ACHIEVE HIGH PERFORMANCE
Window-to-Wall Ratio in High Rise Residential Buildings

There is an expectation that continuous floor-to-ceiling glass in residential units will yield better daylighting and views. It turns out this is not always the case. In an extreme climate like the one we have in Northern Illinois, occupants of residential units with continuous floor-to-ceiling glass are likely to be less comfortable and have less privacy. Glazing upgrades and exterior window shading provide inadequate solutions to these problems and may further compromise daylighting and visual comfort.

The same multi-family building designed with 85 percent WWR will have higher annual energy costs (and carbon footprint) than a comparable building with the prescriptive energy code maximum of 40 percent glazing. In fact, the quantity of exterior glazing is likely to have a greater impact on energy consumption and occupant comfort than any other decision in the design of a Chicago residential high rise.
Daylighting is a function of strategic window positioning, not simply quantity of glass. Daylighting modeling shows that a very high WWR reduces the amount of useful daylighting to a space by up to 20 percent because it creates many hours of excessive, harsh light when occupants must move away from windows or close shades. This reduction does not include hours when shades are closed for privacy or warmth. A 40 percent WWR is well within the range where daylighting is optimized. And in terms of energy, it is not until the WWR is reduced to 20 percent that reducing glazing further would cause an increase in energy costs for lighting, outweighing heating and cooling cost savings.

Buildings with 40 percent WWR can provide greater availability to views than floor-to-ceiling glazing. Window shades that are open provide views; window shades that are closed do not. Thus, privacy, winter thermal comfort and glare control are fundamental to maximizing views. Even when shades are open, if a person stands more than a few feet away, the window is a small piece of their overall view regardless of whether there is 100 or 40 percent glass in the building’s exterior. It is only when the person moves closer to the window that they are immersed in the exterior view. Even then, there is little difference between the up-
close view through continuous floor-to-ceiling glass or through strategically placed windows. Lastly, unlike continuous floor-to-ceiling glazing, reduced window areas do not require aggressive solar heat gain coefficient (SHGC) reductions to achieve code compliance. SHGC reductions can result in glazing that is noticeably darker in appearance. Excessive glass does not provide more views; good design does that.

**GREATER COMFORT**

Buildings with 40 percent WWR are more comfortable. In summer, excessive direct solar gain is reduced. In winter, cold air convective drafts are reduced and the radiant wall/window surface temperature will be warmer. Even if the thermostat is held at 70 degrees, if an entire wall is a glass surface at 40 degrees, the space will be uncomfortable—particularly near the windows. A strategic combination of vision glass and opaque wall is more comfortable.

A southwest-facing residential unit in a building with 40 percent WWR has approximately 1,000 more comfortable hours per year than a unit with continuous floor-to-ceiling glass. About a third of those additional comfortable hours occur from 5 to 10 p.m. when units are typically occupied. And in those hours, window shades are more likely to be open (see Better Daylighting and Optimized Views).

**OPTIONS CONSIDERED**

Lowering SHGC can be very effective in reducing heat gain from windows. This helps with cooling loads in summer; but can result in an energy and comfort penalty in winter when well-controlled solar gain could provide some passive heating.

**ENVELOPE THERMAL LOAD:** Code baseline insulated exterior walls have far better thermal performance than even the best double glazing (R-18.2 vs. R-2.9). Increasing from 40 to 85 percent WWR nearly doubles envelope thermal load and more than doubles solar heat gain. Installing better glazing and insulation over the entire envelope makes up less than half the difference.
in Chicago’s cold climate. It is important to strike the right balance for the specific window orientation and overall building performance goals.

Designers sometimes consider adding exterior shading to overcome some of the visual and thermal comfort issues caused by large areas of glazing. Unfortunately, exterior shading is quite often eliminated due to high initial cost. Even when exterior shading is included in the construction, final attachment details can result in poor overall building performance including higher energy use, potential material degradation and thermal comfort issues—all due to thermal bridging (see inset). Also, shading east- and west-facing windows to effectively reduce glare and heat gain is nearly impossible since sun angles shift so dramatically during the course of a day and throughout the year. At high occupancy times (morning and evening) in residential spaces, exterior shading on east or west exposures would do little to mitigate the need for interior blinds being drawn.

Designers also consider the use of more advanced window technologies such as triple-pane glazing systems with argon fill, low-emissivity (low-e) coatings and ‘smart glass’ technologies (e.g. electrochromic glass). But even the best triple-pane windows with argon and low-e coatings are still limited to about R-5.5 (U-0.18) for the assembly, including high-performance thermal barrier framing. Code compliant insulated walls provide triple that performance.

**AN OFF-THE-SHELF PATH TOWARD ARCHITECTURE 2030**

Buildings today have a unique opportunity to significantly beat the energy code using common technologies. It starts with striking the correct balance of vision and opaque assemblies on the building. Meeting the prescriptive envelope code requirements means that improvements in other building systems—lighting, HVAC and domestic hot water heating—become beyond-code measures.

Common technologies could yield annual energy cost savings upward of $0.20/gsf plus one-time ComEd incentives of roughly the same magnitude at construction completion. In recent years, the ComEd Energy Efficiency Program has seen LED lighting become more common as costs have brought it within reach; for the time being, LED lighting can still significantly beat code lighting power densities, while providing superior lighting. The HVAC industry generally tracks equipment performance with

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**THERMAL BRIDGING** occurs where a thermally conductive material—e.g. concrete, structural framing members, aluminum window framing and other attachments or fasteners—penetrates the primary insulating layer of the building envelope. This provides a bypass route for heat loss or gain that significantly diminishes the net performance of the assembly.
code updates, meaning code-compliant and even code-beating equipment and controls should be standard. It is common in the Chicago market to see glazing with improved SHGCs of 0.3 and assembly U-values of 0.38 or better, particularly for tightly-engineered, off-the-shelf systems. Some buildings are using these common energy-efficient technologies to compensate for the energy penalty of excessive glazing in order to minimally comply with the code. A forward-looking project realizes the opportunity is ripe for deep savings with market standard technologies.

**REDUCING INITIAL COSTS**

An integrative approach to analyzing initial costs can be complex, yet could offer a successful argument in favor of 40 percent WWR. Conversations with contractors\(^6\) suggest, in the Chicago market, that standard glazing in window/wall systems is often the same cost or cheaper than well-insulated opaque wall assemblies.

In high-rise applications, opaque assemblies must be robust enough to withstand window loads, contributing to their higher cost. Labor costs are higher for opaque assemblies that must be built up, compared to modular systems that can be installed quickly. Lastly, volume pricing for high amounts of glass on a façade results in lower per unit costs. Some spandrel assemblies of curtainwall may face a similar story, considering the required addition of an interior finish and the cavity insulation required to approach the code requirements of insulated metal-framed wall construction. For a lower WWR building to be competitive on an initial cost basis, opaque assemblies must be specifically designed for lower material and installation cost.

Project engineers must also capture the cost savings from reduced HVAC system capacity and reduced or eliminated perimeter heating from a lower WWR project (a rough cost exercise suggests a $0.40–$1.10/ gsf HVAC initial cost reduction\(^6\) may be possible by reducing WWR from 85 to 40 percent). In fact, forced-air heating and cooling can potentially be eliminated altogether.
A NEXT-GENERATION RESIDENTIAL HIGH-RISE

A powerful advantage of a lower WWR building is the flexibility to install radiant heating and cooling thanks to reduced cooling loads during Chicago’s hot, humid summers. Radiant systems pump warm or cool water through the slab or panels in the space, controlling both air and surface temperatures. The energy required to pump water is less than what is required to operate fans in other HVAC systems and equipment runs more efficiently at the modest temperatures required for radiant systems. Next-generation radiant systems provide a quantum leap in performance and achieve deep efficiency. They also enable a clean interior design, superior comfort, better air quality and quiet operation.

Such next-generation designs do not happen by accident. They happen when the owner, architect, engineers, cost estimator, general contractor and subcontractors are all at the same table early in the design process. This is how integrative design results in a superior product.

THE REAL WOW FACTOR

Optimizing high-rise WWR designs has many benefits—more usable daylight, more hours with window shades open, improved comfort and significantly less energy consumption. And, perhaps most enticing to developers, initial costs can be reduced through an optimized façade design using a true integrative design approach.

A 40 percent glazed building can be a finely-tuned, inspiring, superior addition to a developer’s portfolio.

LINK TO END NOTES

The ComEd Energy Efficiency Program can help you achieve superior performance on your next project and it can start as early as the RFP. Ask us how.

For more information about the ComEd Energy Efficiency Program, visit ComEd.com/BizIncentives, call 855-433-2700, or email us at BusinessEE@ComEd.com.