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Replacement Windows

by Harwood W. Loomis, AIA

Until the oil embargoes of the mid-1970's, the United States was blessed with an abundant supply of inexpensive energy. Not a lot of consideration was given to energy efficiency and conservation. Heating plants were routinely over-sized to provide for potential future expansions...without much concern that an oversized plant does not operate efficiently at reduced outputs. Building insulation was frequently minimal, or not used.

Because energy was cheap, for both heating and cooling, there was no economic pressure to improve the window product. Some of the aesthetic developments, such as butt glazing replacing mullions, required the use of single plate glass, and thus, mitigated against thermal improvements such as insulating glass.

The dramatic rise in energy costs in the 1970's changed the designers', owners' and building managers' outlook on windows very quickly. Glass, even insulating glass, is a poor insulator relative to opaque materials. Combined with deterioration of existing windows in older buildings, windows became one of the first items to look at in any program to reduce energy loss.

Wood windows and frames rotted and twisted out of shape. Steel sash were generally never weatherstripped. Both conditions result in infiltration of cold, outdoor air. Steel and aluminum sash and frames conducted heat very effectively from indoors to outdoors.

As concern was focused on windows as an energy problem, the marketplace responded with product improvements to update thermal performance and to improve maintainability.

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Thermal Performance of Glass

Assuming a sound, relatively well-fitted window – one that is not a source of considerable infiltration or maintenance problems – one place to begin improving thermal performance is the glass itself. If the configuration of the window frame permits, single glass may be replaced with insulating glass.

Insulating value is expressed in terms of resistance to heat flow, or "R-value." Higher numbers indicate greater resistance to heat flow, and thus better insulating qualities. A single sheet of glass provides an "R"-value of approximately 0.88, for example. If this can be upgraded to insulating glass with a one-quarter inch dead air space between two sheets of glass, the "R"-value increases to 1.64, nearly double. If the air space can be increased to one-half inch, the "R"-value goes up to 1.82.

It is also possible to improve the thermal performance of single glass without replacing it. A number of transparent film materials are available that can be applied to the surface of existing glass to provide a reflective coating. This coating acts to reduce solar heat gain, reducing summer air conditioning costs, and to reduce heat loss in winter.

Storm Windows

If existing windows are not too deteriorated, but allow more infiltration than desirable (or are conductive), such as steel windows or non-thermally improved aluminum, it is possible to install storm windows on the interior to stop the drafts and gain the insulating value of a dead air space between two sheets of glass. Such interior storm windows can be found in a range of prices and quality, from units that are essentially residential grade, up to products that closely approximate installing a new prime window inside the existing window.

Interior storm windows are not a panacea – they cannot arrest or correct badly deteriorated windows. But, if the existing windows are relatively serviceable, there is a need or desire for absolute minimal disruption to the workplace, or exterior appearance of the windows is to be maintained, interior storm windows can improve the thermal qualities of the existing windows.

As with any multiple glazing installation, they also help reduce the amount of outdoor noise transmitted through the windows. The higher quality units are contemporary, even monumental in styling, and some can incorporate an integral mini-blind. It is, thus, possible to leave the exterior of a building completely unchanged in appearance...yet – on the interior - provide a clean, modern appearing window which compliments contemporary office planning and furnishing.

reflective glass cuts down solar gain

One manufacturer cites laboratory tests showing an interior, add-on window providing an "R"-value of 2.13, good resistance to condensation, and an infiltration rate of less than .025 CFM per lineal foot of (perimeter) crack. *(By comparison, data from the ASHRAE Guide Book tells designers to allow for infiltration rates of 21 CFM through a non-weatherstripped wood window, and 47 CFM through a non-weatherstripped metal window – at a wind velocity of only 10 miles per hour.)*

It is important to keep in mind, however, that with these units the old windows must continue to function as the weather closure. If they leak water, installation of interior storm windows would be a false economy because water would be able to enter the enclosing walls and cause deterioration of finishes and/or the structure of the building.

Replacement prime windows are offered today in three materials: wood, vinyl and aluminum. Of these, aluminum seems to have the greatest acceptance, followed by vinyl, and then wood. A discussion of the advantages and disadvantages of wood and vinyl windows will help explain why aluminum seems to be the favorite, particularly in the commercial market.

Steel Windows

The traditional steel-framed casement or awning window, generally regarded as an "industrial" or "factory" window, was also used as a residential and commercial window. The sections used to fabricate the frames are

older single glazed windows are prime candidates for replacement rolled steel sections. While the sections can be rolled deep enough to accommodate thermal glass in almost any thickness, there is little that can be done to improve the performance of the window itself.

Fabrication of a thermal break feature is essentially impossible, except by "piggy backing" two prime windows with a non-thermally conductive gasket between. Weatherstripping has to be surface-applied, because the intricate channels and receivers found in extruded aluminum sections cannot be duplicated in rolled steel. Surface-applied weatherstripping may not be as effective as other forms, and is subject to loss or damage resulting from deterioration of adhesives.

And, of course, steel rusts. Steel windows require periodic painting to maintain the level of thermal protection they provide.

Wood Windows

Of all the materials in general use for windows today, wood has the longest history. Wood can be shaped easily into a variety of shapes and profiles. It provides a comparatively good insulating value, and does not readily conduct heat. It is a renewable resource.

On the debit side, wood is organic. If not properly sealed and protected from weather, it rots. All materials expand and contract with temperature changes; wood has a coefficient of thermal expansion roughly ⅓ that of steel, and ⅙ that of aluminum.

However, unlike steel, aluminum and vinyl, wood also expands and contracts as its internal moisture content changes. This is harder to predict, and is the cause of windows that may stick on humid summer days, and rattle loosely on dry winter days.

Until recently *(within the last 15 to 20 years),* wood windows were not weatherstripped, but were constructed such that the sash *(the individual halves of a window that slide up or down)* rode in slots formed by wood rails. More recently, the wood rails have been replaced by formed aluminum or vinyl assemblies that provide a tighter, more permanent fit.

One of the drawbacks of an all-wood window is the glazing – the means of holding the glass in the sash. Wood windows are designed to be glazed from the outside, using a beveled bead of putty or glazing compound to seal the glass to the wood. Glazing compound relies on oils and volatiles to remain plastic. Once in place, it must be painted shortly after initial curing or "set" to keep from drying out entirely.

When wood gets very dry, it may suck all the oil out of glazing compound at the point of contact, resulting in a loose fit and possible leaks. Unfortunately, many of the new construction and glazing sealants such as silicone do not provide reliable adhesion to wood, and so are not recommended for reglazing wood windows.

Vinyl Windows

Vinyl windows are new to the marketplace. They were introduced in the United States in the late 1970's, originally with a European window. The window is similar in manufacture to an aluminum window: frame and sash members are extruded to shape out of a structural-grade vinyl.

Vinyl is a soft material relative to aluminum. Hardware attachment is a problem, because screws do not hold well in the material. Most vinyl windows use some steel reinforcement at critical points, both to receive screws and to ensure rigidity. Since the steel is completely encased in vinyl, it does not rust, and does not leave a surface exposed to condensation or frost.

Aluminum Windows

Like vinyl windows, aluminum windows are manufactured by extruding the frame and sash members. This allows a virtually infinite selection of cross sectional profiles, by simply making up new extrusion dies. It also allows manufacturers to find a cure for the chronic problems of condensation and frost on the inside surfaces of metal windows. A specially shaped void is made part of the extruded section. This is then filled with a structural-grade urethane, which is *not* a good conductor of heat. After the urethane has cured, the aluminum "bridge" at this point is machined away, leaving two sections of aluminum connected only by non-conductive urethane. This is referred to as a thermal break, and the windows using this are called "thermally improved."

Aluminum windows are offered in "mill" finish *(natural),* painted with high performance paints *(usually electrostatically applied, for better adhesion)* and anodized. Several colors are available in anodized, and a large variety in painted. Aluminum windows can be glazed using gaskets rather than sealants, so that protection of glazing compounds is not consideration.

They accommodate a variety of single- and thermal-glass thicknesses, permitting the thermal qualities of an installation to be tailored to an owner's needs. Some manufacturers offer different series with matching appearance, allowing the use of high-performance windows at critical locations *(such as upper floors of a high-rise building),* and moderate-performance windows at other locations. In the premium grades,

(continued)

large sizes are available that still provide smooth operation and good thermal performance.

Because aluminum can be extruded to virtually any profile, exterior (and interior) trims and panning systems can readily be produced to cover and reproduce the wood trims on older and historical buildings. These are prefinished to match the windows and, once snapped in place and sealed, provide an almost maintenance-free installation encompassing sash, frame and trim. The perimeter of the trim is sealed to the building using high-performance construction sealants. The only maintenance required is periodic inspection of this sealant.

Any building owner or manager concerned about heat loss through windows has a variety of products, materials and prices from which to choose. Each project has its own critical parameters, so it is impossible to say that any one of the types of products discussed in this article is "best."

Rather, a review of the basic needs and criteria of the project should be made to establish the most important factors *(i.e., Does cost outweigh appearance? Is first cost more important than annual energy savings?).* Once the governing criteria are in order, the various products can be investigated to see which best meets the greatest number of factors.

Harwood Loomis is a Project Architect with Hoffmann Architects. He has also published other articles including "The Office of Today," "Managing Consultants." If you would like copies of these articles, please let us know.

"Replacement Windows" was reprinted from the January 1985 issue of Building Operating Management.

Laminated Glass

Laminated glass can be easily used in retrofit situations to improve the safety of a glazed area. However, certain precautions should be taken when glazing with laminated glass to assure long range performance.

1. Insist on dry, covered storage at the site to prevent edge separation. Storage under tarpaulins is not good enough and should be avoided.

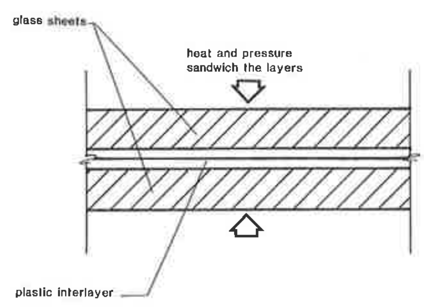
2. If the job is gasket glazed, be sure weep holes are there and not clogged with dirt or debris. Although a zipper gasket may appear to provide a water-tight seal, the film of dirt that builds up on the glass, plus slight movement at the gasket lip, soon carries the dirt under the lip seal. Over time, this creates a path for water to get into the gasket.

3. Laminated glass does not respond well to acetic acid cured silicone sealants. Use neutral cure silicone sealants. Acetic acid cure sealants are readily identifiable by their vinegar-like smell during curing. Polysulfide sealants can also be potentially hazardous if used right against the laminate edge.

4. Taping the edge of insulating glass or laminated glass units with aluminum tape introduces two hazards. Internally reflected ultraviolet light can destroy a thin layer of the tape, opening a perfect water trough. If tape is applied over wet sealant, water produced during curing can be trapped and absorbed into the interlayer of the glass.

5. Avoid the use of chlorinated solvents and cleaning materials.

6. Don't use laminated glass incorporating vacuum-deposited films of



laminated glass

aluminum or copper. These soft surfaces can be damaged by the laminating process. A better idea is to incorporate the reflective glass as the exterior lite of an insulating glass unit and clear laminated glass as the interior lite.

7. Purchase extra units. Manufacturers have been known to change the tint over the years, which makes matching a replacement to the original a little difficult.

8. Watch out for circular patterns occurring in the middle of the glass. This can signal delamination of the material – a manufacturing defect and potential hazard.

9. Use the same thickness of glass throughout. Varying the glass thickness can have a pronounced and easily discernible effect on the apparent color of the glass when seen from a distance.

10. Store laminated glass on edge and almost upright to avoid pressure points.

This material was adapted from the August 15, 1984 issue of Glass Digest.

Sloped Glazing

by George Lambert

Many of today's buildings, to promote energy efficiency or improve aesthetics, include sloped glazing as part of their design. By definition, sloped glazing means that which is tilted inward or outward more than 15 degrees off the vertical. The types of materials presently used for sloped glazing include: insulating glass units, tinted or heat-absorbing glazing, reflective, annealed ("ordinary"), heat-strengthened, tempered, wired or laminated glass.

Before deciding what type of glass to use, the designer must be aware of some of the issues involving the use of sloped glazing. If it is to be located above areas where people pass or work, state and local codes should be consulted for the selection of the proper glass type and requirements for protective designs, especially since "many people involved may have considerable liability such as the owner, the architect, the skylight manufacturer, the glass manufacturer and the installer" according to the Sealed Insulating Glass Manufacturers Association (SIGMA).

Other issues that should concern designers include deflection of the glazing and its supports, additional live loads created by thermal loading from solar radiation, wind forces, snow or rain accumulation, wind-borne, thrown, or falling objects, vandalism, hailstorms or building movement, and the dead load weight of the glass and its supports. The designer must also be aware of the problems that can occur after installation and the difficulty in getting to various sections that have to be repaired or replaced. Last, the designer should realize the solar gain and its effect on the HVAC (heating, ventilation and air conditioning) system requirements for the building. Shading devices may also be required to control undesirable heat build-up and light glare and improve aesthetics.

sloped glazing

Because of these considerations, the probable choice for sloped glazing would be insulating glass units. These units are usually made of two or three lites (glass sheets) that contain a sealed air space between them.

One of the strongest types of glass available is laminated glass (also known as "safety" glass). Laminated glass is comprised of two or more layers of annealed, wired, heat-strengthened or tempered glass inter-leaved with a clear or tinted interlayer such as polyvinyl butyral, a plastic. The glass components and the plastic interlayer are bonded into one unit by the application of heat and pressure. The break characteristics of laminated glass depend on the type of glass which is laminated. It is best glazed on the interior side of an insulating glass unit because, if the glass breaks, the fragments tend to adhere to the interlayer, affording increased protection against falling glass. If broken by impact, the interlayer will resist penetration of the impacting object. Overall, laminated glass is considered to be the safest glass to use. Nevertheless, breakage cannot be eliminated in its entirety. Therefore falling glass must be controlled in areas where the safety of pedestrians or valuable objects is concerned.

To conclude, there are many considerations before one should choose the right type of glass for sloped glazing. These considerations include code and safety requirements, design strength, energy efficiency, as well as aesthetics. Moreover, "the designer and owner should be aware of the potential glass replacement factors and associated costs for the various glazing options before the specifications are released," according to the AAMA. Thus one must study the precise need of each job, and select the materials best suited to assure a safe, pleasing result.

SOURCES:

Sealed Insulating Glass Manufacturers Association. "Voluntary Guidelines for Sloped Glazing of Organically Sealed Insulating Glass Units." *Chicago, Illinois. Document A-2801-77 (83).*

Architectural Aluminum Manufacturers Association. "Sloped Glazing Guidelines." *Chicago, Illinois. Document AAMA TIR-A7-83.*

services

Representative Projects

Hoffmann Architects is studying the fifty-year-old windows at Rockefeller Center in New York City to determine their upgrade or rehabilitation potential. This survery is being done for the Rockefeller Center Management Coprporation, New York. For a large institutional investor, we are examining the glazed curtain wall system of a four story suburban office building in Wethersfield, Connecticut to make recommendations on repairs or replacement of the glazing system. The decorative grillwork on a twelve story building in New Haven, Connecticut is the subject of a study for the Southern New England Telephone Company.

project architect Ted Babbitt inspects deteriorated steel beams

In Albert Lea, Minnesota, Hoffmann Architects is monitoring the construction of an enclosed shopping mall for the Broadview Savings and Loan Company, Cleveland, Ohio. For the same client, we have reviewed the plans and specifications and are monitoring construction of a 37-story luxury condominium tower being built as an air rights project in New York City.

John Hoffmann examines repairs to a precast concrete parking deck

Hoffmann Architects surveyed a 36,000 square foot office building prior to mortgage closing for Aetna Realty Investors, Hartford, Connecticut. For Goldman, Sachs and Company, we are monitoring the renovations and new construction at the Xerox Corporation building in Greenwich, Connecticut. The Atlanta office recently completed a pre-purchase building condition survey of a six-story hotel in Cobb County, Georgia for Dean Witter Realty, New York, New York.

The above is just a small sample of the types of projects we do. If you would like more information about our services, please give us a call.

Binder and Back Issues

Because so many of you have written to let us know that you think our newsletter is useful, interesting and informative, we are offering a three ring binder (free of charge) in which to store your newsletters for future reference.

We also have a limited supply of back issues of the newsletter available by request on a first come, first served basis. The issues available are summer and autumn 83, general repair and rehabilitation topics; first issue 84, masonry; second issue 84, roofing; third issue 84, concrete rehabilitation; and first issue 85, sealants. The roofing and sealant issues each include glossaries.

If you would like to receive one of our free newsletter binders or any of the back issues, please write to Dori Marias at Hoffmann Architects, 3074 Whitney Avenue, Hamden, CT 06518 or call (203) 281-4440 and we will be happy to send them to you.

Journal *is a publication of Hoffmann Architects, specialists in investigative and rehabilitative architecture/engineering, including the analysis and solution of roofing, masonry, glazed curtain wall and structural problems. Our offices are located at 3074 Whitney Avenue, Hamden, CT 06518, Phone (203) 281-4440 and 1925 Century Boulevard, Suite 4, Atlanta, GA 30345, Phone (404) 633-7817.*

*We welcome contributions to HA/J from our clients and friends. Please send news and technical information to Karen L. Warseck, Editor, Hoffmann Architects/*Journal *at the Atlanta address. Address changes and additions to the mailing list should be sent to Dori Marias in Hamden.*

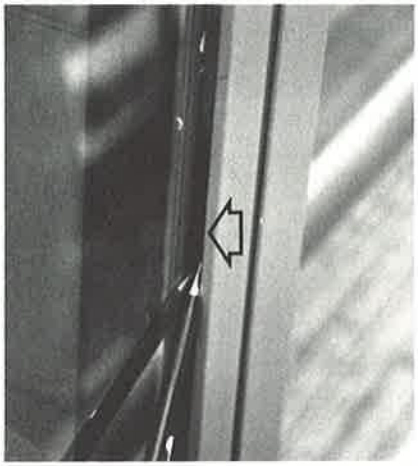
Questions and Answers

Question – *When the rubber glazing gaskets in our windows were installed, they fit perfectly. Now there is about a quarter inch gap at each of the corners. What happened?*

Answer – Rubber glazing gaskets are often stretched during installation. Afterwards, they will tend to shrink back to their original shape and size, leaving the gaps you see at the corners of the windows.

gap at corner of glazing gasket

thorough investigation of the glazing system should determine causes of problems



loose gasket allows water to enter curtain wall

Question – *The glass lites in our glazed curtain wall are breaking. Why?*

Answer – There are any number of reasons for this to happen. The curtain wall may have been incorrectly designed, fabricated or installed. Thermal stresses within the glass can cause delayed breakage of any edge-damaged pieces. Water may be backing up in clogged weep holes and freezing, causing the glass to break. Differential movement of the glass and curtain wall can cause damage. We would suggest that you have a thorough investigation of the curtain wall be done to determine the exact causes of the damage and how they may be remedied.

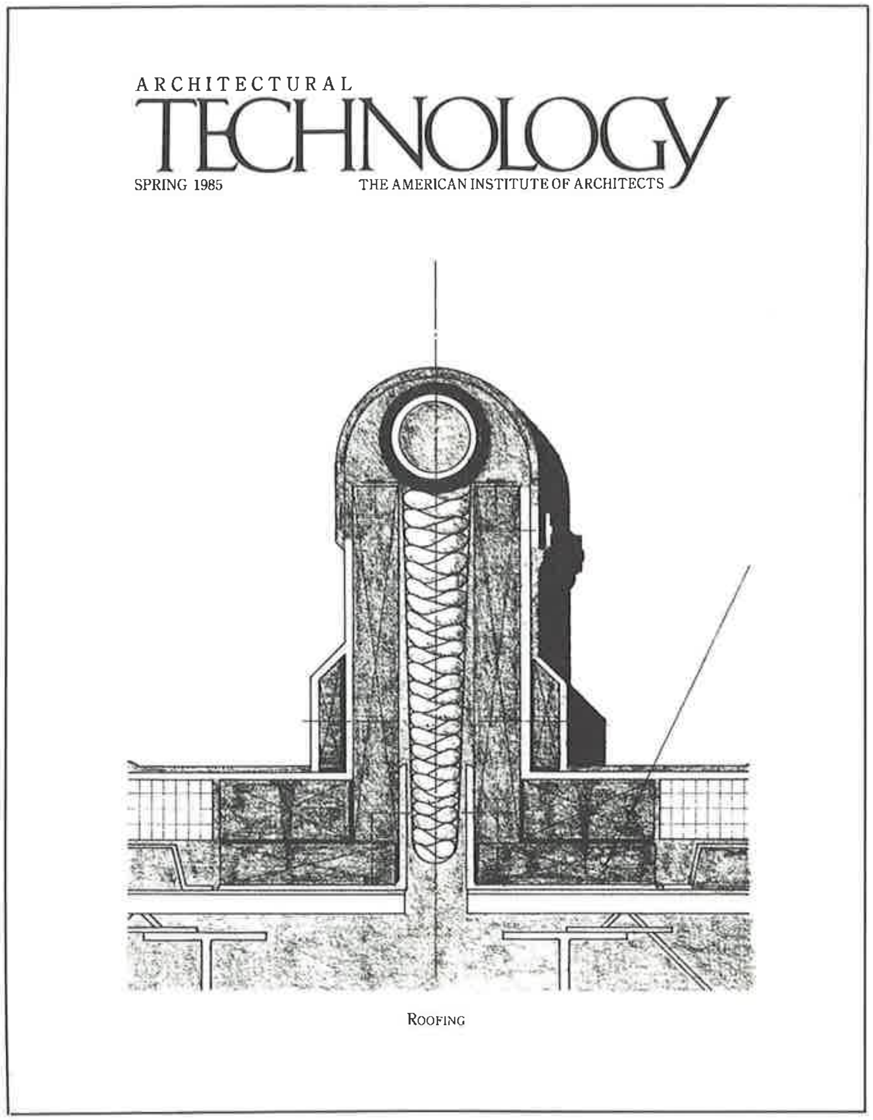
While Hoffmann Architects/Journal attempts to provide the most accurate information on general subjects, it is not intended to be a substitute for professional architectural/engineering services. We strongly urge you to consult a qualified rehabilitation architecture/engineering firm (ours) for answers to specific questions.

Question – *Why can't tempered glass be cut after it has been tempered?*

Answer – The reason has to do with the physical properties of glass in general and with what happens to the glass when it is tempered. Glass is a very strong material when subjected to compressive (squeezing) stresses. However, being a very brittle material, in tension (stretching) it shatters. Thus to make it stronger, you increase the compressive stress within the glass itself. Tempering does just that on all the glass surfaces, but it also increases the tensile stress in the interior of the sheet. When the strong compressive layer at the edge of the sheet is removed by cutting, the inner tensile stresses cause the glass to instantaneously self-destruct.

repairs to an aluminum curtain wall

Staff News



This cover of the Spring 1985 issue of *Architectural Technology* magazine features a rendered version of a roof expansion joint detail drawn by **Russell M. Sanders.** Russ, besides being a talented roof designer and drafter, also coordinates Hoffmann Architects' inspection program for General Electric Company's and Dow Corning Corporation's silicone/urethane roofing system warranties.

Russell was also responsible for the roofing details that appeared in the article "How Much Should You Show?" in the same issue. The article, written by managing editor James B. Gardner, included quotes by **John J. Hoffmann** and focused on the architect's responsibilities in detailing a roof.

Architectural Technology is a national publication of the American Institute of Architects that publishes articles on topics related to the more technical aspects of the profession and practice of architecture.

Hoffmann Architects is pleased to introduce the newest member of our staff, drafter **Pamela Cunningham.** Pam is a graduate of Porter-Chester Institute and has over ten years experience in the detailing and production of working drawings for construction.

Amy C. Kilburn, AIA attended a seminar in Washington, DC entitled "Working with the AIA Contract Forms." The seminar analyzed the American Institute of Architects contract documents from both an architectural and legal standpoint.

Walter E. Damuck, CSI, AIA, was an instructor on Materials and Methods of Construction for a seminar sponsored by the Connecticut Society of Architects. The program is to help interns prepare for the Architectural Registration Examination. Walt also was a delegate to the Construction Specifications Institute national convention in Orlando, Florida.

John J. Hoffmann, AIA, as President of the Connecticut Society of Architects, was a delegate to the American Institute of Architects national convention in San Francisco. As treasurer of the Southern Connecticut Chapter of the Building Owners and Managers Association, he also attended the BOMA national convention in Boston.