar application of sealant on the exterior. The receptors are commonly set with carbon steel fasteners (heads often crowned with splotches of sealant) that have been repeatedly exposed to moisture. Add the silt and organic materials (holding moisture) that accumulate in the receptor, and you have a great environment for corrosion and, in some instances, vegetation growth (*Figure 11*). It is not unreasonable to assume that most of the carbon steel fastener heads, set in the wet zone established by the receptor, are lost to corrosion. In the absence of the fastener, free moisture can move into the gap between the above-described inboard and outboard beads of sealant at the floor line, and again move laterally below the sill receptor. Additionally, it could be argued that the beads of sealant at the floor line offer more lateral support to the sill receptor and window assembly than the once-present fasteners that have been lost to corrosion.

The likelihood of success in stopping leakage by installing an extended vertical leg at the sill condition on the interior of a vintage window assembly is, at best, limited. As described above, there are typically two paths for lateral movement of water: the sill receptor, and the space between the two sealant beads at the floor line. For an extended vertical leg to have favorable results, it would have to be carried down to the concrete deck on the interior, and the concrete would have to be free of cracks. Shrinkage cracks—most notably at the leading edge of cast-in-place concrete floor slabs—are present in most every building of that type and will pass water to the building interior if left exposed to the elements.

Figure 11 – Silt and organic material can result in significant compromise to the intended water management system of the window assembly's fourth-floor occupancy.

By some estimations, the introduction of a vertical leg extension on the interior would be characterized as a last resort with little promise of improvements in water management.

Weep ports that remain in the assembly are isolated to the terrace doors. The terrace doors are characterized as stand-alone zones accepting of remedial repairs. In the barrier conversion promoted for this project, the factory-established weep ports and paths of water management for the terrace doors remain. It is not recommended that after the repair of the "zone" established by the terrace doors (new fasteners at the sill, new end zone dams), that reticulated foam be installed in the weep ports (*Figure 12*). The "inviting" geometry of the sill extrusion of the terrace doors accelerates the accumulation of silt and organic materials in the hollows of the sill extrusion. These locations are prone to "flushing" in the presence of heavy rains. The sudden charge of water through the confines of the sill extrusion carries organic material to the weep ports, and the reticulated foam will very quickly silt up, resulting in the retention of water to the extent that it may overtop the vertical leg height on the interior, resulting in leakage.

Figure 12 – Reticulated foam stuffed into weep ports of the terrace slider do more harm than good. Any porosity the material had is compromised by 1) forcing the material in a hole smaller than the piece of material that is intended to fill it and 2) the material fulfills the role of a clogged filter due to the abundance of silt in the subframe.

REMARKS

A widely accepted descriptor of the receptor portion of the assembly would be a C-channel laid on its back, establishing a static connection for the receptor to the structure and a pocket accepting of the window frame. The expectation is that the receptor component will additionally provide a means of water management as evidenced by the weep systems integral to the piece. A more critical definition based on present-day form and function may be a "gutter" with structural integrity, fitted with holes in the bottom that may or may not be sealed, with no end caps and no means to reasonably access the interior for the expressed intent of cleaning or executing repairs.

Aging or vintage receptor-set floor-to-ceiling glazing assemblies constructed in the past 12-20 years will predictably continue to drive random and unpredictable leakage to the building interior. Conversion of these assemblies to a barrier system can result in appreciable gains in service life. The expected life span of in-service sealants can reportedly be in the range of 20 years.

The organic material/silt stored within the assembly holds water against sealants that generally perform poorly in immersed conditions (urethane base reverting to a bubblegum-like consistency). These moisture-sensitive sealants were routinely used for end and zone dams as well, which are critical to establishing and maintaining control of water movement laterally from one zone to another.

On this project, the testing clearly demonstrated that water that ultimately presented itself at the terrace door was sourced to the weep structure of the hopper window. The only way to convert the hopper windows to a barrier system was to seal them shut on the exterior (operating under the assumption that fresh air is overrated). Based on the uniformity of the opening (the remaining frame, less all hardware once the existing sash is removed), the concept of "nesting" a new frame and sash with an independent, dedicated weep structure was realized as a viable option. The ultimate success of any repairs to these types of assemblies must place an emphasis on the conversion of the receptor from an integral part of the water management system (capture, retain, and drain) to a dry zone that is not expected to manage and drain water.

Don Kilpatrick

Don Kilpatrick, an employee of Inspec, Inc., has been active in the industry for over 34 years. In the capacity of a project manager, he has been responsible for the initial sale of services, client relations, scope awareness, acquisition of field data, design, and coordination of all team members for both self-performed and subcontracted services. He is a longtime member of RCI's Interface Editorial Board and a frequent contributor to the journal.

RCI Elects New Region Directors

Michael Violette, RRC, PE
Region I Director

Chris Dawkins, PE
Region II Director

Gene Keeton, CxA+BE, BECxP
Region III Director

Jennifer Hogan, RRO, CET, LEED AP
Region VII Director

Four new region directors were elected by the voting membership of RCI, Inc. in January. Running and winning re-election for a second term were both Michael Violette, RRC, PE, for Region I director (Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Puerto Rico, Rhode Island, Vermont, and West Virginia); and Gene Keeton, CxA+BE, BECxP, for Region III director (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, and Wisconsin).

Chris Dawkins, PE, running unopposed in Region II (Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, and Virginia), was elected as director of that region.

In Region VII (Newfoundland/Labrador, Quebec, Prince Edward Island, Nova Scotia, New Brunswick, and Ontario), Jennifer Hogan, RRO, CET, LEED AP, beat Stephanie Robinson to become the first female region director of RCI.

In the second year of their two-year terms are Region IV Director Neal Johnson, RRO, AIA; Region V Director Szymon Zienkiewicz, RRC, RRO; and Region VI Director Blair Baxter, RRC. The new directors will begin their two-year terms at the conclusion of the Annual Meeting of the Members on March 18 during the 2019 RCI International Convention in Orlando, Florida.

Denver Replaces 2017 Green Roof Law

Denver City Council has voted to repeal and replace the green roof law it passed in 2017. The older law required rooftop greenery on reroofs or new commercial buildings larger than 25,000 sq. ft. The revised law will require light-colored, reflective cool roofs. Building developers can choose several new options for attaining environmental goals, including build a green space into the structure or lot; pay a per-square-foot fee to fund energy efficiency elsewhere; implement renewable energy; or meet standards for an environmental certification program, such as LEED.

The changes were made after real estate developers opposed the original law, arguing it would add nearly 3 percent to the cost of constructing large buildings.

